Data Mining Analysis and Modeling Cell

Compendium of Material Composition Data for Radiation Transport Modeling

200-DMAMC-128170
PNNL-15870, Rev. 2

April 2021

Homeland Security

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Executive Summary

In 2011, Pacific Northwest National Laboratory (PNNL) produced a document known as the *Materials Compendium, or Compendium of Material Composition Data for Radiation Transport Modeling*, PNNL-15870, Rev. 1, that contains material information useable for modeling purposes. Revision 1 captured the properties of 372 materials, including material densities, atom density, and elemental composition provided as weight and atom fraction. This information is used in several modeling programs used by the radiological/nuclear community, though it is primarily tailored for the Monte-Carlo-N-Particle code produced by Los Alamos National Laboratory. References for the source of each material's data are provided. The values given here are reasonably representative; however, variations in material composition and density are expected in practice. PNNL developed Revision 1 using internally maintained Excel database for compiling materials data and materials conversion calculations.

Revision 2 of the *Materials Compendium* (this document) is a joint effort including multiple organizations in the update, review, and ownership of this important product for the radiological/nuclear modeling community. The new document includes a complete review and update of all materials data and references, addressing discrepancies and changes in materials data or references that have occurred since the first revision. An additional 39 materials have been added, primarily newer detector materials developed since the previous revision. The materials data are now maintained in a website database, which allows ease of access outside of PNNL. Nuclear data for modeling continues to increase in its isotopic specificity. The website therefore now includes an option for isotope specifications of all material formulations.

Acknowledgments

The authors acknowledge the Countering Weapons of Mass Destruction Office of the U.S. Department of Homeland Security, which provided funding for this work through the Data Mining Analysis and Modeling Cell (DMAMC) program. The authors also would like to acknowledge the members of the Materials Compendium Working Group for their help in review and updating the materials in this Compendium, including Giuseppe Camarda (Brookhaven National Laboratory), Christopher Lavelle (Johns Hopkins University Applied Physics Laboratory), Douglas Peplow (Oak Ridge National Laboratory), Mark Strickman (Naval Research Laboratory), Scott Thompson (Idaho National Laboratory), and Daniel Weidinger (DMAMC program manager, Countering Weapons of Mass Destruction Office, U.S. Department of Homeland Security).

Acronyms and Abbreviations

ASTAR	Alpha Stopping-Power and Range
CEPXS/ONELD	Coupled Electron-Photon One-Dimensional Discrete Ordinates (code)
DMAMC	Data Mining Analysis and Modeling Cell
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
INL	Idaho National Laboratory
MCNP	Monte-Carlo-N-Particle (code)
NCRP	National Council on Radiation Protection and Measurements Definition
NIST	National Institute of Standards and Technology
ORNL	Oak Ridge National Laboratory
PNNL	Pacific Northwest National Laboratory
PSTAR	Proton Stopping-Power and Range
RSICC	Radiation Safety Information Computational Center
SCALE	Standardized Computer Analysis for Licensing Evaluation

Revision Log

Compendium of Material Composition Data for Radiation Transport Modeling

Rev. No.	Date	Describe Changes	Pages Changed
0	10/31/2006	Original document was published as PNNL-15870 only, not as an RPMP document. Therefore, Revision 1 is the first version of this document to be issued under PIET-43741-TM-963.	NA
1	03/04/11	Revised to correct errors or inconsistencies in the data for the original materials, as well as to increase the number of materials listed.	All
2	06/26/2020	Reviewed and updated materials data and references, corrected known discrepancies, and increased the number of materials listed, adding 39 new materials including new scintillator detector materials. CEPXS specifications were removed.	All

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Introduction

Meaningful simulations of radiation transport applications require realistic definitions of material composition and densities. Researchers often encounter a variety of materials for which elemental compositions are not readily available or densities that are not defined when developing models for applications in fields such as homeland security, radiation shielding and protection, and criticality safety. The *Compendium of Material Composition Data for Radiation Transport Modeling* addresses this problem. A single common set of material definitions helps with standardization and provides for a common basis of materials for inter-comparison of model results.The Compendium has been used by the modeling community throughout the world, even being included with recent revisions of the Monte Carlo N-Particle Transport (MCNP) code.

Publication of the *Compendium of Material Composition Data for Radiation Transport Modeling*, Revision 0, in 2006 was the first step, listing 121 materials from the combined personal libraries of staff at the Pacific Northwest National Laboratory (PNNL). The revision (*Materials Compendium*, PNNL-15870, Rev. 1) extended the initial number of materials from 121 to 372 per user suggestions, corrected inconsistencies in the original data, and also addressed data quality checks by first compiling all of the materials information into a single database maintained at PNNL, with calculations contained in an extensive Excel workbook. The data listed in the 2006 document were compiled, evaluated, entered, and error-checked by a group of individuals by hand. This method provided no library file or mechanism for revising the data in a consistent and traceable manner.

Representatives from the radiological/nuclear modeling community at PNNL, Oak Ridge National Laboratory (ORNL), Brookhaven National Laboratory, Idaho National Laboratory (INL), Naval Research Laboratory, and Johns Hopkins Applied Physics Laboratory collaborated to develop Revision 2. Based on the group input, the current document also include a quality check—a review of all materials data, references, and website address links and provides updates where needed. The group also reviewed the spreadsheet calculations and produced the document *Spreadsheet Calculations White Paper*. Revision 2 includes new detector materials and other new materials and addresses known errors from the previous compilation. Revision 2 also includes isotopic specific data, which were necessary due to changes in the underlying cross section information used in modeling codes such as Monte-Carlo-N-Particle (MCNP) and Standardized Computer Analysis for Licensing Evaluation (SCALE). The isotopic information enables more efficient access to the isotopic specificity provided by the latest Evaluated Nuclear Data File[1] cross sections. The isotopic information provided is for natural isotopic compositions for most natural elements, and several actinides based upon the specific data needs of MCNP6.2. Isotopic information is included for all elements with isotopic cross sections currently in the MCNP6.2 library, which incorporates ENDF7.1 cross sections. In addition, elements Cd and Cl are broken out isotopically due to their importance in neutron reactions.

Revision 2 also employs a new method of delivery, the use of an online web interface. This interface allows user interaction, provides an easier way for the modeling community to access the data in different formats and types, and captures user feedback. It can be found at https://compendium.cwmd.pnnl.gov/ . The site includes material densities, elemental or isotopic compositions, weight and atom fractions, as well as atom density for all materials specified. Data may be downloaded in elemental or isotopic specification. Isotopic and atomic masses are taken from the NIST website at (https://www.nist.gov/pml/atomic-weights-and-isotopic-compositions-relative-atomic-masses). References to compositional data are provided for each material. PNNL has addressed the issue of

[1] https://www-nds.iaea.org/exfor/endf.htm

material density by including a range of densities within the "Comments" and "References" sections for each material when such information could be obtained.

The 411 materials included in this document are shown in Table 1. The materials were selected based on their inclusion in standard references and user input from the modeling community. Where possible, exact formulas and associated atom fractions were used as input. Key references are listed below:

- *Compendium of Material Composition Data for Radiation Transport Modeling*, Revision 1 (McConn et al. 2011)
- *Criticality Calculations with MCNP5: A Primer*, Appendix B, pp. 131-140 (Brewer 2009)
- "Standard Composition Library" for the SCALE code system in *SCALE Ver 6.2.4: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design.* ORNL/TM-2005/39, Version 6.2.4 (April 2020)
- *Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu, and ^{233}U: 1986 Revision,* Appendix, pp 200-201 (Paxton and Pruvost 1986)
- *Radiation Detection and Measurement* (Knoll 2000)
- "Materials: Volume 1" in *Reactor Handbook* (Hungerford 1960)
- *Criticality Handbook,* Volume 1, pp II.F.1-1 to 1-8 (Carter et al. 1968)
- "Shielding Materials" in Volume 2 of *Engineering Compendium on Radiation Shielding* (Jaeger et al.)
- *Radiation Protection for Particle Accelerator Facilities* (NCRP 2003)
- *Principles of Radiation Shielding* (Chilton et al. 1984)
- *Radiation Shielding* (Shultis and Faw 1996)
- *Reactor Shielding for Nuclear Engineers* (Schaeffer 1973)
- National Institute of Standards and Technology (NIST) Standard Reference Database 124 on the PSTAR and ASTAR lists at http://physics.nist.gov/PhysRefData/Star/Text/Table2.html (NIST 2017)
- NIST Standard Reference Database 126 X-Ray Mass Attenuation Coefficients (Table 2), at http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html (NIST 2004)
- DOE-STD-3013-2018, Stabilization, Packaging and Storage of Plutonium-Bearing Materials at https://www.standards.doe.gov/news/new-doe-std-3013-2018-stabilization-packaging-and-storage-of-plutonium-bearing-materials

Data in this document are listed in formats and quantities suitable for use in MCNP,[2] SCALE[3] and SoftWare for Optimization of Radiation Detectors (SWORD)[4]. The data for each material are divided into

[2] MCNP is a trademark of Los Alamos National Security, LLC, Los Alamos National Laboratory. The MCNP code and manuals can be obtained from the Radiation Safety Information Computational Center (RSICC), P.O. Box 2008, Oak Ridge, TN, 37831-6362, (ID#: C00850MNYCP00, RSICC#: CCC-850).

[3] SCALE was developed and maintained by the Oak Ridge National Laboratory, the code and manuals can be obtained from RSICC, ID#: C00834MNYCP06/07, RSICC#: CCC-834. Updates are available at http://scale.ornl.gov.

[4] SWORD was developed through the Naval Research Laboratory in Washington, DC and can be obtained from RSICC, ID#: C00767MNYPC06, RSICC#: CCC-767.

three blocks: 1) base information with density, molecular weight, and formula; 2) the MCNP/SCALE card blocks for isotopic and elemental specifications; and 3) the references and comments. The previous Coupled Electron-Photon Cross Section (CEPXS)[5] block has been removed as these data can be derived from the provided material information and do not need a separate entry. The base information block contains the elemental composition of the material listed using standard elemental symbols. The elements are listed by weight fraction and atom fraction, both normalized to unity. The elements are also listed by atom density (atoms per barn-cm) individually and summed, based on the provided density.

It should be noted that the density of a material may vary widely from typical or average values, especially for foams and insulating or shock-absorbing materials. Project-specific density values should always be used, if available, instead of the density values used here. In particular, users should be careful to use the appropriate type of density, (i.e., theoretical density versus bulk density), for their application. Bulk densities are sometimes discussed in the comments and reference block. Sources for bulk densities include the following:

- Density for materials compositions listed on the NIST Standard Reference Database 124 and 126 websites (NIST 2004 and 2017)
- Density of bulk materials chart at http://www.simetric.co.uk/si_materials.htm (Walker 2009)
- MatWeb material property database at http://www.matweb.com/search/search.aspx (MatWeb Material Property Data 2020)
- Table 6.1.5 of *Mark's Standard Handbook for Mechanical Engineers* (Avallone and Baumeister III 1996)
- Table 51.65 of Hungerford (1960).

As in the previous versions, users are cautioned regarding the precision of the values listed here. The calculated weight fractions, atom fractions, and atom densities are all formatted in scientific notation using a fixed format that keeps five digits to the right of the decimal point. Do not infer from this convention that these values are all significant, since in almost every case, the input density has a much larger uncertainty than this. For example, the density used for wood (0.65 g/cm^3) is for southern pine, which generally has a range of 0.61 to 0.67 g/cm^3, but other types of pine can range from 0.43 to 0.71 g/cm^3, and other types of wood can range from 0.11 to 1.33 g/cm^3. However, the weight fractions, atom fractions, and atom densities for wood are calculated using the input density of 0.65 g/cm^3 as though it is an exact value. Users ultimately must consider the effect of uncertainties in the material density and composition. Comments regarding this document or suggestions for materials to be included in possible future revisions may be submitted to compendium@pnnl.gov.

[5] CEPXS can also be obtained from the Radiation Safety Information Computational Center (RSICC), ID#: C00837MNYCP00, RSICC#: CCC-837.

Table 1. Materials Included in This Compendium

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Materials

1. A-150 Tissue-Equivalent Plastic

Formula =		Molecular Weight (g/mole) =	
Density (g/cm3) =	1.127	Total Atom Weight (atoms/b-cm) =	1.169E-01

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not

addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101300	1001	0.583563	1001	0.068218
H2	1002	-0.000023	1002	0.000067	1002	0.000008
C	6000	-0.775500	6000	0.374869	6000	0.043822
N14	7014	-0.034920	7014	0.014478	7014	0.001692
N15	7015	-0.000137	7015	0.000053	7015	0.000006
O16	8016	-0.052174	8016	0.018938	8016	0.002214
O17	8017	-0.000021	8017	0.000007	8017	0.000001
O18	8018	-0.000121	8018	0.000039	8018	0.000005
F19	9019	-0.017422	9019	0.005324	9019	0.000622
Ca	20000	-0.018378	20000	0.002662	20000	0.000311
Elemental						
H	1000	-0.101327	1000	0.583630	1000	0.068226
C	6000	-0.775500	6000	0.374869	6000	0.043822
N	7000	-0.035057	7000	0.014531	7000	0.001699
O	8000	-0.052316	8000	0.018984	8000	0.002219
F	9000	-0.017422	9000	0.005324	9000	0.000622
Ca	20000	-0.018378	20000	0.002662	20000	0.000311

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=099.

2. Acetone

Formula = C3H6O Molecular Weight (g/mole) = 58.079050
Density (g/cm3) = 0.7899 Total Atom Weight (atoms/b-cm) = 8.190E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.104104	1001	0.599931	1001	0.049137
H2	1002	-0.000024	1002	0.000069	1002	0.000006
C	6000	-0.620393	6000	0.300000	6000	0.024571
O16	8016	-0.274730	8016	0.099757	8016	0.008170
O17	8017	-0.000111	8017	0.000038	8017	0.000003
O18	8018	-0.000635	8018	0.000205	8018	0.000017
Elemental						
H	1000	-0.104131	1000	0.600000	1000	0.049142
C	6000	-0.620393	6000	0.300000	6000	0.024571
O	8000	-0.275476	8000	0.100000	8000	0.008190

Comments and References
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=100. Formula from http://www.matweb.com/search/DataSheet.aspx?MatGUID=1f9fd4a5357e428f9a82e750f4fbbf0e. Formula and density = 0.7845 in CRC Handbook of Chemistry and Physics, 89th edition, page 3-4, available at http://www.hbcpnetbase.com/.

3. Acetylene

Formula = C2H2 Molecular Weight (g/mole) = 26.037150
Density (g/cm3) = 0.0010967 Total Atom Weight (atoms/b-cm) = 1.020E-04

The above density is estimated to be accurate to 5 significant digits. Uncertainties are not addressed.The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.077405	1001	0.499943	1001	0.000051
H2	1002	-0.000018	1002	0.000058	1002	0.000000
C	6000	-0.922574	6000	0.500000	6000	0.000051
Elemental						
H	1000	-0.077426	1000	0.500000	1000	0.000051
C	6000	-0.922574	6000	0.500000	6000	0.000051

Comments and References
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=101. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 3-6.

4. Air (dry, near sea level)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.001205 Total Atom Weight (atoms/b-cm) = 5.000E-05

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. Dry air near sea levelThe NIST data yields a CO2 content in air of about 299 ppm by volume whereas measurements at the Mauna Loa Observatory indicate an average CO2 content of 377.38 ppm in 2004 (CRC Handbook of Chemistry and Physics, 90th edition, page 14-28).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000124	6000	0.000150	6000	0.000000
N14	7014	-0.752316	7014	0.781574	7014	0.000039
N15	7015	-0.002944	7015	0.002855	7015	0.000000
O16	8016	-0.231153	8016	0.210238	8016	0.000010
O17	8017	-0.000094	8017	0.000080	8017	0.000000

O18	8018	-0.000535	8018	0.000432	8018	0.000000
Ar	18000	-0.012827	18000	0.004671	18000	0.000000
Elemental						
C	6000	-0.000124	6000	0.000150	6000	0.000000
N	7000	-0.755268	7000	0.784429	7000	0.000039
O	8000	-0.231781	8000	0.210750	8000	0.000011
Ar	18000	-0.012827	18000	0.004671	18000	0.000000
Comments and References						
Density and weight fractions from http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html.						

5. Alanine

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.42 Total Atom Weight (atoms/b-cm) = 1.248E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.079169	1001	0.538378	1001	0.067175
H2	1002	-0.000018	1002	0.000062	1002	0.000008
C	6000	-0.404439	6000	0.230784	6000	0.028796
N14	7014	-0.156598	7014	0.076645	7014	0.009563
N15	7015	-0.000613	7015	0.000280	7015	0.000035
O16	8016	-0.358185	8016	0.153477	8016	0.019150
O17	8017	-0.000145	8017	0.000058	8017	0.000007
O18	8018	-0.000828	8018	0.000315	8018	0.000039
Elemental						
H	1000	-0.079190	1000	0.538440	1000	0.067183
C	6000	-0.404439	6000	0.230784	6000	0.028796
N	7000	-0.157213	7000	0.076925	7000	0.009598
O	8000	-0.359159	8000	0.153851	8000	0.019196
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=105. Density of 1.432 g/cm3 at 22 C is also given from PubChem.ncbi.nlm.nih.gov						

6. Aluminum

Formula = Al Molecular Weight (g/mole) = 26.981538
Density (g/cm3) = 2.6989 Total Atom Weight (atoms/b-cm) = 6.024E-02

The above density is estimated to be accurate to 5 significant digits. Uncertainties are not addressed.The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Al27	13027	-1.000000	13027	1.000000	13027	0.060238
Elemental						
Al	13000	-1.000000	13000	1.000000	13000	0.060238
Comments and References						
Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=013.						

7. Aluminum Oxide

Formula = Al2O3 Molecular Weight (g/mole) = 101.961276
Density (g/cm3) = 3.97 Total Atom Weight (atoms/b-cm) = 1.172E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Also called alumina or corundum (http://en.wikipedia.org/wiki/Aluminum_oxide).Bulk density for alumina is 0.64 at http://www.powderandbulk.com/resources/bulk_density/material_bulk_density_chart_a.htm
The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.469474	8016	0.598542	8016	0.070173
O17	8017	-0.000190	8017	0.000228	8017	0.000027
O18	8018	-0.001086	8018	0.001230	8018	0.000144
Al27	13027	-0.529251	13027	0.400000	13027	0.046896
Elemental						
O	8000	-0.470749	8000	0.600000	8000	0.070344
Al	13000	-0.529251	13000	0.400000	13000	0.046896
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=106. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-45.						

8. Aluminum, alloy 2024-O

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.78 Total Atom Weight (atoms/b-cm) = 6.022E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Weight fractions for Mg, Al, Mn and Cu set at the average of the allowed range. Weight fractions for Si, Ti, Cr, Fe, and Zn were set at 56.7% of their upper limits to allow the total to sum

to unity						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Mg	12000	-0.015000	12000	0.017157	12000	0.001033
Al27	13027	-0.927000	13027	0.955162	13027	0.057519
Si	14000	-0.002833	14000	0.002804	14000	0.000169
Ti	22000	-0.000850	22000	0.000494	22000	0.000030
Cr	24000	-0.000567	24000	0.000303	24000	0.000018
Mn55	25055	-0.006000	25055	0.003036	25055	0.000183
Fe	26000	-0.002833	26000	0.001410	26000	0.000085
Cu	29000	-0.043500	29000	0.019031	29000	0.001146
Zn	30000	-0.001417	30000	0.000603	30000	0.000036
Elemental						
Mg	12000	-0.015000	12000	0.017157	12000	0.001033
Al	13000	-0.927000	13000	0.955162	13000	0.057519
Si	14000	-0.002833	14000	0.002804	14000	0.000169
Ti	22000	-0.000850	22000	0.000494	22000	0.000030
Cr	24000	-0.000567	24000	0.000303	24000	0.000018
Mn	25000	-0.006000	25000	0.003036	25000	0.000183
Fe	26000	-0.002833	26000	0.001410	26000	0.000085
Cu	29000	-0.043500	29000	0.019031	29000	0.001146
Zn	30000	-0.001417	30000	0.000603	30000	0.000036
Comments and References						
Density = 2.78 g/cm3 and weight fractions from http://www.matweb.com/search/DataSheet.aspx?MatGUID=642e240585794f0ab91428aa78c27b4e.						

9. Aluminum, alloy 2090-T83

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.59 Total Atom Weight (atoms/b-cm) = 6.052E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Weight fractions for Li, Al, Cu, and Zr set at the average of the allowed range. Weight fractions for Mg, Si, Ti, Cr, Mn, Fe, and Zn were set at 65.2% of their upper limits to allow the total to sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.001474	3006	0.006317	3006	0.000382
Li7	3007	-0.020937	3007	0.076911	3007	0.004655
Mg	12000	-0.001631	12000	0.001729	12000	0.000105
Al27	13027	-0.944001	13027	0.901710	13027	0.054570
Si	14000	-0.000652	14000	0.000598	14000	0.000036
Ti	22000	-0.000979	22000	0.000527	22000	0.000032

Cr	24000	-0.000326	24000	0.000162	24000	0.000010
Mn55	25055	-0.000326	25055	0.000153	25055	0.000009
Fe	26000	-0.000783	26000	0.000361	26000	0.000022
Cu	29000	-0.027000	29000	0.010951	29000	0.000663
Zn	30000	-0.000652	30000	0.000257	30000	0.000016
Zr90	40090	-0.000583	40090	0.000167	40090	0.000010
Zr91	40091	-0.000129	40091	0.000036	40091	0.000002
Zr92	40092	-0.000199	40092	0.000056	40092	0.000003
Zr94	40094	-0.000206	40094	0.000056	40094	0.000003
Zr96	40096	-0.000034	40096	0.000009	40096	0.000001
Elemental						
Li	3000	-0.022500	3000	0.083227	3000	0.005037
Mg	12000	-0.001631	12000	0.001729	12000	0.000105
Al	13000	-0.944001	13000	0.901710	13000	0.054570
Si	14000	-0.000652	14000	0.000598	14000	0.000036
Ti	22000	-0.000979	22000	0.000527	22000	0.000032
Cr	24000	-0.000326	24000	0.000162	24000	0.000010
Mn	25000	-0.000326	25000	0.000153	25000	0.000009
Fe	26000	-0.000783	26000	0.000361	26000	0.000022
Cu	29000	-0.027000	29000	0.010951	29000	0.000663
Zn	30000	-0.000652	30000	0.000257	30000	0.000016
Zr	40000	-0.001150	40000	0.000325	40000	0.000020

Comments and References

Density = 2.59 g/cm3 and weight fractions from http://www.matweb.com/search/datasheet.aspx?matguid=a79a000ba9314c8d90fe75dc76efcc8a&ckck=1.

10. Aluminum, alloy 3003

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.73 Total Atom Weight (atoms/b-cm) = 6.035E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Al, Mn, and Cu set at the average of the allowed range. Weight fractions for Si, Fe, and Zn were set at 55.4% of their upper limits to allow the total to sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Al27	13027	-0.978500	13027	0.987924	13027	0.059622
Si	14000	-0.003321	14000	0.003221	14000	0.000194
Mn55	25055	-0.012500	25055	0.006198	25055	0.000374
Fe	26000	-0.003875	26000	0.001890	26000	0.000114
Cu	29000	-0.001250	29000	0.000536	29000	0.000032
Zn	30000	-0.000554	30000	0.000231	30000	0.000014
Elemental						

Al	13000	-0.978500	13000	0.987924	13000	0.059622
Si	14000	-0.003321	14000	0.003221	14000	0.000194
Mn	25000	-0.012500	25000	0.006198	25000	0.000374
Fe	26000	-0.003875	26000	0.001890	26000	0.000114
Cu	29000	-0.001250	29000	0.000536	29000	0.000032
Zn	30000	-0.000554	30000	0.000231	30000	0.000014
Comments and References						
Density = 2.73 g/cm3 and weight fractions from http://www.matweb.com/search/DataSheet.aspx?MatGUID=fd4a40f87d3f4912925e5e6eab1fbc40.						

11. Aluminum, alloy 4043-O

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.69 Total Atom Weight (atoms/b-cm) = 5.966E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Al and Si set at the average of the allowed range. Weight fractions for Be, Mg, Ti, Mn, Fe, Cu, and Zn were set at 56.6% of their upper limits to allow the total to sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Be9	4009	-0.000005	4009	0.000015	4009	0.000001
Mg	12000	-0.000283	12000	0.000316	12000	0.000019
Al27	13027	-0.939000	13027	0.944964	13027	0.056377
Si	14000	-0.052500	14000	0.050758	14000	0.003028
Ti	22000	-0.001133	22000	0.000643	22000	0.000038
Mn55	25055	-0.000283	25055	0.000140	25055	0.000008
Fe	26000	-0.004531	26000	0.002203	26000	0.000131
Cu	29000	-0.001699	29000	0.000726	29000	0.000043
Zn	30000	-0.000566	30000	0.000235	30000	0.000014
Elemental						
Be	4000	-0.000005	4000	0.000015	4000	0.000001
Mg	12000	-0.000283	12000	0.000316	12000	0.000019
Al	13000	-0.939000	13000	0.944964	13000	0.056377
Si	14000	-0.052500	14000	0.050758	14000	0.003028
Ti	22000	-0.001133	22000	0.000643	22000	0.000038
Mn	25000	-0.000283	25000	0.000140	25000	0.000008
Fe	26000	-0.004531	26000	0.002203	26000	0.000131
Cu	29000	-0.001699	29000	0.000726	29000	0.000043
Zn	30000	-0.000566	30000	0.000235	30000	0.000014
Comments and References						

Density = 2.69 g/cm3 and weight fractions from
http://www.matweb.com/search/DataSheet.aspx?
MatGUID=febb330c9c0548b39ed4105628912ffd.

12. Aluminum, alloy 5086-O

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.66 Total Atom Weight (atoms/b-cm) = 5.928E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Mg, Al, Cr and Mn set at the average of the allowed range. Weight fractions for Si, Ti, Fe, Cu, and Zn were set at 53.6% of their upper limits to allow the total to sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Mg	12000	-0.040000	12000	0.044472	12000	0.002636
Al27	13027	-0.946499	13027	0.947942	13027	0.056193
Si	14000	-0.002143	14000	0.002062	14000	0.000122
Ti	22000	-0.000804	22000	0.000454	22000	0.000027
Cr	24000	-0.001500	24000	0.000780	24000	0.000046
Mn55	25055	-0.004500	25055	0.002213	25055	0.000131
Fe	26000	-0.002679	26000	0.001296	26000	0.000077
Cu	29000	-0.000536	29000	0.000228	29000	0.000014
Zn	30000	-0.001339	30000	0.000553	30000	0.000033
Elemental						
Mg	12000	-0.040000	12000	0.044472	12000	0.002636
Al	13000	-0.946499	13000	0.947942	13000	0.056193
Si	14000	-0.002143	14000	0.002062	14000	0.000122
Ti	22000	-0.000804	22000	0.000454	22000	0.000027
Cr	24000	-0.001500	24000	0.000780	24000	0.000046
Mn	25000	-0.004500	25000	0.002213	25000	0.000131
Fe	26000	-0.002679	26000	0.001296	26000	0.000077
Cu	29000	-0.000536	29000	0.000228	29000	0.000014
Zn	30000	-0.001339	30000	0.000553	30000	0.000033

Comments and References

Density = 2.66 g/cm3 and weight fractions from
http://www.matweb.com/search/DataSheet.aspx?MatGUID=d0271cf3b5f84d63a17e328d02419587.

13. Aluminum, alloy 6061-O

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.70 Total Atom Weight (atoms/b-cm) = 5.993E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Mg, Al, Si, Cr and Cu set at the average of the allowed range. Weight fractions for Ti, Mn, Fe, and Zn were set at 58.4% of their upper limits to allow the total to sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Mg	12000	-0.010000	12000	0.011162	12000	0.000669
Al27	13027	-0.972000	13027	0.977330	13027	0.058575
Si	14000	-0.006000	14000	0.005796	14000	0.000347
Ti	22000	-0.000876	22000	0.000496	22000	0.000030
Cr	24000	-0.001950	24000	0.001017	24000	0.000061
Mn55	25055	-0.000876	25055	0.000433	25055	0.000026
Fe	26000	-0.004088	26000	0.001986	26000	0.000119
Cu	29000	-0.002750	29000	0.001174	29000	0.000070
Zn	30000	-0.001460	30000	0.000606	30000	0.000036
Elemental						
Mg	12000	-0.010000	12000	0.011162	12000	0.000669
Al	13000	-0.972000	13000	0.977330	13000	0.058575
Si	14000	-0.006000	14000	0.005796	14000	0.000347
Ti	22000	-0.000876	22000	0.000496	22000	0.000030
Cr	24000	-0.001950	24000	0.001017	24000	0.000061
Mn	25000	-0.000876	25000	0.000433	25000	0.000026
Fe	26000	-0.004088	26000	0.001986	26000	0.000119
Cu	29000	-0.002750	29000	0.001174	29000	0.000070
Zn	30000	-0.001460	30000	0.000606	30000	0.000036

Comments and References

Density = 2.70 g/cm3 and weight fractions from http://www.matweb.com/search/DataSheet.aspx?MatGUID=626ec8cdca604f1994be4fc2bc6f7f63.

14. Aluminum, alloy 7075-O

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.81 Total Atom Weight (atoms/b-cm) = 5.999E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Mg, Al, Cr, Cu and Zn set at the average of the allowed range. Weight fractions for Si, Ti, Mn and Fe were set at 58.6% of their upper limits to allow the total to sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Mg	12000	-0.025000	12000	0.029013	12000	0.001741
Al27	13027	-0.892500	13027	0.933052	13027	0.055976
Si	14000	-0.002343	14000	0.002353	14000	0.000141

Ti	22000	-0.001171	22000	0.000690	22000	0.000041
Cr	24000	-0.002300	24000	0.001248	24000	0.000075
Mn55	25055	-0.001757	25055	0.000902	25055	0.000054
Fe	26000	-0.002929	26000	0.001479	26000	0.000089
Cu	29000	-0.016000	29000	0.007102	29000	0.000426
Zn	30000	-0.056000	30000	0.024161	30000	0.001449
Elemental						
Mg	12000	-0.025000	12000	0.029013	12000	0.001741
Al	13000	-0.892500	13000	0.933052	13000	0.055976
Si	14000	-0.002343	14000	0.002353	14000	0.000141
Ti	22000	-0.001171	22000	0.000690	22000	0.000041
Cr	24000	-0.002300	24000	0.001248	24000	0.000075
Mn	25000	-0.001757	25000	0.000902	25000	0.000054
Fe	26000	-0.002929	26000	0.001479	26000	0.000089
Cu	29000	-0.016000	29000	0.007102	29000	0.000426
Zn	30000	-0.056000	30000	0.024161	30000	0.001449
Comments and References						
Density = 2.81 g/cm3 and weight fractions from http://www.matweb.com/search/DataSheet.aspx?MatGUID=da98aea5e9de44138a7d28782f60a836.						

15. Ammonia (liquid at T= -79 C)

Formula = NH3 Molecular Weight (g/mole) = 17.030780
Density (g/cm3) = 0.771 Total Atom Weight (atoms/b-cm) = 1.091E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Density = 0.771 at T = -79C from Table 51.11 of Reactor HandbookAt room temperature, ammonia is a gas with density = 8.26019e-04 The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.177510	1001	0.749914	1001	0.081779
H2	1002	-0.000041	1002	0.000086	1002	0.000009
N14	7014	-0.819229	7014	0.249090	7014	0.027164
N15	7015	-0.003206	7015	0.000910	7015	0.000099
Elemental						
H	1000	-0.177556	1000	0.750000	1000	0.081788
N	7000	-0.822444	7000	0.250000	7000	0.027263
Comments and References						
Weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=108. Density = 0.771 at T = -79C from Table 51.11 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960. At room temperature, ammonia is a gas with density = 8.26019e-04 (http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=108).						

16. Anthracene

Formula = C14H10 Molecular Weight (g/mole) = 178.228150
Density (g/cm3) = 1.28 Total Atom Weight (atoms/b-cm) = 1.038E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.056540	1001	0.416619	1001	0.043245
H2	1002	-0.000013	1002	0.000048	1002	0.000005
C	6000	-0.943445	6000	0.583333	6000	0.060550
Elemental						
H	1000	-0.056555	1000	0.416667	1000	0.043250
C	6000	-0.943445	6000	0.583333	6000	0.060550

Comments and References

https://webbook.nist.gov/cgi/inchi?ID=C120127&Mask=10
https://en.wikipedia.org/wiki/Anthracene (density of 1.28g/cm3)
https://pubchem.ncbi.nlm.nih.gov/compound/Anthracenehttps://deq.mt.gov/Portals/112/Land/hazwaste/documents/Anthracene.pdf (density of 1.25g)

17. Argon

Formula = Ar Molecular Weight (g/mole) = 39.948000
Density (g/cm3) = 0.001662 Total Atom Weight (atoms/b-cm) = 2.500E-05

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ar	18000	-1.000000	18000	1.000000	18000	0.000025
Elemental						
Ar	18000	-1.000000	18000	1.000000	18000	0.000025

Comments and References

Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=018.

18. Asbestos (Chrysotile)

Formula = Mg3Si2O9H4 Molecular Weight (g/mole) = 277.113000
Density (g/cm3) = 2.53 Total Atom Weight (atoms/b-cm) = 9.896E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.014546	1001	0.222197	1001	0.021990
H2	1002	-0.000003	1002	0.000026	1002	0.000003
O16	8016	-0.518216	8016	0.498785	8016	0.049363
O17	8017	-0.000210	8017	0.000190	8017	0.000019
O18	8018	-0.001198	8018	0.001025	8018	0.000101
Mg	12000	-0.263129	12000	0.166667	12000	0.016494
Si	14000	-0.202697	14000	0.111111	14000	0.010996
Elemental						
H	1000	-0.014550	1000	0.222222	1000	0.021992
O	8000	-0.519624	8000	0.500000	8000	0.049483
Mg	12000	-0.263129	12000	0.166667	12000	0.016494
Si	14000	-0.202697	14000	0.111111	14000	0.010996

Comments and References

Wikiopedia (chrysolite) says 'Chrysotile or white asbestos is the most commonly encountered form of asbestos, accounting for approximately 95% of the asbestos in the United States and a similar proportion in other countries.'WebMineral.com lists density of 2.53 g/cm3 for chrysotile. MatWeb.com lists density range of 2.00-2.80 g/cm3 for 'asbestos.'PubChem.ncbi.nlm.nih.gov lists density range of 2.2-2.6 g/cm3 for chrysotile.

19. Asphalt

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.3 Total Atom Weight (atoms/b-cm) = 1.373E-01

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.Asphalt is often called asphaltum or bitumen. It is a sticky tar-like form of petroleum with a consistency much like cold molasses. It is primarily used in road construction as the glue or binder for the aggregate particles. The weight fractions are an average of the 4 asphalt compositions from different crude sources from Table 2 of International Programme on Chemical Safety (IPCS), Concise International Chemical Assessment Document 59: Asphalt (Bitumen) at http://www.inchem.org/documents/cicads/cicads/cicad59.htm #2.0. Note, Table 2 gives weight % from four locations and the asphalt elemental weight %'s here here are calculated as the average of these. Density = 1.1 to 1.5 g/cm3 in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers, edited by E. A. Avallone and T. Baumeister III, 10th edition. Also in Table 2-120 of Perry's Chemical Engineer's Handbook, 8th edition, by Don W. Green and Robert H. Perry, 2008.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.103697	1001	0.586677	1001	0.080552
H2	1002	-0.000024	1002	0.000067	1002	0.000009
C	6000	-0.848048	6000	0.402599	6000	0.055278

N14	7014	-0.006026	7014	0.002454	7014	0.000337
N15	7015	-0.000024	7015	0.000009	7015	0.000001
O16	8016	-0.004039	8016	0.001440	8016	0.000198
O17	8017	-0.000002	8017	0.000001	8017	0.000000
O18	8018	-0.000009	8018	0.000003	8018	0.000000
S	16000	-0.037700	16000	0.006703	16000	0.000920
V	23000	-0.000393	23000	0.000044	23000	0.000006
Ni	28000	-0.000034	28000	0.000003	28000	0.000000
Elemental						
H	1000	-0.103725	1000	0.586745	1000	0.080561
C	6000	-0.848048	6000	0.402599	6000	0.055278
N	7000	-0.006050	7000	0.002463	7000	0.000338
O	8000	-0.004050	8000	0.001443	8000	0.000198
S	16000	-0.037700	16000	0.006703	16000	0.000920
V	23000	-0.000393	23000	0.000044	23000	0.000006
Ni	28000	-0.000034	28000	0.000003	28000	0.000000

Comments and References

Concise International Chemical Assessment Document 59: Asphalt (Bitumen) at http://www.inchem.org/documents/cicads/cicads/cicad59.htm #2.0., Table 2 of International Programme on Chemical Safety (IPCS)Mark's Standard Handbook for Mechanical Engineers, edited by E. A. Avallone and T. Baumeister III, 10th edition. Also in Table 2-120 of Perry's Chemical Engineer's Handbook, 8th edition, by Don W. Green and Robert H. Perry, 2008.

20. Asphalt pavement

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.5784 Total Atom Weight (atoms/b-cm) = 8.962E-02

Weight fractions were updated since the average rock material has been updated.Asphalt pavement can also be called asphalt concrete, asphalt pavement, or blacktop. It is a mixture of asphalt (as discussed above) and aggregate, and can also simply be called asphalt. Density and weight fractions are based on a mixture of 6 wt.% asphalt and 94% aggregate. It may also be necessary to allow for void. The aggregate is based on Rock (Average of 5 types), and asphalt composition (prior material).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.007508	1001	0.129074	1001	0.011568
H2	1002	-0.000002	1002	0.000015	1002	0.000001
C	6000	-0.106744	6000	0.153985	6000	0.013800
N14	7014	-0.000362	7014	0.000447	7014	0.000040
N15	7015	-0.000001	7015	0.000002	7015	0.000000
O16	8016	-0.423081	8016	0.458290	8016	0.041072
O17	8017	-0.000171	8017	0.000175	8017	0.000016
O18	8018	-0.000978	8018	0.000942	8018	0.000084

Na23	11023	-0.013149	11023	0.009910	11023	0.000888
Mg	12000	-0.031061	12000	0.022142	12000	0.001984
Al27	13027	-0.054927	13027	0.035271	13027	0.003161
Si	14000	-0.195830	14000	0.120810	14000	0.010827
P31	15031	-0.000448	15031	0.000251	15031	0.000022
S	16000	-0.010764	16000	0.005816	16000	0.000521
K	19000	-0.016001	19000	0.007091	19000	0.000635
Ca	20000	-0.102275	20000	0.044214	20000	0.003962
Ti	22000	-0.003421	22000	0.001238	22000	0.000111
V	23000	-0.000024	23000	0.000008	23000	0.000001
Mn55	25055	-0.000427	25055	0.000135	25055	0.000012
Fe	26000	-0.032824	26000	0.010184	26000	0.000913
Ni	28000	-0.000002	28000	0.000001	28000	0.000000
Elemental						
H	1000	-0.007510	1000	0.129089	1000	0.011569
C	6000	-0.106744	6000	0.153985	6000	0.013800
N	7000	-0.000363	7000	0.000449	7000	0.000040
O	8000	-0.424231	8000	0.459406	8000	0.041172
Na	11000	-0.013149	11000	0.009910	11000	0.000888
Mg	12000	-0.031061	12000	0.022142	12000	0.001984
Al	13000	-0.054927	13000	0.035271	13000	0.003161
Si	14000	-0.195830	14000	0.120810	14000	0.010827
P	15000	-0.000448	15000	0.000251	15000	0.000022
S	16000	-0.010764	16000	0.005816	16000	0.000521
K	19000	-0.016001	19000	0.007091	19000	0.000635
Ca	20000	-0.102275	20000	0.044214	20000	0.003962
Ti	22000	-0.003421	22000	0.001238	22000	0.000111
V	23000	-0.000024	23000	0.000008	23000	0.000001
Mn	25000	-0.000427	25000	0.000135	25000	0.000012
Fe	26000	-0.032824	26000	0.010184	26000	0.000913
Ni	28000	-0.000002	28000	0.000001	28000	0.000000

Comments and References

The aggregate is based on Rock (Average of 5 types), and asphalt composition (prior material in this compendium).
https://en.wikipedia.org/wiki/Asphalt#Rolled_asphalt_concrete

21. Bakelite

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.25 Total Atom Weight (atoms/b-cm) = 9.935E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Chemical name: phenol-formaldehyde resin or polymer.

	Weight Fractions	Atom Fractions	Atom Densities
Isotopic			

H1	1001	-0.057429	1001	0.431754	1001	0.042895
H2	1002	-0.000013	1002	0.000050	1002	0.000005
C	6000	-0.774588	6000	0.488651	6000	0.048548
O16	8016	-0.167513	8016	0.079352	8016	0.007884
O17	8017	-0.000068	8017	0.000030	8017	0.000003
O18	8018	-0.000387	8018	0.000163	8018	0.000016
Elemental						
H	1000	-0.057444	1000	0.431804	1000	0.042900
C	6000	-0.774588	6000	0.488651	6000	0.048548
O	8000	-0.167968	8000	0.079545	8000	0.007903
Comments and References						
http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html						

22. Barium Fluoride

Formula = BaF2 Molecular Weight (g/mole) = 175.323806
Density (g/cm3) = 4.89 Total Atom Weight (atoms/b-cm) = 5.039E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
F19	9019	-0.216724	9019	0.666667	9019	0.033593
Ba130	56130	-0.000785	56130	0.000353	56130	0.000018
Ba132	56132	-0.000760	56132	0.000337	56132	0.000017
Ba134	56134	-0.018460	56134	0.008057	56134	0.000406
Ba135	56135	-0.050723	56135	0.021973	56135	0.001107
Ba136	56136	-0.060881	56136	0.026180	56136	0.001319
Ba137	56137	-0.087708	56137	0.037440	56137	0.001887
Ba138	56138	-0.563958	56138	0.238993	56138	0.012043
Elemental						
F	9000	-0.216724	9000	0.666667	9000	0.033593
Ba	56000	-0.783276	56000	0.333333	56000	0.016797
Comments and References						
Density = 4.89 g/cm3 and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=113. Density = 4.89 g/cm3 and formula from page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000.						

23. Barium sulfate

Formula = BaSO4 Molecular Weight (g/mole) = 233.392100
Density (g/cm3) = 4.5 Total Atom Weight (atoms/b-cm) = 6.967E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.273463	8016	0.665046	8016	0.046332
O17	8017	-0.000111	8017	0.000253	8017	0.000018
O18	8018	-0.000632	8018	0.001367	8018	0.000095
S	16000	-0.137398	16000	0.166667	16000	0.011611
Ba130	56130	-0.000590	56130	0.000177	56130	0.000012
Ba132	56132	-0.000571	56132	0.000168	56132	0.000012
Ba134	56134	-0.013867	56134	0.004028	56134	0.000281
Ba135	56135	-0.038103	56135	0.010987	56135	0.000765
Ba136	56136	-0.045734	56136	0.013090	56136	0.000912
Ba137	56137	-0.065886	56137	0.018720	56137	0.001304
Ba138	56138	-0.423645	56138	0.119497	56138	0.008325
Elemental						
O	8000	-0.274206	8000	0.666666	8000	0.046445
S	16000	-0.137398	16000	0.166667	16000	0.011611
Ba	56000	-0.588396	56000	0.166667	56000	0.011611

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=114 Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-51.

24. Benzene

Formula = C6H6 Molecular Weight (g/mole) = 78.111450
Density (g/cm3) = 0.8786 Total Atom Weight (atoms/b-cm) = 8.129E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.CRC Handbook of Chemistry and Physics, 89th ed., p.3-32, but NIST density = 0.87865 g/cc. Formula from MatWeb which has a density of 0.8765 g/ccThe following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.077405	1001	0.499943	1001	0.040640
H2	1002	-0.000018	1002	0.000058	1002	0.000005
C	6000	-0.922574	6000	0.500000	6000	0.040645
Elemental						
H	1000	-0.077426	1000	0.500000	1000	0.040645
C	6000	-0.922574	6000	0.500000	6000	0.040645

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=115. Formula from http://www.matweb.com/search/DataSheet.aspx?MatGUID=e6a3974d195942d4941514c285151f10 but MatWeb density is 0.8765 g/cc

25. Beryllium

Formula = Be Molecular Weight (g/mole) = 9.012183
Density (g/cm3) = 1.848 Total Atom Weight (atoms/b-cm) = 1.235E-01

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Be9	4009	-1.000000	4009	1.000000	4009	0.123487
Elemental						
Be	4000	-1.000000	4000	1.000000	4000	0.123487

Comments and References

Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=004.

26. Beryllium Carbide

Formula = Be2C Molecular Weight (g/mole) = 30.034966
Density (g/cm3) = 1.9 Total Atom Weight (atoms/b-cm) = 1.143E-01

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Be9	4009	-0.600113	4009	0.666667	4009	0.076192
C	6000	-0.399887	6000	0.333333	6000	0.038096
Elemental						
Be	4000	-0.600113	4000	0.666667	4000	0.076192
C	6000	-0.399887	6000	0.333333	6000	0.038096

Comments and References

Formula and density from CRC Handbook of Chemistry and Physics, 89th edition, page 4-51. Formula and density confirmed at Matweb http://www.matweb.com/search/DataSheet.aspx?MatGUID=5b6377199dd340719c9f58640e6dac5f Density also in Table 51.14 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.

27. Beryllium Oxide

Formula = BeO Molecular Weight (g/mole) = 25.011583
Density (g/cm3) = 3.01 Total Atom Weight (atoms/b-cm) = 1.449E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Be9	4009	-0.360320	4009	0.500000	4009	0.072473
O16	8016	-0.637946	8016	0.498785	8016	0.072297
O17	8017	-0.000258	8017	0.000190	8017	0.000028
O18	8018	-0.001475	8018	0.001025	8018	0.000149
Elemental						
Be	4000	-0.360320	4000	0.500000	4000	0.072473
O	8000	-0.639680	8000	0.500000	8000	0.072473

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=116. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-51.Density = 2.3 g/cm3 for hot-pressed blocks (Table 51.14, Reactor Handbook, 2nd edition, Vol. 1, Materials, C. R. Tipton, 1960).

28. Bismuth

Formula = Bi Molecular Weight (g/mole) = 208.980400
Density (g/cm3) = 9.747 Total Atom Weight (atoms/b-cm) = 2.809E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Bi209	83209	-1.000000	83209	1.000000	83209	0.028088
Elemental						
Bi	83000	-1.000000	83000	1.000000	83000	0.028088

Comments and References

Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=083.

29. Bismuth Germanate (BGO)

Formula = Bi4Ge3O12 Molecular Weight (g/mole) = 1245.804400
Density (g/cm3) = 7.13 Total Atom Weight (atoms/b-cm) = 6.549E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not

addressed. Note this is scintillator formula, not pizeoelectric formula						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.153694	8016	0.630044	8016	0.041259
O17	8017	-0.000062	8017	0.000240	8017	0.000016
O18	8018	-0.000355	8018	0.001295	8018	0.000085
Ge70	32070	-0.034636	32070	0.032479	32070	0.002127
Ge72	32072	-0.047542	32072	0.043342	32072	0.002838
Ge73	32073	-0.013609	32073	0.012237	32073	0.000801
Ge74	32074	-0.064973	32074	0.057632	32074	0.003774
Ge76	32076	-0.014132	32076	0.012205	32076	0.000799
Bi209	83209	-0.670989	83209	0.210526	83209	0.013786
Elemental						
O	8000	-0.154112	8000	0.631579	8000	0.041359
Ge	32000	-0.174899	32000	0.157895	32000	0.010340
Bi	83000	-0.670989	83000	0.210526	83000	0.013786
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=117, where it is called Bismuth Germanium Oxide. Same density given on page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000. Same density and formula at http://www.matweb.com/search/DataSheet.aspx?MatGUID=2d1d6d96969a448f8806b19c12e37d5a						

30. Bismuth Iodide

Formula = BiI3		Molecular Weight (g/mole) = 589.693810				
Density (g/cm3) = 5.778		Total Atom Weight (atoms/b-cm) = 2.360E-02				
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
I127	53127	-0.645612	53127	0.750000	53127	0.017702
Bi209	83209	-0.354388	83209	0.250000	83209	0.005901
Elemental						
I	53000	-0.645612	53000	0.750000	53000	0.017702
Bi	83000	-0.354388	83000	0.250000	83000	0.005901
Comments and References						
MatWeb.com lists density of 5.778 g/cm3.						

31. Blood (ICRP)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.06 Total Atom Weight (atoms/b-cm) = 1.017E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101839	1001	0.634523	1001	0.064504
H2	1002	-0.000023	1002	0.000073	1002	0.000007
C	6000	-0.100020	6000	0.052293	6000	0.005316
N14	7014	-0.029524	7014	0.013239	7014	0.001346
N15	7015	-0.000116	7015	0.000048	7015	0.000005
O16	8016	-0.757356	8016	0.297328	8016	0.030226
O17	8017	-0.000307	8017	0.000113	8017	0.000012
O18	8018	-0.001751	8018	0.000611	8018	0.000062
Na23	11023	-0.001850	11023	0.000505	11023	0.000051
Mg	12000	-0.000040	12000	0.000010	12000	0.000001
Si	14000	-0.000030	14000	0.000007	14000	0.000001
P31	15031	-0.000350	15031	0.000071	15031	0.000007
S	16000	-0.001850	16000	0.000362	16000	0.000037
Cl35	17035	-0.002077	17035	0.000373	17035	0.000038
Cl37	17037	-0.000703	17037	0.000119	17037	0.000012
K	19000	-0.001630	19000	0.000262	19000	0.000027
Ca	20000	-0.000060	20000	0.000009	20000	0.000001
Fe	26000	-0.000460	26000	0.000052	26000	0.000005
Zn	30000	-0.000010	30000	0.000001	30000	0.000000
Elemental						
H	1000	-0.101866	1000	0.634596	1000	0.064511
C	6000	-0.100020	6000	0.052293	6000	0.005316
N	7000	-0.029640	7000	0.013288	7000	0.001351
O	8000	-0.759414	8000	0.298052	8000	0.030299
Na	11000	-0.001850	11000	0.000505	11000	0.000051
Mg	12000	-0.000040	12000	0.000010	12000	0.000001
Si	14000	-0.000030	14000	0.000007	14000	0.000001
P	15000	-0.000350	15000	0.000071	15000	0.000007
S	16000	-0.001850	16000	0.000362	16000	0.000037
Cl	17000	-0.002780	17000	0.000492	17000	0.000050
K	19000	-0.001630	19000	0.000262	19000	0.000027
Ca	20000	-0.000060	20000	0.000009	20000	0.000001
Fe	26000	-0.000460	26000	0.000052	26000	0.000005
Zn	30000	-0.000010	30000	0.000001	30000	0.000000

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=118. See also The International Commission on Radiological

Protection,ICRP PUBLICATION 89,Basic Anatomical and Physiological Data for Use in Radiological Protection: Refence Values, J. Valentin, Editor, 2003 ICRP Published by Elsevier Science Ltd.

32. Bone Equivalent Plastic, B-100

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.45 Total Atom Weight (atoms/b-cm) = 1.104E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.065454	1001	0.513739	1001	0.056711
H2	1002	-0.000015	1002	0.000059	1002	0.000007
C	6000	-0.536944	6000	0.353638	6000	0.039038
N14	7014	-0.021416	7014	0.012098	7014	0.001335
N15	7015	-0.000084	7015	0.000044	7015	0.000005
O16	8016	-0.031998	8016	0.015825	8016	0.001747
O17	8017	-0.000013	8017	0.000006	8017	0.000001
O18	8018	-0.000074	8018	0.000033	8018	0.000004
F19	9019	-0.167411	9019	0.069704	9019	0.007695
Ca	20000	-0.176589	20000	0.034854	20000	0.003847
Elemental						
H	1000	-0.065471	1000	0.513799	1000	0.056718
C	6000	-0.536944	6000	0.353638	6000	0.039038
N	7000	-0.021500	7000	0.012142	7000	0.001340
O	8000	-0.032085	8000	0.015863	8000	0.001751
F	9000	-0.167411	9000	0.069704	9000	0.007695
Ca	20000	-0.176589	20000	0.034854	20000	0.003847

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=111.

33. Bone Equivalent Plastic, B-110

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.785 Total Atom Weight (atoms/b-cm) = 9.798E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The carbon fraction was adjusted from 0.3672 to 0.3673 to provide normalization to 1

	Weight Fractions	Atom Fractions	Atom Densities

Isotopic						
H1	1001	-0.035491	1001	0.386351	1001	0.037855
H2	1002	-0.000008	1002	0.000044	1002	0.000004
C	6000	-0.367300	6000	0.335513	6000	0.032873
N14	7014	-0.039545	7014	0.030983	7014	0.003036
N15	7015	-0.000155	7015	0.000113	7015	0.000011
O16	8016	-0.045177	8016	0.030988	8016	0.003036
O17	8017	-0.000018	8017	0.000012	8017	0.000001
O18	8018	-0.000104	8018	0.000064	8018	0.000006
F19	9019	-0.249300	9019	0.143965	9019	0.014106
Ca	20000	-0.262900	20000	0.071968	20000	0.007051
Elemental						
H	1000	-0.035500	1000	0.386395	1000	0.037859
C	6000	-0.367300	6000	0.335513	6000	0.032873
N	7000	-0.039700	7000	0.031096	7000	0.003047
O	8000	-0.045300	8000	0.031063	8000	0.003044
F	9000	-0.249300	9000	0.143965	9000	0.014106
Ca	20000	-0.262900	20000	0.071968	20000	0.007051
Comments and References						
Density and weight fractions in J. J. Spokas and D. R. White, A Conducting Plastic Simulating Cortical Bone at https://iopscience.iop.org/article/10.1088/0031-9155/27/1/012/pdf; with the carbon fraction adjusted from 0.3672 to 0.3673 to provide normalization to 1						

34. Bone, Compact (ICRU)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.85 Total Atom Weight (atoms/b-cm) = 1.340E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Based on the International Commission on Radiation Units and Measurements (ICRU).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.063967	1001	0.527816	1001	0.070712
H2	1002	-0.000015	1002	0.000061	1002	0.000008
C	6000	-0.278000	6000	0.192482	6000	0.025787
N14	7014	-0.026894	7014	0.015972	7014	0.002140
N15	7015	-0.000105	7015	0.000058	7015	0.000008
O16	8016	-0.408905	8016	0.212594	8016	0.028482
O17	8017	-0.000166	8017	0.000081	8017	0.000011
O18	8018	-0.000946	8018	0.000437	8018	0.000059
Mg	12000	-0.002000	12000	0.000684	12000	0.000092
P31	15031	-0.070000	15031	0.018794	15031	0.002518
S	16000	-0.002000	16000	0.000519	16000	0.000069
Ca	20000	-0.147000	20000	0.030502	20000	0.004086

Elemental						
H	1000	-0.063984	1000	0.527877	1000	0.070720
C	6000	-0.278000	6000	0.192482	6000	0.025787
N	7000	-0.027000	7000	0.016030	7000	0.002148
O	8000	-0.410016	8000	0.213112	8000	0.028551
Mg	12000	-0.002000	12000	0.000684	12000	0.000092
P	15000	-0.070000	15000	0.018794	15000	0.002518
S	16000	-0.002000	16000	0.000519	16000	0.000069
Ca	20000	-0.147000	20000	0.030502	20000	0.004086
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=119.						

35. Bone, Cortical (ICRP)

Formula =		Molecular Weight (g/mole) =			
Density (g/cm3) =	1.85	Total Atom Weight (atoms/b-cm) = 1.098E-01			
The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Based on the International Commission on Radiological Protection (ICRP).					
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.047222	1001	0.475325	1001	0.052201
H2	1002	-0.000011	1002	0.000055	1002	0.000006
C	6000	-0.144330	6000	0.121907	6000	0.013388
N14	7014	-0.041826	7014	0.030301	7014	0.003328
N15	7015	-0.000164	7015	0.000111	7015	0.000012
O16	8016	-0.444887	8016	0.282166	8016	0.030988
O17	8017	-0.000180	8017	0.000107	8017	0.000012
O18	8018	-0.001029	8018	0.000580	8018	0.000064
Mg	12000	-0.002200	12000	0.000918	12000	0.000101
P31	15031	-0.104970	15031	0.034380	15031	0.003776
S	16000	-0.003150	16000	0.000997	16000	0.000109
Ca	20000	-0.209930	20000	0.053138	20000	0.005836
Zn	30000	-0.000100	30000	0.000016	30000	0.000002
Elemental						
H	1000	-0.047234	1000	0.475379	1000	0.052207
C	6000	-0.144330	6000	0.121907	6000	0.013388
N	7000	-0.041990	7000	0.030412	7000	0.003340
O	8000	-0.446096	8000	0.282853	8000	0.031063
Mg	12000	-0.002200	12000	0.000918	12000	0.000101
P	15000	-0.104970	15000	0.034380	15000	0.003776
S	16000	-0.003150	16000	0.000997	16000	0.000109
Ca	20000	-0.209930	20000	0.053138	20000	0.005836
Zn	30000	-0.000100	30000	0.000016	30000	0.000002

Comments and References
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=120. See also The International Commission on Radiological Protection,ICRP PUBLICATION 89,Basic Anatomical and Physiological Data for Use in Radiological Protection: Refence Values, J. Valentin, Editor, 2003 ICRP Published by Elsevier Science Ltd., which gives a density range of 1.3 to 2.3 for adult bone, with hydrated cortical bone density as 1.9.

36. Boral (65% Al-35% B4C)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.53 Total Atom Weight (atoms/b-cm) = 8.495E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Note that this material is without aluminum cladding.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.050489	5010	0.090435	5010	0.007683
B11	5011	-0.223448	5011	0.364014	5011	0.030923
C	6000	-0.076000	6000	0.113488	6000	0.009641
Al27	13027	-0.650000	13027	0.432063	13027	0.036704
Elemental						
B	5000	-0.274000	5000	0.454449	5000	0.038606
C	6000	-0.076000	6000	0.113488	6000	0.009641
Al	13000	-0.650000	13000	0.432063	13000	0.036704

Comments and References

Density and weight fractions from LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009. This data in LA-UR-09-00380 evidently came from page II.F.1-1 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf).

37. Boral (Aluminum 10% boron alloy)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.6 Total Atom Weight (atoms/b-cm) = 6.647E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.Averages for Al and B were used from the range provided, the minimum value for Ti was used. Note reference lists 0.0001 fraction for 'other' The boron contents at MatWeb include 3%, 4%, 5%, 8%, and 10%.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.018427	5010	0.043350	5010	0.002881
B11	5011	-0.081550	5011	0.174489	5011	0.011598

Na23	11023	-0.005000	11023	0.005123	11023	0.000341
Al27	13027	-0.879000	13027	0.767405	13027	0.051009
Si	14000	-0.002500	14000	0.002097	14000	0.000139
K	19000	-0.010000	19000	0.006025	19000	0.000400
Ti	22000	-0.000500	22000	0.000246	22000	0.000016
Fe	26000	-0.003000	26000	0.001265	26000	0.000084
Elemental						
B	5000	-0.100000	5000	0.217839	5000	0.014480
Na	11000	-0.005000	11000	0.005123	11000	0.000341
Al	13000	-0.879000	13000	0.767405	13000	0.051009
Si	14000	-0.002500	14000	0.002097	14000	0.000139
K	19000	-0.010000	19000	0.006025	19000	0.000400
Ti	22000	-0.000500	22000	0.000246	22000	0.000016
Fe	26000	-0.003000	26000	0.001265	26000	0.000084

Comments and References

The composition is for 10.0 wt% boron in an aluminum-boron alloy from KB alloys listed at http://www.matweb.com/search/DataSheet.aspx?MatGUID=4e768e906fb74ce6a21fdebac258894d. Density is from American Elements at https://www.americanelements.com/boralcan-al-b4c-matrix-composite.

38. Boral (Aluminum 5% boron alloy)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.6 Total Atom Weight (atoms/b-cm) = 6.214E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Averages for Al and B were used from the range provided - note that the average for Al is 0.9282,not 0.9295 as was listed. the minimum value for Ti was used. Note reference lists 0.0001 fraction for 'other' The boron contents at MatWeb include 3%, 4%, 5%, 8%, and 10%. A reference for the density could not be found so 2.6 g/cm3 was assumed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.009225	5010	0.023216	5010	0.001443
B11	5011	-0.040828	5011	0.093448	5011	0.005807
Na23	11023	-0.005007	11023	0.005487	11023	0.000341
Al27	13027	-0.929407	13027	0.867980	13027	0.053934
Si	14000	-0.002003	14000	0.001797	14000	0.000112
K	19000	-0.010013	19000	0.006453	19000	0.000401
Ti	22000	-0.000501	22000	0.000264	22000	0.000016
Fe	26000	-0.003004	26000	0.001355	26000	0.000084
Elemental						
B	5000	-0.050065	5000	0.116664	5000	0.007249
Na	11000	-0.005007	11000	0.005487	11000	0.000341
Al	13000	-0.929407	13000	0.867980	13000	0.053934
Si	14000	-0.002003	14000	0.001797	14000	0.000112

K	19000	-0.010013	19000	0.006453	19000	0.000401
Ti	22000	-0.000501	22000	0.000264	22000	0.000016
Fe	26000	-0.003004	26000	0.001355	26000	0.000084

Comments and References

The composition is for 5.0 wt% boron in an aluminum-boron alloy from KB alloys listed at http://www.matweb.com/search/DataSheet.aspx?MatGUID=2d8cc1b6af7f4747aec9dfdd65d4f97a.

39. Borax

Formula = Na2B4O17H20 Molecular Weight (g/mole) = 381.382838
Density (g/cm3) = 1.73 Total Atom Weight (atoms/b-cm) = 1.175E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Na23	11023	-0.120560	11023	0.046512	11023	0.005463
B10	5010	-0.020898	5010	0.018512	5010	0.002174
B11	5011	-0.092489	5011	0.074512	5011	0.008752
O16	8016	-0.711235	8016	0.394388	8016	0.046326
O17	8017	-0.000288	8017	0.000150	8017	0.000018
O18	8018	-0.001645	8018	0.000810	8018	0.000095
H1	1001	-0.052845	1001	0.465063	1001	0.054628
H2	1002	-0.000012	1002	0.000053	1002	0.000006
Elemental						
Na	11000	-0.120560	11000	0.046512	11000	0.005463
B	5000	-0.113414	5000	0.093023	5000	0.010927
O	8000	-0.713167	8000	0.395349	8000	0.046439
H	1000	-0.052859	1000	0.465116	1000	0.054634

Comments and References

Density and formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-91, for sodium tetraborate decahydrate. Also listed at LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.Criticality Handbook Volume 1 (ARH-600, 1968) per page II.F.1-1 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf)

40. Boric Acid

Formula = BO3H3 Molecular Weight (g/mole) = 61.835625
Density (g/cm3) = 1.5 Total Atom Weight (atoms/b-cm) = 1.023E-01

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not

addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.048890	1001	0.428522	1001	0.043820
H2	1002	-0.000011	1002	0.000049	1002	0.000005
B10	5010	-0.032224	5010	0.028429	5010	0.002907
B11	5011	-0.142611	5011	0.114429	5011	0.011701
O16	8016	-0.774119	8016	0.427530	8016	0.043719
O17	8017	-0.000313	8017	0.000163	8017	0.000017
O18	8018	-0.001790	8018	0.000879	8018	0.000090
Elemental						
H	1000	-0.048903	1000	0.428571	1000	0.043825
B	5000	-0.174875	5000	0.142857	5000	0.014608
O	8000	-0.776222	8000	0.428571	8000	0.043825

Comments and References

Formula and density (1.5 g/cm3) in CRC Handbook of Chemistry and Physics, 89th edition, page 4-53.Also at http://www.matweb.com/search/DataSheet.aspx?MatGUID=333ef3745d6b4128a1255988669596e8. Weight fractions from LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.Density = 1.435 g/cm3 in LA-UR-09-00380 Also at http://en.wikipedia.org/wiki/Boric_acid.

41. Boron

Formula = B Molecular Weight (g/mole) = 10.813500
Density (g/cm3) = 2.37 Total Atom Weight (atoms/b-cm) = 1.320E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.184267	5010	0.199000	5010	0.026266
B11	5011	-0.815504	5011	0.801000	5011	0.105722
Elemental						
B	5000	-1.000000	5000	1.000000	5000	0.131988

Comments and References

Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=005.

42. Boron Carbide

Formula = B4C Molecular Weight (g/mole) = 55.264600
Density (g/cm3) = 2.52 Total Atom Weight (atoms/b-cm) = 1.373E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. MatWeb also lists reactor grade boron carbide with 2.65 density, density varies between 2.5 to 2.65g/cc.The MCNP primer lists density as 2.51.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.144221	5010	0.159200	5010	0.021858
B11	5011	-0.638271	5011	0.640800	5011	0.087983
C	6000	-0.217329	6000	0.200000	6000	0.027460
Elemental						
B	5000	-0.782671	5000	0.800000	5000	0.109841
C	6000	-0.217329	6000	0.200000	6000	0.027460

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=121. Formula also from http://www.matweb.com/search/datasheet.aspx?MatGUID=45fd34d496fe48e3ab513bcbc4079430 Also listed at LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.

43. Boron Fluoride (B2F4)

Formula = B2F4 Molecular Weight (g/mole) = 97.620612
Density (g/cm3) = 0.004058 Total Atom Weight (atoms/b-cm) = 1.500E-04

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.040823	5010	0.066333	5010	0.000010
B11	5011	-0.180668	5011	0.267000	5011	0.000040
F19	9019	-0.778459	9019	0.666667	9019	0.000100
Elemental						
B	5000	-0.221541	5000	0.333333	5000	0.000050
F	9000	-0.778459	9000	0.666667	9000	0.000100

Comments and References

The 0.004058 g/cm3 density is calculated for 20C and 1.0 atmosphere using the ideal gas law. Density = 0.00399 g/cm3 at http://www.matweb.com/search/DataSheet.aspx?MatGUID=1505ad001ba3450db792e036eba3cc5d is evidently for 25C and 1.0 atmosphere.

44. Boron Fluoride (BF3)

Formula = BF3 Molecular Weight (g/mole) = 67.808709
Density (g/cm3) = 0.002831 Total Atom Weight (atoms/b-cm) = 1.000E-04

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.029385	5010	0.049750	5010	0.000005
B11	5011	-0.130049	5011	0.200250	5011	0.000020
F19	9019	-0.840529	9019	0.750000	9019	0.000075
Elemental						
B	5000	-0.159471	5000	0.250000	5000	0.000025
F	9000	-0.840529	9000	0.750000	9000	0.000075

Comments and References

The density is calculated for 20C and 1.0 atmosphere using a Van der Waals equation of state. Density = 0.002771 g/cm3 at http://www.matweb.com/search/DataSheet.aspx?MatGUID=d5db4876db3f4107aa3340d0f3ceb633 is evidently for 25C and 1.0 atmosphere.

45. Boron Oxide

Formula = B2O3 Molecular Weight (g/mole) = 69.625200
Density (g/cm3) = 1.812 Total Atom Weight (atoms/b-cm) = 7.836E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.057237	5010	0.079600	5010	0.006238
B11	5011	-0.253312	5011	0.320400	5011	0.025108
O16	8016	-0.687512	8016	0.598542	8016	0.046904
O17	8017	-0.000278	8017	0.000228	8017	0.000018
O18	8018	-0.001590	8018	0.001230	8018	0.000096
Elemental						
B	5000	-0.310620	5000	0.400000	5000	0.031345
O	8000	-0.689380	8000	0.600000	8000	0.047018

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=122. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-53. http://www.matweb.com/search/datasheettext.aspx?matguid=329160a7a5554daf8005575640db71a3.

46. Brain (ICRP)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.03 Total Atom Weight (atoms/b-cm) = 1.040E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.110638	1001	0.654629	1001	0.068094
H2	1002	-0.000025	1002	0.000075	1002	0.000008
C	6000	-0.125420	6000	0.062270	6000	0.006477
N14	7014	-0.013228	7014	0.005633	7014	0.000586
N15	7015	-0.000052	7015	0.000021	7015	0.000002
O16	8016	-0.735724	8016	0.274290	8016	0.028531
O17	8017	-0.000298	8017	0.000104	8017	0.000011
O18	8018	-0.001701	8018	0.000564	8018	0.000059
Na23	11023	-0.001840	11023	0.000477	11023	0.000050
Mg	12000	-0.000150	12000	0.000037	12000	0.000004
P31	15031	-0.003540	15031	0.000682	15031	0.000071
S	16000	-0.001770	16000	0.000329	16000	0.000034
Cl35	17035	-0.001764	17035	0.000301	17035	0.000031
Cl37	17037	-0.000597	17037	0.000096	17037	0.000010
K	19000	-0.003100	19000	0.000473	19000	0.000049
Ca	20000	-0.000090	20000	0.000013	20000	0.000001
Fe	26000	-0.000050	26000	0.000005	26000	0.000001
Zn	30000	-0.000010	30000	0.000001	30000	0.000000
Elemental						
H	1000	-0.110667	1000	0.654704	1000	0.068101
C	6000	-0.125420	6000	0.062270	6000	0.006477
N	7000	-0.013280	7000	0.005654	7000	0.000588
O	8000	-0.737723	8000	0.274958	8000	0.028601
Na	11000	-0.001840	11000	0.000477	11000	0.000050
Mg	12000	-0.000150	12000	0.000037	12000	0.000004
P	15000	-0.003540	15000	0.000682	15000	0.000071
S	16000	-0.001770	16000	0.000329	16000	0.000034
Cl	17000	-0.002360	17000	0.000397	17000	0.000041
K	19000	-0.003100	19000	0.000473	19000	0.000049
Ca	20000	-0.000090	20000	0.000013	20000	0.000001
Fe	26000	-0.000050	26000	0.000005	26000	0.000001
Zn	30000	-0.000010	30000	0.000001	30000	0.000000

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=123. See also The International Commission on Radiological Protection,ICRP PUBLICATION 89, Basic Anatomical and Physiological Data for Use in Radiological Protection: Refence Values, J. Valentin, Editor, 2003 ICRP Published by Elsevier Science Ltd., which gives the brain density as 1.04.

47. Brass (typical composition)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8.07 Total Atom Weight (atoms/b-cm) = 7.613E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Hundreds of types of brass are listed at this site. Caution: best to input your specific weight fractions.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Fe	26000	-0.000868	26000	0.000992	26000	0.000076
Cu	29000	-0.665384	29000	0.668462	29000	0.050887
Zn	30000	-0.325699	30000	0.318026	30000	0.024210
Sn	50000	-0.002672	50000	0.001437	50000	0.000109
P31	15031	-0.005377	15031	0.011083	15031	0.000844
Elemental						
Fe	26000	-0.000868	26000	0.000992	26000	0.000076
Cu	29000	-0.665384	29000	0.668462	29000	0.050887
Zn	30000	-0.325699	30000	0.318026	30000	0.024210
Sn	50000	-0.002672	50000	0.001437	50000	0.000109
P	15000	-0.005377	15000	0.011083	15000	0.000844
Comments and References						
Average density, Weight fractions are adjusted so that they sum to unity, based on average values from: http://www.matweb.com/search/DataSheet.aspx?MatGUID=d3bd4617903543ada92f4c101c2a20e5 several trace elements not includedHundreds of types of brass are listed at this site. Caution: best to input your specific weight fractions.						

48. Brick, Common Silica

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.8 Total Atom Weight (atoms/b-cm) = 5.362E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.523577	8016	0.661815	8016	0.035483
O17	8017	-0.000212	8017	0.000252	8017	0.000014
O18	8018	-0.001211	8018	0.001360	8018	0.000073
Al27	13027	-0.005000	13027	0.003747	13027	0.000201
Si	14000	-0.449000	14000	0.323229	14000	0.017330

Ca	20000	-0.014000	20000	0.007063	20000	0.000379
Fe	26000	-0.007000	26000	0.002534	26000	0.000136
Elemental						
O	8000	-0.525000	8000	0.663427	8000	0.035570
Al	13000	-0.005000	13000	0.003747	13000	0.000201
Si	14000	-0.449000	14000	0.323229	14000	0.017330
Ca	20000	-0.014000	20000	0.007063	20000	0.000379
Fe	26000	-0.007000	26000	0.002534	26000	0.000136
Comments and References						
Density and weight fractions from LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.Also found density and weight fractions from ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf), page II.F1-2. Density = 1.6 to 2.0 g/cm3 for medium brick in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers, edited by E. A. Avallone and T. Baumeister III, 10th edition.						

49. Brick, Fire

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.1 Total Atom Weight (atoms/b-cm) = 6.174E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.495653	8016	0.634788	8016	0.039189
O17	8017	-0.000201	8017	0.000242	8017	0.000015
O18	8018	-0.001146	8018	0.001304	8018	0.000081
Mg	12000	-0.006000	12000	0.005057	12000	0.000312
Al27	13027	-0.212000	13027	0.160954	13027	0.009937
Si	14000	-0.252000	14000	0.183806	14000	0.011347
Ca	20000	-0.007000	20000	0.003578	20000	0.000221
Ti	22000	-0.012000	22000	0.005135	22000	0.000317
Fe	26000	-0.014000	26000	0.005135	26000	0.000317
Elemental						
O	8000	-0.497000	8000	0.636335	8000	0.039285
Mg	12000	-0.006000	12000	0.005057	12000	0.000312
Al	13000	-0.212000	13000	0.160954	13000	0.009937
Si	14000	-0.252000	14000	0.183806	14000	0.011347
Ca	20000	-0.007000	20000	0.003578	20000	0.000221
Ti	22000	-0.012000	22000	0.005135	22000	0.000317
Fe	26000	-0.014000	26000	0.005135	26000	0.000317
Comments and References						

Density and weight fractions from LA-UR-09-00380, Criticality Calculations with MCNP5: A Primer, Jan. 09,which were taken from ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf), page II.F1-2.

50. Brick, Kaolin (white)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.1 Total Atom Weight (atoms/b-cm) = 6.221E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.498963	8016	0.634198	8016	0.039451
O17	8017	-0.000202	8017	0.000242	8017	0.000015
O18	8018	-0.001154	8018	0.001303	8018	0.000081
Mg	12000	-0.001205	12000	0.001008	12000	0.000063
Al27	13027	-0.240568	13027	0.181264	13027	0.011276
Si	14000	-0.242823	14000	0.175774	14000	0.010934
Ca	20000	-0.000714	20000	0.000362	20000	0.000023
Ti	22000	-0.010179	22000	0.004323	22000	0.000269
Fe	26000	-0.004192	26000	0.001526	26000	0.000095
Elemental						
O	8000	-0.500319	8000	0.635743	8000	0.039547
Mg	12000	-0.001205	12000	0.001008	12000	0.000063
Al	13000	-0.240568	13000	0.181264	13000	0.011276
Si	14000	-0.242823	14000	0.175774	14000	0.010934
Ca	20000	-0.000714	20000	0.000362	20000	0.000023
Ti	22000	-0.010179	22000	0.004323	22000	0.000269
Fe	26000	-0.004192	26000	0.001526	26000	0.000095

Comments and References

Density = 2.1 g/cm3 and composition (52 wt% SiO2, 45.5% Al2O3, 0.6% Fe2O3, 1.7% TiO2, 0.2% MgO, and 0.1% CaO) from Tables 51.67 and 51.68 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.Chapter 51, The Nuclear, Physical and Mechanical Properties of Shielding Materials, H.E. Hungerford.See Tables 12-6 and 12-7, Materials Data Book, by E.R. Parker, McGraw-Hill, 1967, for other types of bricks.

51. Bronze (typical composition)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8.4 Total Atom Weight (atoms/b-cm) = 8.152E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not

addressed.Caution: best to input your specific weight fractions.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Al27	13027	-0.028528	13027	0.065612	13027	0.005349
Si	14000	-0.003339	14000	0.007378	14000	0.000601
Mn55	25055	-0.003555	25055	0.004016	25055	0.000327
Fe	26000	-0.010208	26000	0.011343	26000	0.000925
Ni	28000	-0.006718	28000	0.007103	28000	0.000579
Cu	29000	-0.874155	29000	0.853653	29000	0.069587
Zn	30000	-0.036037	30000	0.034205	30000	0.002788
Sn	50000	-0.024503	50000	0.012809	50000	0.001044
Pb	82000	-0.012957	82000	0.003881	82000	0.000316
Elemental						
Al	13000	-0.028528	13000	0.065612	13000	0.005349
Si	14000	-0.003339	14000	0.007378	14000	0.000601
Mn	25000	-0.003555	25000	0.004016	25000	0.000327
Fe	26000	-0.010208	26000	0.011343	26000	0.000925
Ni	28000	-0.006718	28000	0.007103	28000	0.000579
Cu	29000	-0.874155	29000	0.853653	29000	0.069587
Zn	30000	-0.036037	30000	0.034205	30000	0.002788
Sn	50000	-0.024503	50000	0.012809	50000	0.001044
Pb	82000	-0.012957	82000	0.003881	82000	0.000316

Comments and References

Weight fractions are adjusted so that they sum to unity, based on average values from: http://www.matweb.com/search/DataSheet.aspx?MatGUID=66575ff2cd5249c49d76df15b47dbca4. Note 7.425 is average density, large range (5.6 to 9.25), several trace elements not included.Hundreds of types of bronze are listed at this site. Caution: best to input your specific weight fractions.

52. C-552 Air-Equivalent Plastic

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.76 Total Atom Weight (atoms/b-cm) = 9.662E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.024674	1001	0.268560	1001	0.025948
H2	1002	-0.000006	1002	0.000031	1002	0.000003
C	6000	-0.501611	6000	0.458140	6000	0.044266
O16	8016	-0.004515	8016	0.003096	8016	0.000299
O17	8017	-0.000002	8017	0.000001	8017	0.000000
O18	8018	-0.000010	8018	0.000006	8018	0.000001

F19	9019	-0.465209	9019	0.268613	9019	0.025953
Si	14000	-0.003973	14000	0.001552	14000	0.000150
Elemental						
H	1000	-0.024680	1000	0.268591	1000	0.025951
C	6000	-0.501611	6000	0.458140	6000	0.044266
O	8000	-0.004527	8000	0.003104	8000	0.000300
F	9000	-0.465209	9000	0.268613	9000	0.025953
Si	14000	-0.003973	14000	0.001552	14000	0.000150
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=126.						

53. CELOTEX (Lignocellulosic Fiberboard)

Formula = C6H10O5 Molecular Weight (g/mole) = 162.140350
Density (g/cm3) = 0.25 Total Atom Weight (atoms/b-cm) = 1.950E-02

Celotex ~ C6H10O5 (cellulose) Range of density: 0.18 g/cm3 (11.23 lb/ft3) to 0.31 g/cm3 (19.34 lb/ft3)

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.444452	6000	0.285714	6000	0.005571
H1	1001	-0.062150	1001	0.476136	1001	0.009284
H2	1002	-0.000014	1002	0.000055	1002	0.000001
O16	8016	-0.492044	8016	0.237517	8016	0.004631
O17	8017	-0.000199	8017	0.000090	8017	0.000002
O18	8018	-0.001138	8018	0.000488	8018	0.000010
Elemental						
C	6000	-0.444452	6000	0.285714	6000	0.005571
H	1000	-0.062167	1000	0.476190	1000	0.009285
O	8000	-0.493381	8000	0.238095	8000	0.004643
Comments and References						
Celotex, which is a registered brand name, refers to a lignocellulosic fiberboard made by Celotex corp. Density is about 15 lb/ft3 = 0.24 g/cm3 from Table 4 of http://sti.srs.gov/fulltext/tr2000444/tr2000444.html. The density range can be 0.18 up to 0.31 g/cm3 (page 134 of LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009). This reference uses cellulose (C6H10O5) as the formula of celotex.						

54. CLLB(Ce) - Cesium Lithium Lanthanum Bromide - 0.3 wt% Cerium doped

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	4.2		Total Atom Weight (atoms/b-cm) = 2.838E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cs133	55133	-0.298151	55133	0.199940	55133	0.005674
Li6	3006	-0.000512	3006	0.007588	3006	0.000215
Li7	3007	-0.007272	3007	0.092382	3007	0.002622
La138	57138	-0.000137	57138	0.000089	57138	0.000003
La139	57139	-0.155668	57139	0.099881	57139	0.002835
Br79	35079	-0.269225	35079	0.304048	35079	0.008629
Br81	35081	-0.268526	35081	0.295771	35081	0.008394
Ce136	58136	-0.000001	58136	0.000001	58136	0.000000
Ce138	58138	-0.000001	58138	0.000001	58138	0.000000
Ce140	58140	-0.000418	58140	0.000266	58140	0.000008
Ce142	58142	-0.000053	58142	0.000033	58142	0.000001
Elemental						
Cs	55000	-0.298151	55000	0.199940	55000	0.005674
Li	3000	-0.007815	3000	0.099970	3000	0.002837
La	57000	-0.155806	57000	0.099970	57000	0.002837
Br	35000	-0.537755	35000	0.599819	35000	0.017022
Ce	58000	-0.000473	58000	0.000301	58000	0.000009
Comments and References						
Formula is Cs2LiLaBr6(Ce) but the formula isn't used in the calculation due to the Tl dopant Material information from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/cllb-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain email communication indicating final weight percent of 0.3% Ce in the final crystal						

55. Cadmium

Formula =	Cd		Molecular Weight (g/mole) = 112.414000			
Density (g/cm3) =	8.65		Total Atom Weight (atoms/b-cm) = 4.634E-02			
The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cd106	48106	-0.011776	48106	0.012500	48106	0.000579
Cd108	48108	-0.008543	48108	0.008900	48108	0.000412
Cd110	48110	-0.122110	48110	0.124900	48110	0.005788

Cd111	48111	-0.126281	48111	0.128000	48111	0.005931
Cd112	48112	-0.240203	48112	0.241300	48112	0.011182
Cd113	48113	-0.122733	48113	0.122200	48113	0.005663
Cd114	48114	-0.291106	48114	0.287300	48114	0.013313
Cd116	48116	-0.077226	48116	0.074900	48116	0.003471
Elemental						
Cd	48000	-1.000000	48000	1.000000	48000	0.046339
Comments and References						
Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=048.						

56. Cadmium Nitrate Tetrahydrate

Formula = CdN2O10H8 Molecular Weight (g/mole) = 308.485510
Density (g/cm3) = 2.45 Total Atom Weight (atoms/b-cm) = 1.004E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.026133	1001	0.380909	1001	0.038258
H2	1002	-0.000006	1002	0.000044	1002	0.000004
N14	7014	-0.090455	7014	0.094891	7014	0.009531
N15	7015	-0.000354	7015	0.000347	7015	0.000035
O16	8016	-0.517239	8016	0.475033	8016	0.047712
O17	8017	-0.000209	8017	0.000181	8017	0.000018
O18	8018	-0.001196	8018	0.000976	8018	0.000098
Cd106	48106	-0.004291	48106	0.000595	48106	0.000060
Cd108	48108	-0.003113	48108	0.000424	48108	0.000043
Cd110	48110	-0.044498	48110	0.005948	48110	0.000597
Cd111	48111	-0.046018	48111	0.006095	48111	0.000612
Cd112	48112	-0.087531	48112	0.011490	48112	0.001154
Cd113	48113	-0.044725	48113	0.005819	48113	0.000584
Cd114	48114	-0.106081	48114	0.013681	48114	0.001374
Cd116	48116	-0.028142	48116	0.003567	48116	0.000358
Elemental						
H	1000	-0.026140	1000	0.380952	1000	0.038262
N	7000	-0.090810	7000	0.095238	7000	0.009566
O	8000	-0.518644	8000	0.476190	8000	0.047828
Cd	48000	-0.364406	48000	0.047619	48000	0.004783
Comments and References						
Density and formula from http://www.matweb.com/search/DataSheet.aspx?MatGUID=80e2491150724055982967256325061f.						

57. Cadmium Telluride

Formula = CdTe Molecular Weight (g/mole) = 240.014000
Density (g/cm3) = 6.2 Total Atom Weight (atoms/b-cm) = 3.111E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cd106	48106	-0.005516	48106	0.006250	48106	0.000194
Cd108	48108	-0.004001	48108	0.004450	48108	0.000138
Cd110	48110	-0.057192	48110	0.062450	48110	0.001943
Cd111	48111	-0.059145	48111	0.064000	48111	0.001991
Cd112	48112	-0.112502	48112	0.120650	48112	0.003754
Cd113	48113	-0.057484	48113	0.061100	48113	0.001901
Cd114	48114	-0.136344	48114	0.143650	48114	0.004469
Cd116	48116	-0.036170	48116	0.037450	48116	0.001165
Te120	52120	-0.000450	52120	0.000450	52120	0.000014
Te122	52122	-0.012951	52122	0.012750	52122	0.000397
Te123	52123	-0.004557	52123	0.004450	52123	0.000138
Te124	52124	-0.024469	52124	0.023700	52124	0.000737
Te125	52125	-0.036793	52125	0.035350	52125	0.001100
Te126	52126	-0.098828	52126	0.094200	52126	0.002931
Te128	52128	-0.169144	52128	0.158700	52128	0.004938
Te130	52130	-0.184456	52130	0.170400	52130	0.005302
Elemental						
Cd	48000	-0.468364	48000	0.500000	48000	0.015556
Te	52000	-0.531636	52000	0.500000	52000	0.015556

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=127. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-54 http://www.matweb.com/search/DataSheet.aspx?MatGUID=3f3bbec8a6664fc3963fe8d79adc2622, matweb lists density as 5.86

58. Cadmium Tungstate (CWO)

Formula = CdWO4 Molecular Weight (g/mole) = 360.251600
Density (g/cm3) = 7.9 Total Atom Weight (atoms/b-cm) = 7.924E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.177166	8016	0.665046	8016	0.052696
O17	8017	-0.000072	8017	0.000253	8017	0.000020

O18	8018	-0.000410	8018	0.001367	8018	0.000108
Cd106	48106	-0.003675	48106	0.002083	48106	0.000165
Cd108	48108	-0.002666	48108	0.001483	48108	0.000118
Cd110	48110	-0.038104	48110	0.020817	48110	0.001649
Cd111	48111	-0.039405	48111	0.021333	48111	0.001690
Cd112	48112	-0.074954	48112	0.040217	48112	0.003187
Cd113	48113	-0.038298	48113	0.020367	48113	0.001614
Cd114	48114	-0.090838	48114	0.047883	48114	0.003794
Cd116	48116	-0.024098	48116	0.012483	48116	0.000989
W	74000	-0.510310	74000	0.166667	74000	0.013206
Elemental						
O	8000	-0.177647	8000	0.666666	8000	0.052824
Cd	48000	-0.312043	48000	0.166667	48000	0.013206
W	74000	-0.510310	74000	0.166667	74000	0.013206
Comments and References						
Density = 7.9 g/cm3 and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=128. Formula and same density on page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000. http://www.matweb.com/search/datasheet.aspx?matguid=7a2e1c6f9256490c8d1f175d306a4265						

59. Cadmium Zinc Telluride (CZT)

Formula = CdZnTe Molecular Weight (g/mole) = 305.394000
Density (g/cm3) = 5.78 Total Atom Weight (atoms/b-cm) = 3.419E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cd106	48106	-0.004335	48106	0.004167	48106	0.000142
Cd108	48108	-0.003145	48108	0.002967	48108	0.000101
Cd110	48110	-0.044948	48110	0.041633	48110	0.001424
Cd111	48111	-0.046483	48111	0.042667	48111	0.001459
Cd112	48112	-0.088417	48112	0.080433	48112	0.002750
Cd113	48113	-0.045177	48113	0.040733	48113	0.001393
Cd114	48114	-0.107155	48114	0.095767	48114	0.003275
Cd116	48116	-0.028426	48116	0.024967	48116	0.000854
Zn	30000	-0.214084	30000	0.333333	30000	0.011398
Te120	52120	-0.000353	52120	0.000300	52120	0.000010
Te122	52122	-0.010179	52122	0.008500	52122	0.000291
Te123	52123	-0.003582	52123	0.002967	52123	0.000101
Te124	52124	-0.019231	52124	0.015800	52124	0.000540
Te125	52125	-0.028916	52125	0.023567	52125	0.000806
Te126	52126	-0.077671	52126	0.062800	52126	0.002147
Te128	52128	-0.132933	52128	0.105800	52128	0.003618
Te130	52130	-0.144967	52130	0.113600	52130	0.003884

Elemental						
Cd	48000	-0.368095	48000	0.333333	48000	0.011398
Zn	30000	-0.214084	30000	0.333333	30000	0.011398
Te	52000	-0.417821	52000	0.333333	52000	0.011398
Comments and References						
Density from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3297127/ doi: 10.3390/s90503491						

60. Calcium Carbonate

Formula = CaCO3 Molecular Weight (g/mole) = 100.086800
Density (g/cm3) = 2.8 Total Atom Weight (atoms/b-cm) = 8.424E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Calcium carbonate is the mineral calcite, which is the main constituent of limestone, which is a sedimentary rock (http://en.wikipedia.org/wiki/Limestone). The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.120002	6000	0.200000	6000	0.016847
O16	8016	-0.478266	8016	0.598542	8016	0.050419
O17	8017	-0.000194	8017	0.000228	8017	0.000019
O18	8018	-0.001106	8018	0.001230	8018	0.000104
Ca	20000	-0.400432	20000	0.200000	20000	0.016847
Elemental						
C	6000	-0.120002	6000	0.200000	6000	0.016847
O	8000	-0.479566	8000	0.600000	8000	0.050542
Ca	20000	-0.400432	20000	0.200000	20000	0.016847
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=129. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-54. http://www.matweb.com/search/DataSheet.aspx?MatGUID=bea4bfa9c8bd462093d50da5eebe78ac Matweb gives density range of 2.72 to 2.81. Calcium carbonate is the mineral calcite, which is the main constituent of limestone, which is a sedimentary rock (http://en.wikipedia.org/wiki/Limestone).						

61. Calcium Fluoride

Formula = CaF2 Molecular Weight (g/mole) = 78.074806
Density (g/cm3) = 3.18 Total Atom Weight (atoms/b-cm) = 7.359E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
F19	9019	-0.486672	9019	0.666667	9019	0.049057
Ca	20000	-0.513328	20000	0.333333	20000	0.024528
Elemental						
F	9000	-0.486672	9000	0.666667	9000	0.049057
Ca	20000	-0.513328	20000	0.333333	20000	0.024528
Comments and References						
Density = 3.18 g/cm3 and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=130. Density and formula from http://www.matweb.com/search/DataSheet.aspx?MatGUID=38f5aafee1374126a59bcf6894171bac Density = 3.19 g/cm3 on page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000.						

62. Calcium Oxide

Formula = CaO Molecular Weight (g/mole) = 56.077400
Density (g/cm3) = 3.3 Total Atom Weight (atoms/b-cm) = 7.088E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.284536	8016	0.498785	8016	0.035353
O17	8017	-0.000115	8017	0.000190	8017	0.000013
O18	8018	-0.000658	8018	0.001025	8018	0.000073
Ca	20000	-0.714691	20000	0.500000	20000	0.035439
Elemental						
O	8000	-0.285309	8000	0.500000	8000	0.035439
Ca	20000	-0.714691	20000	0.500000	20000	0.035439
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=131. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-55.Matweb density is 3.34.						

63. Calcium Sulfate

Formula = CaSO4 Molecular Weight (g/mole) = 136.143100
Density (g/cm3) = 2.96 Total Atom Weight (atoms/b-cm) = 7.856E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.468802	8016	0.665046	8016	0.052246
O17	8017	-0.000190	8017	0.000253	8017	0.000020
O18	8018	-0.001084	8018	0.001367	8018	0.000107
S	16000	-0.235543	16000	0.166667	16000	0.013093
Ca	20000	-0.294381	20000	0.166667	20000	0.013093
Elemental						
O	8000	-0.470076	8000	0.666666	8000	0.052373
S	16000	-0.235543	16000	0.166667	16000	0.013093
Ca	20000	-0.294381	20000	0.166667	20000	0.013093
Comments and References						
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=132http://www.matweb.com/search/DataSheet.aspx?MatGUID=58448e223d9a4f45ae0ad1155771c210 Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-56.						

64. Calcium Tungstate

Formula = CaWO4 Molecular Weight (g/mole) = 287.915600
Density (g/cm3) = 7.9 Total Atom Weight (atoms/b-cm) = 9.914E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ca	20000	-0.139201	20000	0.166667	20000	0.016524
W	74000	-0.638520	74000	0.166667	74000	0.016524
O16	8016	-0.221677	8016	0.665046	8016	0.065935
O17	8017	-0.000090	8017	0.000253	8017	0.000025
O18	8018	-0.000513	8018	0.001367	8018	0.000135
Elemental						
Ca	20000	-0.139201	20000	0.166667	20000	0.016524
W	74000	-0.638520	74000	0.166667	74000	0.016524
O	8000	-0.222279	8000	0.666666	8000	0.066096
Comments and References						
Density and formula from https://physics.nist.gov/cgi-bin/Star/compos.pl?matno=133 and https://www.surfacenet.de/calcium-tungstate.html						

65. Carbon Dioxide

Formula = CO2 Molecular Weight (g/mole) = 44.009400
Density (g/cm3) = 0.001842 Total Atom Weight (atoms/b-cm) = 7.500E-05

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not

addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.272910	6000	0.333333	6000	0.000025
O16	8016	-0.725120	8016	0.665047	8016	0.000050
O17	8017	-0.000294	8017	0.000253	8017	0.000000
O18	8018	-0.001677	8018	0.001367	8018	0.000000
Elemental						
C	6000	-0.272910	6000	0.333333	6000	0.000025
O	8000	-0.727090	8000	0.666667	8000	0.000050

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=134
MatWeb gives density = 0.001799 g/cc
http://www.matweb.com/search/datasheet.aspx?matguid=5d8d9e87288943928df12425308a822d

66. Carbon Tetrachloride

Formula = CCl4 Molecular Weight (g/mole) = 153.816600
Density (g/cm3) = 1.594 Total Atom Weight (atoms/b-cm) = 3.120E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.078084	6000	0.200000	6000	0.006241
Cl35	17035	-0.688935	17035	0.606080	17035	0.018912
Cl37	17037	-0.233019	17037	0.193920	17037	0.006051
Elemental						
C	6000	-0.078084	6000	0.200000	6000	0.006241
Cl	17000	-0.921916	17000	0.800000	17000	0.024963

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=135
Same density and formula at
http://www.matweb.com/search/DataSheet.aspx?MatGUID=b502c0e948c64229adfed45e890cb3c6

67. Carbon, Activated

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.45 Total Atom Weight (atoms/b-cm) = 2.256E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The presence of boron to represent impurities is discussed below under Carbon, Graphite.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.000000	5010	0.000000	5010	0.000000
B11	5011	-0.000001	5011	0.000001	5011	0.000000
C	6000	-0.999999	6000	0.999999	6000	0.022563
Elemental						
B	5000	-0.000001	5000	0.000001	5000	0.000000
C	6000	-0.999999	6000	0.999999	6000	0.022563

Comments and References

Average Density = 0.45 from https://en.wikipedia.org/wiki/Activated_carbonimpurities are listed at https://www.researchgate.net/figure/Chemical-composition-of-activated-carbon_tbl1_318912346 The presence of boron to represent impurities is discussed below under Carbon, Graphite.

68. Carbon, Amorphous

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.0 Total Atom Weight (atoms/b-cm) = 1.003E-01

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The presence of boron to represent impurities is discussed below under Carbon, Graphite. (Note, NIST lists just Carbon).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.000000	5010	0.000000	5010	0.000000
B11	5011	-0.000001	5011	0.000001	5011	0.000000
C	6000	-0.999999	6000	0.999999	6000	0.100280
Elemental						
B	5000	-0.000001	5000	0.000001	5000	0.000000
C	6000	-0.999999	6000	0.999999	6000	0.100280

Comments and References

Density = 2.0 g/cm3 from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=006. The presence of boron to represent impurities is discussed below under Carbon, Graphite. (Note, NIST lists just Carbon).

69. Carbon, Graphite (reactor grade)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.7 Total Atom Weight (atoms/b-cm) = 8.524E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Density = 1.7 from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=906. This density is appropriate for reactor grade graphite.Avg. density for reactor grade graphite at Hanford = 1.71 g/cm3 (ARH-600, II.F.1-2).A value of 1.67 g/cm3 is listed in LA-10860-MS, Criticality Dimensions of Systems Containing 235U, 239Pu, and 233U by H. C. Paxton and N. L. Pruvost, 1986 revision issued July 1987, page 200. The Graphite Design Handbook by F. Ho (DOE-HTGR-88111, Rev. 0, Sept. 1988) lists 1.78 g/cm3 (p. 3-3, 3-30) for 2020 graphite and 1.74 g/cm3 (p.4-2) for H-451 Graphite. Impurities in commercial graphite can be accounted for by their natural boron equivalence, based on equal reaction rates. Nuclear grade graphite is defined as that having impurities ≤ 5 ppm boron equivalence (A Practical Method for Measuring the Boron Equivalent of Graphite Impurity by A. Bolewski, et al, 2005). A boron equivalence of 1.0 ppm was selected for nuclear graphite based on Evaluation of High Temperature Gas-Cooled Reactor Physics Experiments as VHTR Benchmark Problems, by T. A. Taiwo, et al., ANL-GenIV-059, Sept. 15, 2005.A detailed list of impurities in graphite is at http://www.graphite-eng.com/materials.html. The density and boron equivalence of impurities can vary significantly for different types of graphite, and the boron equivalence of non-burnable impurities should be distinguished from the boron equivalence of burnable impurities in burnup calculations. The user should use values appropriate for his purpose.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.000000	5010	0.000000	5010	0.000000
B11	5011	-0.000001	5011	0.000001	5011	0.000000
C	6000	-0.999999	6000	0.999999	6000	0.085238
Elemental						
B	5000	-0.000001	5000	0.000001	5000	0.000000
C	6000	-0.999999	6000	0.999999	6000	0.085238

Comments and References

Density = 1.7 from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=906. This density is appropriate for reactor grade graphite. The density and boron equivalence of impurities can vary significantly for different types of graphite, and the boron equivalence of non-burnable impurities should be distinguished from the boron equivalence of burnable impurities in burnup calculations. The user should use values appropriate for his purpose.

70. Cat litter (clumping)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.1 Total Atom Weight (atoms/b-cm) = 6.069E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.040385	1001	0.437382	1001	0.026545

H2	1002	-0.000009	1002	0.000050	1002	0.000003
O16	8016	-0.639299	8016	0.436259	8016	0.026477
O17	8017	-0.000259	8017	0.000166	8017	0.000010
O18	8018	-0.001478	8018	0.000897	8018	0.000054
Na23	11023	-0.008399	11023	0.003988	11023	0.000242
Al27	13027	-0.098290	13027	0.039762	13027	0.002413
Si	14000	-0.204580	14000	0.079508	14000	0.004825
Ca	20000	-0.007299	20000	0.001988	20000	0.000121
Elemental						
H	1000	-0.040396	1000	0.437432	1000	0.026548
O	8000	-0.641036	8000	0.437322	8000	0.026541
Na	11000	-0.008399	11000	0.003988	11000	0.000242
Al	13000	-0.098290	13000	0.039762	13000	0.002413
Si	14000	-0.204580	14000	0.079508	14000	0.004825
Ca	20000	-0.007299	20000	0.001988	20000	0.000121

Comments and References

About 69% of the cat litter market is for clumping cat litter. Clumping cat litter usually consists of granulated bentonite clay (calcium bentonite/montmorillonite) and often contains quartz or diatomaceous earth. Cat litter may also contain silica, i.e. silicon dioxide, (http://en.wikipedia.org/wiki/Cat_litter). The clumping cat litter, specified here is assumed to be composed of 100 wt% sodium-calcium bentonite based on the mineral montmorillonite, which has an average density of 2.35 g/cm3. Formula and weight fractions are from http://webmineral.com/data/Montmorillonite.shtml. The formula here is Na0.2Ca0.1Al2Si4O10(OH)2(H2O)10. Density for various types of clumping cat litter = 0.9 to 1.1 g/cm3 at http://www.purapet.com/clumping-cat-litter/. The density was chosen to be the maximum value of 1.1 g/cm3. To bound cat litter or other naturally occurring radioactive material (NORM), a mineral such as potassium aluminum silicate (KAlSi3O8) is sometimes used. Cat litter can also be called kitty litter.

71. Cat litter (non-clumping)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.8 Total Atom Weight (atoms/b-cm) = 3.077E-02

The above density is estimated to be accurate to 1 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.013726	1001	0.213253	1001	0.006562
H2	1002	-0.000003	1002	0.000025	1002	0.000001
O16	8016	-0.538452	8016	0.527100	8016	0.016218
O17	8017	-0.000218	8017	0.000201	8017	0.000006
O18	8018	-0.001245	8018	0.001083	8018	0.000033
Na23	11023	-0.043270	11023	0.029470	11023	0.000907
Mg	12000	-0.050469	12000	0.032513	12000	0.001000

Al27	13027	-0.052129	13027	0.030251	13027	0.000931
Si	14000	-0.293187	14000	0.163456	14000	0.005029
K	19000	-0.003770	19000	0.001510	19000	0.000046
Ca	20000	-0.001340	20000	0.000524	20000	0.000016
Fe	26000	-0.002190	26000	0.000614	26000	0.000019
Elemental						
H	1000	-0.013730	1000	0.213278	1000	0.006562
O	8000	-0.539915	8000	0.528384	8000	0.016258
Na	11000	-0.043270	11000	0.029470	11000	0.000907
Mg	12000	-0.050469	12000	0.032513	12000	0.001000
Al	13000	-0.052129	13000	0.030251	13000	0.000931
Si	14000	-0.293187	14000	0.163456	14000	0.005029
K	19000	-0.003770	19000	0.001510	19000	0.000046
Ca	20000	-0.001340	20000	0.000524	20000	0.000016
Fe	26000	-0.002190	26000	0.000614	26000	0.000019

Comments and References

Cat litter can be either clumping or non-clumping. Non-clumping cat litter is often made of zeolite, diatomaceous earth, and sepiolite, (http://en.wikipedia.org/wiki/Cat_litter). The cat litter specified here is assumed to be non-clumping cat litter composed of 34 wt% diatomaceous earth, 33 wt% sepiolite, and 33 wt% zeolite. Density for various types of non-clumping cat litter = 0.55 to 0.8g/cm3 at http://www.purapet.com/non-clumping-cat-litter/. The density was chosen to be the maximum value of 0.8 g/cm3, assuming that the sepiolite and zeolite fill in some of the space between the diatoms in the diatomaceous earth. Cat litter can also be called kitty litter.

72. Cellulose

Formula = C6H10O5 Molecular Weight (g/mole) = 162.140350
Density (g/cm3) = 1.5 Total Atom Weight (atoms/b-cm) = 1.170E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.062150	1001	0.476136	1001	0.055706
H2	1002	-0.000014	1002	0.000055	1002	0.000006
C	6000	-0.444452	6000	0.285714	6000	0.033427
O16	8016	-0.492044	8016	0.237517	8016	0.027788
O17	8017	-0.000199	8017	0.000090	8017	0.000011
O18	8018	-0.001138	8018	0.000488	8018	0.000057
Elemental						
H	1000	-0.062167	1000	0.476190	1000	0.055712
C	6000	-0.444452	6000	0.285714	6000	0.033427
O	8000	-0.493381	8000	0.238095	8000	0.027856

Comments and References

Cellulose is a natural organic compound plant cell walls. It forms the basis of paper and cardboard. PubChem.ncbi.nlm.nih.gov lists the molecular formula as (C6H10O5)n or C12H22O11 with a density range of 1.27-1.61 g/cm^3.

73. Cellulose Acetate

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.42 Total Atom Weight (atoms/b-cm) = 1.108E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.062148	1001	0.476124	1001	0.052733
H2	1002	-0.000014	1002	0.000055	1002	0.000006
C	6000	-0.444459	6000	0.285724	6000	0.031645
O16	8016	-0.492039	8016	0.237518	8016	0.026306
O17	8017	-0.000199	8017	0.000090	8017	0.000010
O18	8018	-0.001138	8018	0.000488	8018	0.000054
Elemental						
H	1000	-0.062164	1000	0.476179	1000	0.052739
C	6000	-0.444459	6000	0.285724	6000	0.031645
O	8000	-0.493376	8000	0.238097	8000	0.026370

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=136.

74. Ceric Sulfate Dosimeter Solution

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.03 Total Atom Weight (atoms/b-cm) = 1.005E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Assumes a solution of H2O:Ce2SO4

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.107568	1001	0.659004	1001	0.066204
H2	1002	-0.000025	1002	0.000076	1002	0.000008
N14	7014	-0.000797	7014	0.000351	7014	0.000035
N15	7015	-0.000003	7015	0.000001	7015	0.000000
O16	8016	-0.872605	8016	0.336843	8016	0.033840
O17	8017	-0.000353	8017	0.000128	8017	0.000013
O18	8018	-0.002018	8018	0.000692	8018	0.000070

S	16000	-0.014627	16000	0.002816	16000	0.000283
Ce136	58136	-0.000004	58136	0.000000	58136	0.000000
Ce138	58138	-0.000005	58138	0.000000	58138	0.000000
Ce140	58140	-0.001767	58140	0.000078	58140	0.000008
Ce142	58142	-0.000225	58142	0.000010	58142	0.000001
Elemental						
H	1000	-0.107596	1000	0.659080	1000	0.066212
N	7000	-0.000800	7000	0.000353	7000	0.000035
O	8000	-0.874976	8000	0.337663	8000	0.033922
S	16000	-0.014627	16000	0.002816	16000	0.000283
Ce	58000	-0.002001	58000	0.000088	58000	0.000009
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=139.						

75. Cerium Bromide

Formula = CeBr3(Ce) Molecular Weight (g/mole) = 379.828000
Density (g/cm3) = 5.2 Total Atom Weight (atoms/b-cm) = 3.298E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ce136	58136	-0.000662	58136	0.000463	58136	0.000015
Ce138	58138	-0.000911	58138	0.000628	58138	0.000021
Ce140	58140	-0.325796	58140	0.221125	58140	0.007292
Ce142	58142	-0.041524	58142	0.027785	58142	0.000916
Br79	35079	-0.315962	35079	0.380175	35079	0.012537
Br81	35081	-0.315141	35081	0.369825	35081	0.012196
Elemental						
Ce	58000	-0.368893	58000	0.250000	58000	0.008245
Br	35000	-0.631107	35000	0.750000	35000	0.024734
Comments and References						
CeBr3(Ce)) is Enhanced Lanthanum Bromide Density and formula from https://www.berkeleynucleonics.com/sites/default/files/products/datasheets/cebr3_datasheet_2017.pdf. Advatech at https://www.advatech-uk.co.uk/cebr3.html gives a density of 5.1.						

76. Cerium Fluoride

Formula = CeF3 Molecular Weight (g/mole) = 197.111209
Density (g/cm3) = 6.16 Total Atom Weight (atoms/b-cm) = 7.528E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not

addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
F19	9019	-0.289153	9019	0.750000	9019	0.056460
Ce136	58136	-0.001276	58136	0.000463	58136	0.000035
Ce138	58138	-0.001756	58138	0.000628	58138	0.000047
Ce140	58140	-0.627800	58140	0.221125	58140	0.016646
Ce142	58142	-0.080015	58142	0.027785	58142	0.002092
Elemental						
F	9000	-0.289153	9000	0.750000	9000	0.056460
Ce	58000	-0.710847	58000	0.250000	58000	0.018820

Comments and References

Density = 6.16 g/cm3 and formula from page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000.

77. Cesium Iodide - 1 wt% Sodium doped

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.51 Total Atom Weight (atoms/b-cm) = 2.099E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cs133	55133	-0.511097	55133	0.497513	55133	0.010445
I127	53127	-0.488019	53127	0.497512	53127	0.010444
Na23	11023	-0.000884	11023	0.004975	11023	0.000104
Elemental						
Cs	55000	-0.511097	55000	0.497513	55000	0.010445
I	53000	-0.488019	53000	0.497512	53000	0.010444
Na	11000	-0.000884	11000	0.004975	11000	0.000104

Comments and References

Formula is CsI(Na) but the formula isn't used in the calculation due to the Na dopant Material information from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=141. Material information from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/lanthanum-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain Safety Data Sheets and literature at St Gobain resource library @ https://www.crystals.saint-gobain.com/document-center

78. Cesium Iodide - 1 wt% Thalium doped

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.51 Total Atom Weight (atoms/b-cm) = 2.085E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cs133	55133	-0.507556	55133	0.497512	55133	0.010372
I127	53127	-0.484639	53127	0.497513	53127	0.010372
Tl203	81203	-0.002288	81203	0.001469	81203	0.000031
Tl205	81205	-0.005517	81205	0.003506	81205	0.000073
Elemental						
Cs	55000	-0.507556	55000	0.497512	55000	0.010372
I	53000	-0.484639	53000	0.497513	53000	0.010372
Tl	81000	-0.007805	81000	0.004975	81000	0.000104

Comments and References

Formula is CsI(Tl) but the formula isn't used in the calculation due to the Tl dopant Material information from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=141. Material information from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/lanthanum-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain Safety Data Sheets and literature at St Gobain resource library @ https://www.crystals.saint-gobain.com/document-center

79. Cesium Lithium Yttrium Chloride (CLYC)

Formula = Cs2LiYCl6 Molecular Weight (g/mole) = 574.393244
Density (g/cm3) = 3.31 Total Atom Weight (atoms/b-cm) = 3.470E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cs133	55133	-0.462768	55133	0.200000	55133	0.006941
Li6	3006	-0.000795	3006	0.007590	3006	0.000263
Li7	3007	-0.011288	3007	0.092410	3007	0.003207
Y89	39089	-0.154782	39089	0.100000	39089	0.003470
Cl35	17035	-0.276734	17035	0.454560	17035	0.015775
Cl37	17037	-0.093600	17037	0.145440	17037	0.005047
Elemental						
Cs	55000	-0.462768	55000	0.200000	55000	0.006941
Li	3000	-0.012130	3000	0.100000	3000	0.003470
Y	39000	-0.154782	39000	0.100000	39000	0.003470
Cl	17000	-0.370319	17000	0.600000	17000	0.020822

Comments and References

Density and formula from https://www.americanelements.com/clyc-ce-scintillation-crystal

80. Cesium Lithium Yttrium Chloride (CLYC) with 95% Li6 Enrichment

Formula = Cs2LiYCl6 Molecular Weight (g/mole) = 573.484080
Density (g/cm3) = 3.31 Total Atom Weight (atoms/b-cm) = 3.476E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cs133	55133	-0.463502	55133	0.200000	55133	0.006952
Li6	3006	-0.010036	3006	0.095682	3006	0.003326
Li7	3007	-0.000528	3007	0.004318	3007	0.000150
Y89	39089	-0.155028	39089	0.100000	39089	0.003476
Cl35	17035	-0.277173	17035	0.454560	17035	0.015800
Cl37	17037	-0.093748	17037	0.145440	17037	0.005055
Elemental						
Cs	55000	-0.463502	55000	0.200000	55000	0.006952
Li	3006	-0.010036	3006	0.095682	3006	0.003326
Li	3007	-0.000528	3007	0.004318	3007	0.000150
Y	39000	-0.155028	39000	0.100000	39000	0.003476
Cl	17000	-0.370907	17000	0.600000	17000	0.020855

Comments and References

Density and formula from https://www.americanelements.com/clyc-ce-scintillation-crystal, enrichment of 6Li or 7Li can vary with application, the following reference cites 95% enriched 6Li and also 99% 7Li.
https://www.researchgate.net/publication/302196499_Fast_neutron_measurements_with_7Li_and_6Li_enriched_CLYC_scintillators

81. Chromium

Formula = Cr Molecular Weight (g/mole) = 51.996100
Density (g/cm3) = 7.18 Total Atom Weight (atoms/b-cm) = 8.316E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cr	24000	-1.000000	24000	1.000000	24000	0.083158
Elemental						
Cr	24000	-1.000000	24000	1.000000	24000	0.083158

Comments and References
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=024.

82. Clay

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.2 Total Atom Weight (atoms/b-cm) = 6.333E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.483035	8016	0.631759	8016	0.040010
O17	8017	-0.000196	8017	0.000241	8017	0.000015
O18	8018	-0.001117	8018	0.001298	8018	0.000082
Na23	11023	-0.007608	11023	0.006923	11023	0.000438
Mg	12000	-0.010691	12000	0.009202	12000	0.000583
Al27	13027	-0.122125	13027	0.094688	13027	0.005997
Si	14000	-0.294195	14000	0.219137	14000	0.013878
P31	15031	-0.000113	15031	0.000076	15031	0.000005
K	19000	-0.020427	19000	0.010930	19000	0.000692
Ca	20000	-0.018957	20000	0.009895	20000	0.000627
Ti	22000	-0.004668	22000	0.002040	22000	0.000129
Mn55	25055	-0.000064	25055	0.000024	25055	0.000002
Fe	26000	-0.036804	26000	0.013787	26000	0.000873
Elemental						
O	8000	-0.484347	8000	0.633298	8000	0.040108
Na	11000	-0.007608	11000	0.006923	11000	0.000438
Mg	12000	-0.010691	12000	0.009202	12000	0.000583
Al	13000	-0.122125	13000	0.094688	13000	0.005997
Si	14000	-0.294195	14000	0.219137	14000	0.013878
P	15000	-0.000113	15000	0.000076	15000	0.000005
K	19000	-0.020427	19000	0.010930	19000	0.000692
Ca	20000	-0.018957	20000	0.009895	20000	0.000627
Ti	22000	-0.004668	22000	0.002040	22000	0.000129
Mn	25000	-0.000064	25000	0.000024	25000	0.000002
Fe	26000	-0.036804	26000	0.013787	26000	0.000873

Comments and References

The element weight fractions are calculated based on the listed weight fractions of compounds in 19 clays from 8 regions in the world. Data is from Applied Clay Science, p.461-473 of Vol.4 (1989), p.379-395 of Vol.5 (1991), p.247-266 and 463-477 of Vol.12 (1998), p.337-366 of Vol.15 (Oct.1999), as well as
http://www.springerlink.com/content/u692183538748146/fulltext.pdf and
https://www.mri.psu.edu/conferences/sint03/pdf/Zanelli_1_1.pdf.Density = 2.2 g/cm3 from

Table 51.14 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.This is consistent with a density of 1.8 to 2.6 g/cm3 listed under minerals for marl clay in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers, edited by E. A. Avallone and T. Baumeister III, 10th edition.There is a wide variation of densities for clay depending on the type of clay that is meant. For example, densities for clay from 1.07 to 1.83 g/cm3 are listed at http://www.simetric.co.uk/si_materials.htm, densities from 0.48 to 0.96 g/cm3 are listed at http://www.powderandbulk.com/resources/bulk_density/material_bulk_density_chart_c.htm, and densities from 1.0 to 2.9 are listed in Table 51.59 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.

83. Coal, Anthracite

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.84 Total Atom Weight (atoms/b-cm) = 5.269E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.023994	1001	0.228578	1001	0.012043
H2	1002	-0.000006	1002	0.000026	1002	0.000001
C	6000	-0.937000	6000	0.749029	6000	0.039464
N14	7014	-0.008965	7014	0.006147	7014	0.000324
N15	7015	-0.000035	7015	0.000022	7015	0.000001
O16	8016	-0.023935	8016	0.014367	8016	0.000757
O17	8017	-0.000010	8017	0.000005	8017	0.000000
O18	8018	-0.000055	8018	0.000030	8018	0.000002
S	16000	-0.006000	16000	0.001796	16000	0.000095
Elemental						
H	1000	-0.024000	1000	0.228604	1000	0.012045
C	6000	-0.937000	6000	0.749029	6000	0.039464
N	7000	-0.009000	7000	0.006169	7000	0.000325
O	8000	-0.024000	8000	0.014402	8000	0.000759
S	16000	-0.006000	16000	0.001796	16000	0.000095

Comments and References

Weight fractions from Handbook of Coal Analysis by Janes G Speight, 2015 John Wiley & Sons, and Table 4.1 of Handbook of Petroleum Analysis by James G. Speight, 2001, John Wiley and Sons, ISBN 0-471-36167-4 on Knovel Database.Density = 1.4 to 1.8 g/cm3 and bulk density = 0.75 to 0.93 g/cm3 for piled coal in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers, edited by E. A. Avallone and T. Baumeister III, 10th edition. Density = 1.105 g/cm3 for broken coal and 1.506 for solid coal (http://www.simetric.co.uk/si_materials.htm). Density = 1.3 to 1.7 g/cm3, and bulk density = 0.75 to 0.93 g/cm3, in Table 51.65 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.

84. Coal, Bituminous

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	0.75		Total Atom Weight (atoms/b-cm) = 5.954E-02			
The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.055985	1001	0.421366	1001	0.025090
H2	1002	-0.000013	1002	0.000048	1002	0.000003
C	6000	-0.845000	6000	0.533658	6000	0.031776
N14	7014	-0.015937	7014	0.008633	7014	0.000514
N15	7015	-0.000062	7015	0.000032	7015	0.000002
O16	8016	-0.069810	8016	0.033106	8016	0.001971
O17	8017	-0.000028	8017	0.000013	8017	0.000001
O18	8018	-0.000161	8018	0.000068	8018	0.000004
S	16000	-0.013000	16000	0.003075	16000	0.000183
Elemental						
H	1000	-0.056000	1000	0.421415	1000	0.025093
C	6000	-0.845000	6000	0.533658	6000	0.031776
N	7000	-0.016000	7000	0.008665	7000	0.000516
O	8000	-0.070000	8000	0.033187	8000	0.001976
S	16000	-0.013000	16000	0.003075	16000	0.000183
Comments and References						
Weight fractions from Handbook of Coal Analysis by Janes G Speight, 2015 John Wiley & Sons, and Table 4.1 of Handbook of Petroleum Analysis by James G. Speight, 2001, John Wiley and Sons, ISBN 0-471-36167-4 on Knovel Database.Density = 1.2 to 1.5 g/cm3 and bulk density = 0.64 to 0.87 g/cm3 for piled coal in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers, edited by E. A. Avallone and T. Baumeister III, 10th edition.Density = 0.833 g/cm3 for broken coal and 1.346 for solid coal (http://www.simetric.co.uk/si_materials.htm). Density = 1.2 to 1.4 g/cm3, and bulk density =0.70 to 0.86 g/cm3, in Table 51.65 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.						

85. Coal, Lignite

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	0.75		Total Atom Weight (atoms/b-cm) = 5.264E-02			
The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.041989	1001	0.357455	1001	0.018817

H2	1002	-0.000010	1002	0.000041	1002	0.000002
C	6000	-0.727000	6000	0.519327	6000	0.027339
N14	7014	-0.011953	7014	0.007324	7014	0.000386
N15	7015	-0.000047	7015	0.000027	7015	0.000001
O16	8016	-0.212423	8016	0.113944	8016	0.005998
O17	8017	-0.000086	8017	0.000043	8017	0.000002
O18	8018	-0.000491	8018	0.000234	8018	0.000012
S	16000	-0.006000	16000	0.001605	16000	0.000085
Elemental						
H	1000	-0.042000	1000	0.357496	1000	0.018820
C	6000	-0.727000	6000	0.519327	6000	0.027339
N	7000	-0.012000	7000	0.007350	7000	0.000387
O	8000	-0.213000	8000	0.114221	8000	0.006013
S	16000	-0.006000	16000	0.001605	16000	0.000085
Comments and References						
Weight fractions from Handbook of Coal Analysis by Janes G Speight, 2015 John Wiley & Sons, and Table 4.1 of Handbook of Petroleum Analysis by James G. Speight, 2001, John Wiley and Sons, ISBN 0-471-36167-4 on Knovel Database. Density = 1.1 to 1.4 g/cm3 and bulk density = 0.64 to 0.87 g/cm3 for piled coal in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers, edited by E. A. Avallone and T. Baumeister III, 10th edition.						

86. Concrete [Los Alamos (MCNP) Mix]

Formula =		Molecular Weight (g/mole) =			
Density (g/cm3) =	2.25	Total Atom Weight (atoms/b-cm) = 7.186E-02			
	Weight Fractions		Atom Fractions		Atom Densities
Isotopic					
H1	1001	-0.004529	1001	0.084726	1001	0.006089
H2	1002	-0.000001	1002	0.000010	1002	0.000001
O16	8016	-0.511211	8016	0.602610	8016	0.043306
O17	8017	-0.000207	8017	0.000230	8017	0.000016
O18	8018	-0.001182	8018	0.001238	8018	0.000089
Si	14000	-0.360360	14000	0.241925	14000	0.017386
Al27	13027	-0.035550	13027	0.024842	13027	0.001785
Na23	11023	-0.015270	11023	0.012523	11023	0.000900
Ca	20000	-0.057910	20000	0.027244	20000	0.001958
Fe	26000	-0.013780	26000	0.004652	26000	0.000334
Elemental						
H	1000	-0.004530	1000	0.084736	1000	0.006090
O	8000	-0.512600	8000	0.604078	8000	0.043412
Si	14000	-0.360360	14000	0.241925	14000	0.017386
Al	13000	-0.035550	13000	0.024842	13000	0.001785
Na	11000	-0.015270	11000	0.012523	11000	0.000900

Ca	20000	-0.057910	20000	0.027244	20000	0.001958
Fe	26000	-0.013780	26000	0.004652	26000	0.000334
Comments and References						
Data from page 135 of LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.						

87. Concrete, Barite (Type BA)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.35 Total Atom Weight (atoms/b-cm) = 6.547E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Data in this table is from ANSI/ANS-6.4-1985. This concrete has barytes, a BaSO4 ore, as aggregate.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.003584	1001	0.109587	1001	0.007174
H2	1002	-0.000001	1002	0.000013	1002	0.000001
O16	8016	-0.310778	8016	0.598738	8016	0.039198
O17	8017	-0.000126	8017	0.000228	8017	0.000015
O18	8018	-0.000719	8018	0.001230	8018	0.000081
Mg	12000	-0.001195	12000	0.001515	12000	0.000099
Al27	13027	-0.004183	13027	0.004777	13027	0.000313
Si	14000	-0.010457	14000	0.011474	14000	0.000751
S	16000	-0.107858	16000	0.103647	16000	0.006786
Ca	20000	-0.050194	20000	0.038594	20000	0.002527
Fe	26000	-0.047505	26000	0.026213	26000	0.001716
Ba130	56130	-0.000465	56130	0.000110	56130	0.000007
Ba132	56132	-0.000450	56132	0.000105	56132	0.000007
Ba134	56134	-0.010921	56134	0.002513	56134	0.000165
Ba135	56135	-0.030009	56135	0.006855	56135	0.000449
Ba136	56136	-0.036018	56136	0.008167	56136	0.000535
Ba137	56137	-0.051890	56137	0.011680	56137	0.000765
Ba138	56138	-0.333648	56138	0.074555	56138	0.004881
Elemental						
H	1000	-0.003585	1000	0.109599	1000	0.007175
O	8000	-0.311622	8000	0.600196	8000	0.039293
Mg	12000	-0.001195	12000	0.001515	12000	0.000099
Al	13000	-0.004183	13000	0.004777	13000	0.000313
Si	14000	-0.010457	14000	0.011474	14000	0.000751
S	16000	-0.107858	16000	0.103647	16000	0.006786
Ca	20000	-0.050194	20000	0.038594	20000	0.002527
Fe	26000	-0.047505	26000	0.026213	26000	0.001716
Ba	56000	-0.463400	56000	0.103985	56000	0.006808

Comments and References
Density and weight fractions from http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html.Table 8.8 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996, for a similar composition. Data in this table is from ANSI/ANS-6.4-1985. This concrete has barytes, a BaSO4 ore, as aggregate.

88. Concrete, Barytes-Limonite

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.36 Total Atom Weight (atoms/b-cm) = 8.732E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Weight fractions are adjusted so that they sum to unity. Barytes (a BaSO4 ore) and Limonite (a hydrated Fe2O3 ore) as aggregate.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.010237	1001	0.235385	1001	0.020554
H2	1002	-0.000002	1002	0.000027	1002	0.000002
O16	8016	-0.377450	8016	0.546835	8016	0.047749
O17	8017	-0.000153	8017	0.000208	8017	0.000018
O18	8018	-0.000873	8018	0.001124	8018	0.000098
Na23	11023	-0.000904	11023	0.000911	11023	0.000080
Mg	12000	-0.002309	12000	0.002201	12000	0.000192
Al27	13027	-0.005020	13027	0.004311	13027	0.000376
Si	14000	-0.013553	14000	0.011183	14000	0.000976
S	16000	-0.076097	16000	0.054990	16000	0.004802
Ca	20000	-0.053910	20000	0.031170	20000	0.002722
Mn55	25055	-0.001405	25055	0.000593	25055	0.000052
Fe	26000	-0.137135	26000	0.056904	26000	0.004969
Ba130	56130	-0.000322	56130	0.000057	56130	0.000005
Ba132	56132	-0.000311	56132	0.000055	56132	0.000005
Ba134	56134	-0.007564	56134	0.001309	56134	0.000114
Ba135	56135	-0.020784	56135	0.003570	56135	0.000312
Ba136	56136	-0.024946	56136	0.004254	56136	0.000371
Ba137	56137	-0.035939	56137	0.006083	56137	0.000531
Ba138	56138	-0.231085	56138	0.038830	56138	0.003391
Elemental						
H	1000	-0.010240	1000	0.235412	1000	0.020556
O	8000	-0.378476	8000	0.548167	8000	0.047866
Na	11000	-0.000904	11000	0.000911	11000	0.000080
Mg	12000	-0.002309	12000	0.002201	12000	0.000192
Al	13000	-0.005020	13000	0.004311	13000	0.000376
Si	14000	-0.013553	14000	0.011183	14000	0.000976
S	16000	-0.076097	16000	0.054990	16000	0.004802
Ca	20000	-0.053910	20000	0.031170	20000	0.002722

Mn	25000	-0.001405	25000	0.000593	25000	0.000052
Fe	26000	-0.137135	26000	0.056904	26000	0.004969
Ba	56000	-0.320952	56000	0.054158	56000	0.004729
Comments and References						
Density and weight fractions from Tables 9.1.12-55 and 77 of Engineering Compendium on Radiation Shielding edited by R.G. Jaeger, et al, Vol.2, Shielding Materials, Springer-Verlag, 1975. Weight fractions are adjusted so that they sum to unity.Barytes (a BaSO4 ore) and Limonite (a hydrated Fe2O3 ore) as aggregate.						

89. Concrete, Boron Frits-baryte

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.1 Total Atom Weight (atoms/b-cm) = 7.064E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Weight fractions are adjusted so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.005625	1001	0.147492	1001	0.010419
H2	1002	-0.000001	1002	0.000017	1002	0.000001
B10	5010	-0.001925	5010	0.005082	5010	0.000359
B11	5011	-0.008521	5011	0.020455	5011	0.001445
O16	8016	-0.338676	8016	0.559593	8016	0.039529
O17	8017	-0.000137	8017	0.000213	8017	0.000015
O18	8018	-0.000783	8018	0.001150	8018	0.000081
F19	9019	-0.002311	9019	0.003215	9019	0.000227
Na23	11023	-0.012157	11023	0.013975	11023	0.000987
Mg	12000	-0.002311	12000	0.002513	12000	0.000178
Al27	13027	-0.006430	13027	0.006298	13027	0.000445
Si	14000	-0.033256	14000	0.031294	14000	0.002211
S	16000	-0.091932	16000	0.075765	16000	0.005352
K	19000	-0.001005	19000	0.000679	19000	0.000048
Ca	20000	-0.062896	20000	0.041475	20000	0.002930
Mn55	25055	-0.000201	25055	0.000097	25055	0.000007
Fe	26000	-0.022003	26000	0.010413	26000	0.000736
Zn	30000	-0.006631	30000	0.002680	30000	0.000189
Ba130	56130	-0.000404	56130	0.000082	56130	0.000006
Ba132	56132	-0.000391	56132	0.000078	56132	0.000006
Ba134	56134	-0.009502	56134	0.001875	56134	0.000132
Ba135	56135	-0.026110	56135	0.005115	56135	0.000361
Ba136	56136	-0.031339	56136	0.006094	56136	0.000430
Ba137	56137	-0.045148	56137	0.008715	56137	0.000616
Ba138	56138	-0.290300	56138	0.055633	56138	0.003930
Elemental						
H	1000	-0.005626	1000	0.147509	1000	0.010420

B	5000	-0.010449	5000	0.025537	5000	0.001804
O	8000	-0.339596	8000	0.560956	8000	0.039625
F	9000	-0.002311	9000	0.003215	9000	0.000227
Na	11000	-0.012157	11000	0.013975	11000	0.000987
Mg	12000	-0.002311	12000	0.002513	12000	0.000178
Al	13000	-0.006430	13000	0.006298	13000	0.000445
Si	14000	-0.033256	14000	0.031294	14000	0.002211
S	16000	-0.091932	16000	0.075765	16000	0.005352
K	19000	-0.001005	19000	0.000679	19000	0.000048
Ca	20000	-0.062896	20000	0.041475	20000	0.002930
Mn	25000	-0.000201	25000	0.000097	25000	0.000007
Fe	26000	-0.022003	26000	0.010413	26000	0.000736
Zn	30000	-0.006631	30000	0.002680	30000	0.000189
Ba	56000	-0.403195	56000	0.077594	56000	0.005481
Comments and References						
Density and weight fractions from Tables 51.84 and 51.95 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960.Weight fractions are adjusted so that they sum to unity.						

90. Concrete, Colemanite-baryte

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.2 Total Atom Weight (atoms/b-cm) = 7.845E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Weight fractions are adjusted so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.008562	1001	0.208697	1001	0.016371
H2	1002	-0.000002	1002	0.000024	1002	0.000002
B10	5010	-0.001819	5010	0.004464	5010	0.000350
B11	5011	-0.008052	5011	0.017968	5011	0.001409
O16	8016	-0.350584	8016	0.538456	8016	0.042239
O17	8017	-0.000142	8017	0.000205	8017	0.000016
O18	8018	-0.000811	8018	0.001107	8018	0.000087
Na23	11023	-0.001108	11023	0.001184	11023	0.000093
Mg	12000	-0.002217	12000	0.002241	12000	0.000176
Al27	13027	-0.006146	13027	0.005596	13027	0.000439
Si	14000	-0.017733	14000	0.015511	14000	0.001217
S	16000	-0.097028	16000	0.074331	16000	0.005831
Ca	20000	-0.085239	20000	0.052248	20000	0.004099
Mn55	25055	-0.000101	25055	0.000045	25055	0.000004
Fe	26000	-0.010378	26000	0.004565	26000	0.000358
Ba130	56130	-0.000411	56130	0.000078	56130	0.000006
Ba132	56132	-0.000398	56132	0.000074	56132	0.000006

Ba134	56134	-0.009665	56134	0.001773	56134	0.000139
Ba135	56135	-0.026556	56135	0.004836	56135	0.000379
Ba136	56136	-0.031874	56136	0.005762	56136	0.000452
Ba137	56137	-0.045918	56137	0.008240	56137	0.000646
Ba138	56138	-0.295254	56138	0.052596	56138	0.004126
Elemental						
H	1000	-0.008564	1000	0.208721	1000	0.016373
B	5000	-0.009874	5000	0.022432	5000	0.001760
O	8000	-0.351537	8000	0.539767	8000	0.042342
Na	11000	-0.001108	11000	0.001184	11000	0.000093
Mg	12000	-0.002217	12000	0.002241	12000	0.000176
Al	13000	-0.006146	13000	0.005596	13000	0.000439
Si	14000	-0.017733	14000	0.015511	14000	0.001217
S	16000	-0.097028	16000	0.074331	16000	0.005831
Ca	20000	-0.085239	20000	0.052248	20000	0.004099
Mn	25000	-0.000101	25000	0.000045	25000	0.000004
Fe	26000	-0.010378	26000	0.004565	26000	0.000358
Ba	56000	-0.410076	56000	0.073358	56000	0.005755

Comments and References

Density and weight fractions from Tables 51.84 and 51.95 of Reactor Handbook, 2nd edition, Vol. 1,Materials, edited by C.R. Tipton, 1960. Weight fractions are adjusted so that they sum to unity.

91. Concrete, Ferro-phosphorus

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.8 Total Atom Weight (atoms/b-cm) = 9.039E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.004999	1001	0.158620	1001	0.014337
H2	1002	-0.000001	1002	0.000018	1002	0.000002
O16	8016	-0.103718	8016	0.207377	8016	0.018744
O17	8017	-0.000042	8017	0.000079	8017	0.000007
O18	8018	-0.000240	8018	0.000426	8018	0.000039
Mg	12000	-0.002000	12000	0.002632	12000	0.000238
Al27	13027	-0.004000	13027	0.004741	13027	0.000429
Si	14000	-0.034000	14000	0.038716	14000	0.003499
P31	15031	-0.197000	15031	0.203404	15031	0.018385
Ca	20000	-0.042000	20000	0.033514	20000	0.003029
Fe	26000	-0.612000	26000	0.350473	26000	0.031678
Elemental						
H	1000	-0.005000	1000	0.158638	1000	0.014339

O	8000	-0.104000	8000	0.207882	8000	0.018790
Mg	12000	-0.002000	12000	0.002632	12000	0.000238
Al	13000	-0.004000	13000	0.004741	13000	0.000429
Si	14000	-0.034000	14000	0.038716	14000	0.003499
P	15000	-0.197000	15000	0.203404	15000	0.018385
Ca	20000	-0.042000	20000	0.033514	20000	0.003029
Fe	26000	-0.612000	26000	0.350473	26000	0.031678
Comments and References						
Density and weight fractions from p.1081 and Tables 51.95 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960.						

92. Concrete, Hanford Dry

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.18 Total Atom Weight (atoms/b-cm) = 6.642E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Starting from the data in the Rockwell Hanford Operations for wet concrete, the water content was reduced to model drying for decades in a dry environment. A reasonable minimum hydrogen content for old dry concrete is about 0.4 wt.%. The change in the density due to drying from a hydrogen content of 1.23 to 0.4 wt.%, assuming that the concrete does not shrink as it dries, leads to a reduction in the concrete density from 2.35 g/cm3 to 2.169 g/cm3.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.003999	1001	0.078428	1001	0.005209
H2	1002	-0.000001	1002	0.000009	1002	0.000001
O16	8016	-0.480796	8016	0.594143	8016	0.039463
O17	8017	-0.000195	8017	0.000226	8017	0.000015
O18	8018	-0.001112	8018	0.001221	8018	0.000081
Na23	11023	-0.002168	11023	0.001864	11023	0.000124
Mg	12000	-0.014094	12000	0.011462	12000	0.000761
Al27	13027	-0.069387	13027	0.050830	13027	0.003376
Si	14000	-0.277549	14000	0.195334	14000	0.012974
K	19000	-0.013010	19000	0.006577	19000	0.000437
Ca	20000	-0.080229	20000	0.039567	20000	0.002628
Fe	26000	-0.057461	26000	0.020338	26000	0.001351
Elemental						
H	1000	-0.004000	1000	0.078437	1000	0.005210
O	8000	-0.482102	8000	0.595591	8000	0.039559
Na	11000	-0.002168	11000	0.001864	11000	0.000124
Mg	12000	-0.014094	12000	0.011462	12000	0.000761
Al	13000	-0.069387	13000	0.050830	13000	0.003376
Si	14000	-0.277549	14000	0.195334	14000	0.012974
K	19000	-0.013010	19000	0.006577	19000	0.000437

Ca	20000	-0.080229	20000	0.039567	20000	0.002628
Fe	26000	-0.057461	26000	0.020338	26000	0.001351
Comments and References						
Table 1 of Concrete and Criticality by R. D. Carter, RHO-SA-30, June, 1978, Rockwell Hanford Operations.Based on Table 9.1.12-7 of Engineering Compendium on Radiation Shielding edited by R.G. Jaeger, et al, Vol.2, Shielding Materials, Springer-Verlag, 1975, total concrete shrinkage due to drying can be about 1 part in 1000, so the density would only increase to about 2.169 x 1.001^3 = 2.176 g/cm3.						

93. Concrete, Hanford Wet

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.35 Total Atom Weight (atoms/b-cm) = 8.423E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.This concrete contains 1.23 wt.% hydrogen. This is reasonable for concrete that has not dried for a long time.The weight fractions are adjusted so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.012306	1001	0.205145	1001	0.017280
H2	1002	-0.000003	1002	0.000024	1002	0.000002
O16	8016	-0.511968	8016	0.537774	8016	0.045298
O17	8017	-0.000207	8017	0.000205	8017	0.000017
O18	8018	-0.001184	8018	0.001105	8018	0.000093
Na23	11023	-0.002001	11023	0.001462	11023	0.000123
Mg	12000	-0.013009	12000	0.008992	12000	0.000757
Al27	13027	-0.064045	13027	0.039880	13027	0.003359
Si	14000	-0.256179	14000	0.153253	14000	0.012909
K	19000	-0.012008	19000	0.005160	19000	0.000435
Ca	20000	-0.074052	20000	0.031043	20000	0.002615
Fe	26000	-0.053037	26000	0.015956	26000	0.001344
Elemental						
H	1000	-0.012309	1000	0.205169	1000	0.017282
O	8000	-0.513360	8000	0.539084	8000	0.045408
Na	11000	-0.002001	11000	0.001462	11000	0.000123
Mg	12000	-0.013009	12000	0.008992	12000	0.000757
Al	13000	-0.064045	13000	0.039880	13000	0.003359
Si	14000	-0.256179	14000	0.153253	14000	0.012909
K	19000	-0.012008	19000	0.005160	19000	0.000435
Ca	20000	-0.074052	20000	0.031043	20000	0.002615
Fe	26000	-0.053037	26000	0.015956	26000	0.001344
Comments and References						

Table 1 of Concrete and Criticality by R. D. Carter, RHO-SA-30, June, 1978, Rockwell Hanford Operations.

94. Concrete, Iron-Portland

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 5.9 Total Atom Weight (atoms/b-cm) = 8.633E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Weight fractions are adjusted so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.003320	1001	0.135580	1001	0.011705
H2	1002	-0.000001	1002	0.000016	1002	0.000001
O16	8016	-0.058404	8016	0.150276	8016	0.012974
O17	8017	-0.000024	8017	0.000057	8017	0.000005
O18	8018	-0.000135	8018	0.000309	8018	0.000027
Mg	12000	-0.001308	12000	0.002215	12000	0.000191
Al27	13027	-0.003321	13027	0.005066	13027	0.000437
Si	14000	-0.009157	14000	0.013419	14000	0.001158
S	16000	-0.000503	16000	0.000646	16000	0.000056
Ca	20000	-0.039847	20000	0.040918	20000	0.003533
Mn55	25055	-0.003522	25055	0.002638	25055	0.000228
Fe	26000	-0.880458	26000	0.648860	26000	0.056018
Elemental						
H	1000	-0.003321	1000	0.135596	1000	0.011706
O	8000	-0.058563	8000	0.150642	8000	0.013005
Mg	12000	-0.001308	12000	0.002215	12000	0.000191
Al	13000	-0.003321	13000	0.005066	13000	0.000437
Si	14000	-0.009157	14000	0.013419	14000	0.001158
S	16000	-0.000503	16000	0.000646	16000	0.000056
Ca	20000	-0.039847	20000	0.040918	20000	0.003533
Mn	25000	-0.003522	25000	0.002638	25000	0.000228
Fe	26000	-0.880458	26000	0.648860	26000	0.056018

Comments and References

Density and weight fractions from Tables 51.84 and 51.95 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960.

95. Concrete, Iron-limonite

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.4 Total Atom Weight (atoms/b-cm) = 7.222E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not

addressed. Weight fractions are adjusted so that they sum to unity.Also see Concrete, Limonite and steel.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.000500	1001	0.018198	1001	0.001314
H2	1002	-0.000000	1002	0.000002	1002	0.000000
O16	8016	-0.179422	8016	0.411584	8016	0.029723
O17	8017	-0.000073	8017	0.000157	8017	0.000011
O18	8018	-0.000415	8018	0.000846	8018	0.000061
Mg	12000	-0.001999	12000	0.003018	12000	0.000218
Al27	13027	-0.004998	13027	0.006797	13027	0.000491
Si	14000	-0.013993	14000	0.018281	14000	0.001320
S	16000	-0.001000	16000	0.001144	16000	0.000083
Ca	20000	-0.060970	20000	0.055818	20000	0.004031
Mn55	25055	-0.015992	25055	0.010681	25055	0.000771
Fe	26000	-0.720638	26000	0.473474	26000	0.034193
Elemental						
H	1000	-0.000500	1000	0.018201	1000	0.001314
O	8000	-0.179910	8000	0.412586	8000	0.029796
Mg	12000	-0.001999	12000	0.003018	12000	0.000218
Al	13000	-0.004998	13000	0.006797	13000	0.000491
Si	14000	-0.013993	14000	0.018281	14000	0.001320
S	16000	-0.001000	16000	0.001144	16000	0.000083
Ca	20000	-0.060970	20000	0.055818	20000	0.004031
Mn	25000	-0.015992	25000	0.010681	25000	0.000771
Fe	26000	-0.720638	26000	0.473474	26000	0.034193

Comments and References

Weight fractions from Tables 51.95 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960. Density = 4.27 for wet concrete and 4.3 to 4.5 g/cm3 for hardened concrete (Table 9.1.12-40 of Engineering Compendium on Radiation Shielding edited by R.G. Jaeger, Vol.2, Shielding Materials, Springer-Verlag, 1975.

96. Concrete, Limonite and steel

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.54 Total Atom Weight (atoms/b-cm) = 8.850E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. This concrete has limonite, a hydrated Fe2O3 ore, and steel punchings as aggregate. Also see Concrete, Iron-limonite.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.006838	1001	0.209604	1001	0.018551
H2	1002	-0.000002	1002	0.000024	1002	0.000002

O16	8016	-0.155799	8016	0.300902	8016	0.026631
O17	8017	-0.000063	8017	0.000115	8017	0.000010
O18	8018	-0.000360	8018	0.000618	8018	0.000055
Mg	12000	-0.001545	12000	0.001964	12000	0.000174
Al27	13027	-0.006399	13027	0.007326	13027	0.000648
Si	14000	-0.014784	14000	0.016261	14000	0.001439
K	19000	-0.000883	19000	0.000698	19000	0.000062
Ca	20000	-0.057590	20000	0.044390	20000	0.003929
V	23000	-0.000883	23000	0.000535	23000	0.000047
Fe	26000	-0.754854	26000	0.417563	26000	0.036956
Elemental						
H	1000	-0.006840	1000	0.209628	1000	0.018553
O	8000	-0.156222	8000	0.301635	8000	0.026696
Mg	12000	-0.001545	12000	0.001964	12000	0.000174
Al	13000	-0.006399	13000	0.007326	13000	0.000648
Si	14000	-0.014784	14000	0.016261	14000	0.001439
K	19000	-0.000883	19000	0.000698	19000	0.000062
Ca	20000	-0.057590	20000	0.044390	20000	0.003929
V	23000	-0.000883	23000	0.000535	23000	0.000047
Fe	26000	-0.754854	26000	0.417563	26000	0.036956
Comments and References						
Density = 4.54 g/cm3, and weight fractions calculated from partial densities (g/cm3) for each element, from Table 8.8 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996. Data in this table is from ANSI/ANS-6.4-1985.						

97. Concrete, Luminite-Portland-colemanite-baryte

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.1 Total Atom Weight (atoms/b-cm) = 8.300E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Weight fractions are adjusted so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.011123	1001	0.248244	1001	0.020604
H2	1002	-0.000003	1002	0.000029	1002	0.000002
B10	5010	-0.001901	5010	0.004270	5010	0.000354
B11	5011	-0.008413	5011	0.017188	5011	0.001427
O16	8016	-0.373009	8016	0.524538	8016	0.043536
O17	8017	-0.000151	8017	0.000200	8017	0.000017
O18	8018	-0.000863	8018	0.001078	8018	0.000089
Na23	11023	-0.001113	11023	0.001089	11023	0.000090
Mg	12000	-0.002023	12000	0.001872	12000	0.000155
Al27	13027	-0.013351	13027	0.011130	13027	0.000924
Si	14000	-0.015070	14000	0.012069	14000	0.001002

S	16000	-0.090724	16000	0.063635	16000	0.005282
Ca	20000	-0.077576	20000	0.043537	20000	0.003614
Ti	22000	-0.000718	22000	0.000337	22000	0.000028
Mn55	25055	-0.000405	25055	0.000166	25055	0.000014
Fe	26000	-0.018914	26000	0.007618	26000	0.000632
Ba130	56130	-0.000386	56130	0.000067	56130	0.000006
Ba132	56132	-0.000373	56132	0.000064	56132	0.000005
Ba134	56134	-0.009065	56134	0.001523	56134	0.000126
Ba135	56135	-0.024909	56135	0.004153	56135	0.000345
Ba136	56136	-0.029897	56136	0.004948	56136	0.000411
Ba137	56137	-0.043071	56137	0.007076	56137	0.000587
Ba138	56138	-0.276942	56138	0.045170	56138	0.003749
Elemental						
H	1000	-0.011126	1000	0.248273	1000	0.020606
B	5000	-0.010316	5000	0.021458	5000	0.001781
O	8000	-0.374022	8000	0.525816	8000	0.043642
Na	11000	-0.001113	11000	0.001089	11000	0.000090
Mg	12000	-0.002023	12000	0.001872	12000	0.000155
Al	13000	-0.013351	13000	0.011130	13000	0.000924
Si	14000	-0.015070	14000	0.012069	14000	0.001002
S	16000	-0.090724	16000	0.063635	16000	0.005282
Ca	20000	-0.077576	20000	0.043537	20000	0.003614
Ti	22000	-0.000718	22000	0.000337	22000	0.000028
Mn	25000	-0.000405	25000	0.000166	25000	0.000014
Fe	26000	-0.018914	26000	0.007618	26000	0.000632
Ba	56000	-0.384642	56000	0.063000	56000	0.005229
Comments and References						
Density and weight fractions from Tables 51.84 and 51.95 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960.						

98. Concrete, Luminite-colemanite-baryte

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.1 Total Atom Weight (atoms/b-cm) = 8.194E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Weight fractions are adjusted so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.010954	1001	0.247645	1001	0.020291
H2	1002	-0.000003	1002	0.000028	1002	0.000002
B10	5010	-0.001630	5010	0.003709	5010	0.000304
B11	5011	-0.007214	5011	0.014930	5011	0.001223
O16	8016	-0.370425	8016	0.527662	8016	0.043235
O17	8017	-0.000150	8017	0.000201	8017	0.000016

O18	8018	-0.000857	8018	0.001084	8018	0.000089
Na23	11023	-0.001106	11023	0.001096	11023	0.000090
Mg	12000	-0.001407	12000	0.001319	12000	0.000108
Al27	13027	-0.017692	13027	0.014940	13027	0.001224
Si	14000	-0.009650	14000	0.007829	14000	0.000641
S	16000	-0.091074	16000	0.064710	16000	0.005302
Ca	20000	-0.055086	20000	0.031317	20000	0.002566
Ti	22000	-0.012766	22000	0.006077	22000	0.000498
Mn55	25055	-0.001206	25055	0.000500	25055	0.000041
Fe	26000	-0.030860	26000	0.012591	26000	0.001032
Ba130	56130	-0.000389	56130	0.000068	56130	0.000006
Ba132	56132	-0.000376	56132	0.000065	56132	0.000005
Ba134	56134	-0.009142	56134	0.001556	56134	0.000127
Ba135	56135	-0.025121	56135	0.004243	56135	0.000348
Ba136	56136	-0.030151	56136	0.005055	56136	0.000414
Ba137	56137	-0.043437	56137	0.007229	56137	0.000592
Ba138	56138	-0.279300	56138	0.046145	56138	0.003781
Elemental						
H	1000	-0.010957	1000	0.247673	1000	0.020293
B	5000	-0.008846	5000	0.018639	5000	0.001527
O	8000	-0.371432	8000	0.528948	8000	0.043340
Na	11000	-0.001106	11000	0.001096	11000	0.000090
Mg	12000	-0.001407	12000	0.001319	12000	0.000108
Al	13000	-0.017692	13000	0.014940	13000	0.001224
Si	14000	-0.009650	14000	0.007829	14000	0.000641
S	16000	-0.091074	16000	0.064710	16000	0.005302
Ca	20000	-0.055086	20000	0.031317	20000	0.002566
Ti	22000	-0.012766	22000	0.006077	22000	0.000498
Mn	25000	-0.001206	25000	0.000500	25000	0.000041
Fe	26000	-0.030860	26000	0.012591	26000	0.001032
Ba	56000	-0.387918	56000	0.064361	56000	0.005273
Comments and References						
Density and weight fractions from Tables 51.84 and 51.95 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960.						

99. Concrete, M-1

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	4.5		Total Atom Weight (atoms/b-cm) = 8.790E-02			
The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.007998	1001	0.244653	1001	0.021506

H2	1002	-0.000002	1002	0.000028	1002	0.000002
B10	5010	-0.001658	5010	0.005106	5010	0.000449
B11	5011	-0.007340	5011	0.020553	5011	0.001807
O16	8016	-0.106710	8016	0.205676	8016	0.018080
O17	8017	-0.000043	8017	0.000078	8017	0.000007
O18	8018	-0.000247	8018	0.000423	8018	0.000037
Mg	12000	-0.043000	12000	0.054541	12000	0.004794
Cl35	17035	-0.015693	17035	0.013835	17035	0.001216
Cl37	17037	-0.005308	17037	0.004427	17037	0.000389
Mn55	25055	-0.003000	25055	0.001683	25055	0.000148
Ca	20000	-0.011000	20000	0.008462	20000	0.000744
Fe	26000	-0.798000	26000	0.440534	26000	0.038724
Elemental						
H	1000	-0.008000	1000	0.244682	1000	0.021508
B	5000	-0.009000	5000	0.025659	5000	0.002255
O	8000	-0.107000	8000	0.206177	8000	0.018124
Mg	12000	-0.043000	12000	0.054541	12000	0.004794
Cl	17000	-0.021000	17000	0.018262	17000	0.001605
Mn	25000	-0.003000	25000	0.001683	25000	0.000148
Ca	20000	-0.011000	20000	0.008462	20000	0.000744
Fe	26000	-0.798000	26000	0.440534	26000	0.038724

Comments and References

Density = 4.5 g/cm3 and weight fractions from Tables 51.93 and 51.95 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960.

100. Concrete, MO

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 5.5 Total Atom Weight (atoms/b-cm) = 8.760E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.004999	1001	0.187532	1001	0.016428
H2	1002	-0.000001	1002	0.000022	1002	0.000002
O16	8016	-0.059837	8016	0.141447	8016	0.012391
O17	8017	-0.000024	8017	0.000054	8017	0.000005
O18	8018	-0.000138	8018	0.000291	8018	0.000025
Mg	12000	-0.037000	12000	0.057557	12000	0.005042
Mn55	25055	-0.004000	25055	0.002753	25055	0.000241
Cl35	17035	-0.009715	17035	0.010504	17035	0.000920
Cl37	17037	-0.003286	17037	0.003361	17037	0.000294
Fe	26000	-0.881000	26000	0.596480	26000	0.052252
Elemental						

H	1000	-0.005000	1000	0.187553	1000	0.016430
O	8000	-0.060000	8000	0.141792	8000	0.012421
Mg	12000	-0.037000	12000	0.057557	12000	0.005042
Mn	25000	-0.004000	25000	0.002753	25000	0.000241
Cl	17000	-0.013000	17000	0.013865	17000	0.001215
Fe	26000	-0.881000	26000	0.596480	26000	0.052252
Comments and References						
Density = 5.2 to 5.8 g/cm3 and weight fractions from Tables 51.93 and 51.95 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960.						

101. Concrete, Magnetite

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.53 Total Atom Weight (atoms/b-cm) = 7.970E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. This concrete has magnetite (FeO-Fe2O3) as aggregate.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.003112	1001	0.082368	1001	0.006565
H2	1002	-0.000001	1002	0.000009	1002	0.000001
O16	8016	-0.329608	8016	0.549661	8016	0.043807
O17	8017	-0.000133	8017	0.000209	8017	0.000017
O18	8018	-0.000762	8018	0.001130	8018	0.000090
Mg	12000	-0.009338	12000	0.010248	12000	0.000817
Al27	13027	-0.023486	13027	0.023218	13027	0.001850
Si	14000	-0.025750	14000	0.024456	14000	0.001949
S	16000	-0.001415	16000	0.001177	16000	0.000094
Ca	20000	-0.071024	20000	0.047269	20000	0.003767
Ti	22000	-0.054329	22000	0.030274	22000	0.002413
V	23000	-0.003113	23000	0.001630	23000	0.000130
Cr	24000	-0.001698	24000	0.000871	24000	0.000069
Mn55	25055	-0.001981	25055	0.000962	25055	0.000077
Fe	26000	-0.474250	26000	0.226518	26000	0.018053
Elemental						
H	1000	-0.003113	1000	0.082377	1000	0.006565
O	8000	-0.330504	8000	0.551000	8000	0.043914
Mg	12000	-0.009338	12000	0.010248	12000	0.000817
Al	13000	-0.023486	13000	0.023218	13000	0.001850
Si	14000	-0.025750	14000	0.024456	14000	0.001949
S	16000	-0.001415	16000	0.001177	16000	0.000094
Ca	20000	-0.071024	20000	0.047269	20000	0.003767
Ti	22000	-0.054329	22000	0.030274	22000	0.002413
V	23000	-0.003113	23000	0.001630	23000	0.000130
Cr	24000	-0.001698	24000	0.000871	24000	0.000069

Mn	25000	-0.001981	25000	0.000962	25000	0.000077
Fe	26000	-0.474250	26000	0.226518	26000	0.018053
Comments and References						
Density = 3.53 g/cm3, and weight fractions calculated from partial densities (g/cm3) for each element, from Table 8.8 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996.Data in this table is from ANSI/ANS-6.4-1985. Density = 3.45 g/cm3 and a similar composition in Table 8.3 of Reactor Shielding for Nuclear Engineers by N.M. Schaeffer, TID-25951, U.S. Atomic Energy Commission Office of Information Services, 1973.Density = 3.41 g/cm3 for wet concrete (Table 9.1.12-40 of Engineering Compendium on Radiation Shielding edited by R.G. Jaeger, et al, Vol.2, Shielding Materials, Springer-Verlag, 1975).						

102. Concrete, Magnetite and steel

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	4.64		Total Atom Weight (atoms/b-cm) = 7.646E-02			
The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. This concrete has magnetite (FeO-Fe2O3) and steel as aggregate.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.002373	1001	0.086064	1001	0.006580
H2	1002	-0.000001	1002	0.000010	1002	0.000001
O16	8016	-0.137305	8016	0.313722	8016	0.023987
O17	8017	-0.000056	8017	0.000120	8017	0.000009
O18	8018	-0.000318	8018	0.000645	8018	0.000049
Mg	12000	-0.003669	12000	0.005517	12000	0.000422
Al27	13027	-0.010358	13027	0.014030	13027	0.001073
Si	14000	-0.015753	14000	0.020499	14000	0.001567
Ca	20000	-0.055675	20000	0.050769	20000	0.003882
Ti	22000	-0.015969	22000	0.012192	22000	0.000932
V	23000	-0.000647	23000	0.000464	23000	0.000035
Fe	26000	-0.757877	26000	0.495969	26000	0.037921
Elemental						
H	1000	-0.002374	1000	0.086074	1000	0.006581
O	8000	-0.137678	8000	0.314486	8000	0.024045
Mg	12000	-0.003669	12000	0.005517	12000	0.000422
Al	13000	-0.010358	13000	0.014030	13000	0.001073
Si	14000	-0.015753	14000	0.020499	14000	0.001567
Ca	20000	-0.055675	20000	0.050769	20000	0.003882
Ti	22000	-0.015969	22000	0.012192	22000	0.000932
V	23000	-0.000647	23000	0.000464	23000	0.000035
Fe	26000	-0.757877	26000	0.495969	26000	0.037921
Comments and References						

Density = 4.63 g/cm3, and weight fractions calculated from partial densities (g/cm3) for each element, from Table 8.8 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996.Data in this table is from ANSI/ANS-6.4-1985.

103. Concrete, Magnuson's

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	2.147		Total Atom Weight (atoms/b-cm) = 7.127E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.003318	1001	0.059724	1001	0.004257
H2	1002	-0.000001	1002	0.000007	1002	0.000000
C	6000	-0.105320	6000	0.159072	6000	0.011338
O16	8016	-0.498074	8016	0.564883	8016	0.040262
O17	8017	-0.000202	8017	0.000215	8017	0.000015
O18	8018	-0.001152	8018	0.001161	8018	0.000083
Na23	11023	-0.001411	11023	0.001113	11023	0.000079
Mg	12000	-0.094200	12000	0.070306	12000	0.005011
Al27	13027	-0.007859	13027	0.005284	13027	0.000377
Si	14000	-0.042101	14000	0.027193	14000	0.001938
S	16000	-0.002483	16000	0.001405	16000	0.000100
Cl35	17035	-0.000391	17035	0.000203	17035	0.000014
Cl37	17037	-0.000132	17037	0.000065	17037	0.000005
K	19000	-0.009445	19000	0.004382	19000	0.000312
Ca	20000	-0.226317	20000	0.102437	20000	0.007301
Ti	22000	-0.001488	22000	0.000564	22000	0.000040
Mn55	25055	-0.000512	25055	0.000169	25055	0.000012
Fe	26000	-0.005595	26000	0.001817	26000	0.000130
Elemental						
H	1000	-0.003319	1000	0.059731	1000	0.004257
C	6000	-0.105320	6000	0.159072	6000	0.011338
O	8000	-0.499428	8000	0.566259	8000	0.040360
Na	11000	-0.001411	11000	0.001113	11000	0.000079
Mg	12000	-0.094200	12000	0.070306	12000	0.005011
Al	13000	-0.007859	13000	0.005284	13000	0.000377
Si	14000	-0.042101	14000	0.027193	14000	0.001938
S	16000	-0.002483	16000	0.001405	16000	0.000100
Cl	17000	-0.000523	17000	0.000268	17000	0.000019
K	19000	-0.009445	19000	0.004382	19000	0.000312
Ca	20000	-0.226317	20000	0.102437	20000	0.007301
Ti	22000	-0.001488	22000	0.000564	22000	0.000040
Mn	25000	-0.000512	25000	0.000169	25000	0.000012
Fe	26000	-0.005595	26000	0.001817	26000	0.000130
Comments and References						

B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.5 Alloys and mixtures.

104. Concrete, Oak Ridge (ORNL)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.2994 Total Atom Weight (atoms/b-cm) = 7.966E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.006185	1001	0.106675	1001	0.008498
H2	1002	-0.000001	1002	0.000012	1002	0.000001
C	6000	-0.175193	6000	0.253543	6000	0.020198
O16	8016	-0.409071	8016	0.444546	8016	0.035415
O17	8017	-0.000166	8017	0.000169	8017	0.000013
O18	8018	-0.000946	8018	0.000914	8018	0.000073
Na23	11023	-0.000271	11023	0.000205	11023	0.000016
Mg	12000	-0.032649	12000	0.023349	12000	0.001860
Al27	13027	-0.010830	13027	0.006977	13027	0.000556
Si	14000	-0.034479	14000	0.021339	14000	0.001700
K	19000	-0.001138	19000	0.000506	19000	0.000040
Ca	20000	-0.321286	20000	0.139343	20000	0.011101
Fe	26000	-0.007784	26000	0.002423	26000	0.000193
Elemental						
H	1000	-0.006187	1000	0.106687	1000	0.008499
C	6000	-0.175193	6000	0.253543	6000	0.020198
O	8000	-0.410183	8000	0.445629	8000	0.035501
Na	11000	-0.000271	11000	0.000205	11000	0.000016
Mg	12000	-0.032649	12000	0.023349	12000	0.001860
Al	13000	-0.010830	13000	0.006977	13000	0.000556
Si	14000	-0.034479	14000	0.021339	14000	0.001700
K	19000	-0.001138	19000	0.000506	19000	0.000040
Ca	20000	-0.321286	20000	0.139343	20000	0.011101
Fe	26000	-0.007784	26000	0.002423	26000	0.000193

Comments and References

B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.5 'Alloys and mixtures.'

105. Concrete, Ordinary (NBS 03)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.35 Total Atom Weight (atoms/b-cm) = 7.950E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.008483	1001	0.149840	1001	0.011912
H2	1002	-0.000002	1002	0.000017	1002	0.000001
C	6000	-0.050064	6000	0.074206	6000	0.005899
O16	8016	-0.472200	8016	0.525556	8016	0.041779
O17	8017	-0.000191	8017	0.000200	8017	0.000016
O18	8018	-0.001092	8018	0.001080	8018	0.000086
Mg	12000	-0.024183	12000	0.017713	12000	0.001408
Al27	13027	-0.036063	13027	0.023794	13027	0.001892
Si	14000	-0.145100	14000	0.091975	14000	0.007312
S	16000	-0.002970	16000	0.001649	16000	0.000131
K	19000	-0.001697	19000	0.000773	19000	0.000061
Ca	20000	-0.246924	20000	0.109681	20000	0.008719
Fe	26000	-0.011031	26000	0.003516	26000	0.000280
Elemental						
H	1000	-0.008485	1000	0.149857	1000	0.011913
C	6000	-0.050064	6000	0.074206	6000	0.005899
O	8000	-0.473483	8000	0.526836	8000	0.041881
Mg	12000	-0.024183	12000	0.017713	12000	0.001408
Al	13000	-0.036063	13000	0.023794	13000	0.001892
Si	14000	-0.145100	14000	0.091975	14000	0.007312
S	16000	-0.002970	16000	0.001649	16000	0.000131
K	19000	-0.001697	19000	0.000773	19000	0.000061
Ca	20000	-0.246924	20000	0.109681	20000	0.008719
Fe	26000	-0.011031	26000	0.003516	26000	0.000280

Comments and References

Density = 2.35 g/cm3, and weight fractions calculated from partial densities (g/cm3) listed for each element in Table 8.8 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996.Data from ANSI/ANS-6.4-1985.

106. Concrete, Ordinary (NBS 04)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.35 Total Atom Weight (atoms/b-cm) = 7.533E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.005557	1001	0.103572	1001	0.007803
H2	1002	-0.000001	1002	0.000012	1002	0.000001
O16	8016	-0.496727	8016	0.583387	8016	0.043950
O17	8017	-0.000201	8017	0.000222	8017	0.000017
O18	8018	-0.001149	8018	0.001199	8018	0.000090
Na23	11023	-0.017101	11023	0.013974	11023	0.001053
Mg	12000	-0.002565	12000	0.001982	12000	0.000149
Al27	13027	-0.045746	13027	0.031850	13027	0.002399
Si	14000	-0.315092	14000	0.210759	14000	0.015878
S	16000	-0.001283	16000	0.000752	16000	0.000057
K	19000	-0.019239	19000	0.009244	19000	0.000696
Ca	20000	-0.082941	20000	0.038876	20000	0.002929
Fe	26000	-0.012398	26000	0.004171	26000	0.000314
Elemental						
H	1000	-0.005558	1000	0.103584	1000	0.007803
O	8000	-0.498076	8000	0.584808	8000	0.044057
Na	11000	-0.017101	11000	0.013974	11000	0.001053
Mg	12000	-0.002565	12000	0.001982	12000	0.000149
Al	13000	-0.045746	13000	0.031850	13000	0.002399
Si	14000	-0.315092	14000	0.210759	14000	0.015878
S	16000	-0.001283	16000	0.000752	16000	0.000057
K	19000	-0.019239	19000	0.009244	19000	0.000696
Ca	20000	-0.082941	20000	0.038876	20000	0.002929
Fe	26000	-0.012398	26000	0.004171	26000	0.000314
Comments and References						
Density = 2.35 g/cm3, and weight fractions calculated from partial densities (g/cm3) listed for each element in Table 8.8 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996. Data from ANSI/ANS-6.4-1985.						

107. Concrete, Ordinary (NIST)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.3 Total Atom Weight (atoms/b-cm) = 9.946E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.022094	1001	0.305287	1001	0.030365
H2	1002	-0.000005	1002	0.000035	1002	0.000003
C	6000	-0.002484	6000	0.002880	6000	0.000286
O16	8016	-0.573373	8016	0.499194	8016	0.049652
O17	8017	-0.000232	8017	0.000190	8017	0.000019

O18	8018	-0.001326	8018	0.001026	8018	0.000102
Na23	11023	-0.015208	11023	0.009212	11023	0.000916
Mg	12000	-0.001266	12000	0.000725	12000	0.000072
Al27	13027	-0.019953	13027	0.010298	13027	0.001024
Si	14000	-0.304627	14000	0.151046	14000	0.015024
K	19000	-0.010045	19000	0.003578	19000	0.000356
Ca	20000	-0.042951	20000	0.014924	20000	0.001484
Fe	26000	-0.006435	26000	0.001605	26000	0.000160
Elemental						
H	1000	-0.022100	1000	0.305322	1000	0.030368
C	6000	-0.002484	6000	0.002880	6000	0.000286
O	8000	-0.574931	8000	0.500410	8000	0.049773
Na	11000	-0.015208	11000	0.009212	11000	0.000916
Mg	12000	-0.001266	12000	0.000725	12000	0.000072
Al	13000	-0.019953	13000	0.010298	13000	0.001024
Si	14000	-0.304627	14000	0.151046	14000	0.015024
K	19000	-0.010045	19000	0.003578	19000	0.000356
Ca	20000	-0.042951	20000	0.014924	20000	0.001484
Fe	26000	-0.006435	26000	0.001605	26000	0.000160
Comments and References						
Density and weight fractions from http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html.						

108. Concrete, Portland

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.3 Total Atom Weight (atoms/b-cm) = 8.143E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.009997	1001	0.168734	1001	0.013740
H2	1002	-0.000002	1002	0.000019	1002	0.000002
C	6000	-0.001000	6000	0.001416	6000	0.000115
O16	8016	-0.527673	8016	0.561159	8016	0.045694
O17	8017	-0.000214	8017	0.000214	8017	0.000017
O18	8018	-0.001220	8018	0.001153	8018	0.000094
Na23	11023	-0.016000	11023	0.011838	11023	0.000964
Mg	12000	-0.002000	12000	0.001400	12000	0.000114
Al27	13027	-0.033872	13027	0.021354	13027	0.001739
Si	14000	-0.337021	14000	0.204119	14000	0.016621
K	19000	-0.013000	19000	0.005656	19000	0.000461
Ca	20000	-0.044000	20000	0.018674	20000	0.001521
Fe	26000	-0.014000	26000	0.004264	26000	0.000347

Elemental						
H	1000	-0.010000	1000	0.168753	1000	0.013741
C	6000	-0.001000	6000	0.001416	6000	0.000115
O	8000	-0.529107	8000	0.562526	8000	0.045806
Na	11000	-0.016000	11000	0.011838	11000	0.000964
Mg	12000	-0.002000	12000	0.001400	12000	0.000114
Al	13000	-0.033872	13000	0.021354	13000	0.001739
Si	14000	-0.337021	14000	0.204119	14000	0.016621
K	19000	-0.013000	19000	0.005656	19000	0.000461
Ca	20000	-0.044000	20000	0.018674	20000	0.001521
Fe	26000	-0.014000	26000	0.004264	26000	0.000347
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=144. Confirmed with weight fractions from Tables 51.95 and density from p.1081 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C.R. Tipton, 1960.						

109. Concrete, Regulatory Concrete (developed for U.S. NRC)

Formula =		Molecular Weight (g/mole) =			
Density (g/cm3) =	2.3	Total Atom Weight (atoms/b-cm) = 8.178E-02			
	Weight Fractions		Atom Fractions	Atom Densities	
Isotopic					
H1	1001	-0.009997	1001	0.168013	1001	0.013740
H2	1002	-0.000002	1002	0.000019	1002	0.000002
O16	8016	-0.530558	8016	0.561816	8016	0.045944
O17	8017	-0.000215	8017	0.000214	8017	0.000018
O18	8018	-0.001227	8018	0.001155	8018	0.000094
Na23	11023	-0.029000	11023	0.021365	11023	0.001747
Al27	13027	-0.034000	13027	0.021343	13027	0.001745
Si	14000	-0.337000	14000	0.203235	14000	0.016620
Ca	20000	-0.044000	20000	0.018595	20000	0.001521
Fe	26000	-0.014000	26000	0.004246	26000	0.000347
Elemental						
H	1000	-0.010000	1000	0.168032	1000	0.013741
O	8000	-0.532000	8000	0.563184	8000	0.046056
Na	11000	-0.029000	11000	0.021365	11000	0.001747
Al	13000	-0.034000	13000	0.021343	13000	0.001745
Si	14000	-0.337000	14000	0.203235	14000	0.016620
Ca	20000	-0.044000	20000	0.018595	20000	0.001521
Fe	26000	-0.014000	26000	0.004246	26000	0.000347
Comments and References						

B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.5 'Alloys and mixtures.'Same data listed on page 135 of LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.

110. Concrete, Rocky Flats

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.321 Total Atom Weight (atoms/b-cm) = 7.802E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.007498	1001	0.133282	1001	0.010399
H2	1002	-0.000002	1002	0.000015	1002	0.000001
C	6000	-0.055200	6000	0.082335	6000	0.006424
N14	7014	-0.000199	7014	0.000255	7014	0.000020
N15	7015	-0.000001	7015	0.000001	7015	0.000000
O16	8016	-0.483586	8016	0.541630	8016	0.042259
O17	8017	-0.000196	8017	0.000206	8017	0.000016
O18	8018	-0.001118	8018	0.001113	8018	0.000087
Na23	11023	-0.006300	11023	0.004909	11023	0.000383
Mg	12000	-0.012500	12000	0.009213	12000	0.000719
Al27	13027	-0.021700	13027	0.014408	13027	0.001124
Si	14000	-0.155000	14000	0.098871	14000	0.007714
S	16000	-0.001900	16000	0.001061	16000	0.000083
K	19000	-0.013700	19000	0.006277	19000	0.000490
Ca	20000	-0.230000	20000	0.102809	20000	0.008021
Ti	22000	-0.001000	22000	0.000374	22000	0.000029
Fe	26000	-0.010100	26000	0.003240	26000	0.000253
Elemental						
H	1000	-0.007500	1000	0.133297	1000	0.010400
C	6000	-0.055200	6000	0.082335	6000	0.006424
N	7000	-0.000200	7000	0.000256	7000	0.000020
O	8000	-0.484900	8000	0.542949	8000	0.042362
Na	11000	-0.006300	11000	0.004909	11000	0.000383
Mg	12000	-0.012500	12000	0.009213	12000	0.000719
Al	13000	-0.021700	13000	0.014408	13000	0.001124
Si	14000	-0.155000	14000	0.098871	14000	0.007714
S	16000	-0.001900	16000	0.001061	16000	0.000083
K	19000	-0.013700	19000	0.006277	19000	0.000490
Ca	20000	-0.230000	20000	0.102809	20000	0.008021
Ti	22000	-0.001000	22000	0.000374	22000	0.000029
Fe	26000	-0.010100	26000	0.003240	26000	0.000253

Comments and References
B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.5 'Alloys and mixtures.'

111. Concrete, Serpentine

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.1 Total Atom Weight (atoms/b-cm) = 8.108E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. This concrete has serpentine (3MgO-2SiO2-2H2O) as aggregate.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.015905	1001	0.246166	1001	0.019959
H2	1002	-0.000004	1002	0.000028	1002	0.000002
C	6000	-0.000909	6000	0.001181	6000	0.000096
O16	8016	-0.510432	8016	0.497763	8016	0.040358
O17	8017	-0.000207	8017	0.000190	8017	0.000015
O18	8018	-0.001180	8018	0.001023	8018	0.000083
Na23	11023	-0.004092	11023	0.002776	11023	0.000225
Mg	12000	-0.135003	12000	0.086638	12000	0.007024
Al27	13027	-0.019090	13027	0.011036	13027	0.000895
Si	14000	-0.209087	14000	0.116124	14000	0.009415
K	19000	-0.004091	19000	0.001632	19000	0.000132
Ca	20000	-0.068182	20000	0.026536	20000	0.002151
Cr	24000	-0.000910	24000	0.000273	24000	0.000022
Fe	26000	-0.030908	26000	0.008633	26000	0.000700
Elemental						
H	1000	-0.015910	1000	0.246195	1000	0.019961
C	6000	-0.000909	6000	0.001181	6000	0.000096
O	8000	-0.511818	8000	0.498976	8000	0.040456
Na	11000	-0.004092	11000	0.002776	11000	0.000225
Mg	12000	-0.135003	12000	0.086638	12000	0.007024
Al	13000	-0.019090	13000	0.011036	13000	0.000895
Si	14000	-0.209087	14000	0.116124	14000	0.009415
K	19000	-0.004091	19000	0.001632	19000	0.000132
Ca	20000	-0.068182	20000	0.026536	20000	0.002151
Cr	24000	-0.000910	24000	0.000273	24000	0.000022
Fe	26000	-0.030908	26000	0.008633	26000	0.000700

Comments and References
Density = 2.1 g/cm3, and weight fractions calculated from partial densities (g/cm3) for each element, from Table 8.8 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996.Data is from ANSI/ANS-6.4-1985.Density = 2.13 g/cm3 and a similar

composition in Tables 9.1.12-33 and 34 of Engineering Compendium on Radiation Shielding edited by R.G. Jaeger, et al, Vol.2, Shielding Materials, Springer-Verlag, 1975.

112. Copper

Formula = Cu Molecular Weight (g/mole) = 63.546000
Density (g/cm3) = 8.96 Total Atom Weight (atoms/b-cm) = 8.491E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cu	29000	-1.000000	29000	1.000000	29000	0.084912
Elemental						
Cu	29000	-1.000000	29000	1.000000	29000	0.084912
Comments and References						
Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=029.						

113. Diatomaceous Earth

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.2563 Total Atom Weight (atoms/b-cm) = 9.063E-03

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. Diatomaceous earth is a naturally occurring soft sedimentary rock composed of fossilized remains of diatoms, a type of hard-shelled algae, and is usually a major component of cat litter.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.008954	1001	0.151290	1001	0.001371
H2	1002	-0.000002	1002	0.000017	1002	0.000000
O16	8016	-0.545098	8016	0.580349	8016	0.005260
O17	8017	-0.000221	8017	0.000221	8017	0.000002
O18	8018	-0.001261	8018	0.001193	8018	0.000011
Na23	11023	-0.009896	11023	0.007330	11023	0.000066
Mg	12000	-0.002774	12000	0.001944	12000	0.000018
Al27	13027	-0.015581	13027	0.009834	13027	0.000089
Si	14000	-0.394761	14000	0.239362	14000	0.002169
K	19000	-0.011074	19000	0.004823	19000	0.000044
Ca	20000	-0.003945	20000	0.001676	20000	0.000015
Fe	26000	-0.006434	26000	0.001962	26000	0.000018
Elemental						
H	1000	-0.008956	1000	0.151307	1000	0.001371

O	8000	-0.546579	8000	0.581762	8000	0.005273
Na	11000	-0.009896	11000	0.007330	11000	0.000066
Mg	12000	-0.002774	12000	0.001944	12000	0.000018
Al	13000	-0.015581	13000	0.009834	13000	0.000089
Si	14000	-0.394761	14000	0.239362	14000	0.002169
K	19000	-0.011074	19000	0.004823	19000	0.000044
Ca	20000	-0.003945	20000	0.001676	20000	0.000015
Fe	26000	-0.006434	26000	0.001962	26000	0.000018

Comments and References

Average bulk density of 16lb/cu ft or 0.2563 g/cm3 listed for diatomaceous earth at https://www.flexicon.com/Materials-Handled/Diatomaceous-Earth.html. Higher bulk densities from 22 - 24 lb/cu ft are listed at https://www.grainger.com/ec/pdf/40CH71_2.pdf. Dry density of 1.98-2.5g/cm3 at https://www.sciencedirect.com/topics/engineering/diatomaceous-earth. Water content is typically 3 to 13 wt% based on http://www.mineengineer.com/mining/mineral/diatomaceous-earth.htm. Based on this, the water content was assumed to be 8 wt%.The dry weight fractions are based on http://www.matweb.com/search/DataSheet.aspx?MatGUID=3f468dd193804209b8f28e6bdfdbb379&ckck=1.

114. Diesel Fuel

Formula = C12H23 Molecular Weight (g/mole) = 167.310625
Density (g/cm3) = 0.849 Total Atom Weight (atoms/b-cm) = 1.070E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.138529	1001	0.657067	1001	0.070277
H2	1002	-0.000032	1002	0.000076	1002	0.000008
C	6000	-0.861435	6000	0.342857	6000	0.036670
Elemental						
H	1000	-0.138565	1000	0.657143	1000	0.070285
C	6000	-0.861435	6000	0.342857	6000	0.036670

Comments and References

Wikipedia says 'The average chemical formula for common diesel fuel is C12H23, ranging from approx. C10H20 to C15H28.' and says the density is 0.85 kg/L.InChem.org lists a density range of 0.87-0.95 g/cm3. EngineeringToolBox.com lists densities of USA classes 1D, 2D and 4D diesel fuels as 875, 849 and 959 kg/m3.

115. Earth, Typical Western U.S.

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.52 Total Atom Weight (atoms/b-cm) = 6.831E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not

addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.023828	1001	0.316807	1001	0.021642
H2	1002	-0.000005	1002	0.000036	1002	0.000002
O16	8016	-0.597276	8016	0.500368	8016	0.034181
O17	8017	-0.000242	8017	0.000191	8017	0.000013
O18	8018	-0.001381	8018	0.001028	8018	0.000070
Al27	13027	-0.080446	13027	0.039952	13027	0.002729
Si	14000	-0.296821	14000	0.141618	14000	0.009674
Elemental						
H	1000	-0.023834	1000	0.316843	1000	0.021644
O	8000	-0.598899	8000	0.501587	8000	0.034264
Al	13000	-0.080446	13000	0.039952	13000	0.002729
Si	14000	-0.296821	14000	0.141618	14000	0.009674

Comments and References

Composition (63.5% SiO2, 15.2% Al2O3, and 21.3% H2O) and density from p.135 of LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.

116. Earth, U.S. Average

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.52 Total Atom Weight (atoms/b-cm) = 4.383E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Average of 28 soils (dried) from throughout the U.S.Weight fractions are normalized so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.512323	8016	0.668974	8016	0.029320
O17	8017	-0.000207	8017	0.000255	8017	0.000011
O18	8018	-0.001185	8018	0.001375	8018	0.000060
Na23	11023	-0.006140	11023	0.005578	11023	0.000244
Mg	12000	-0.013304	12000	0.011432	12000	0.000501
Al27	13027	-0.068564	13027	0.053073	13027	0.002326
Si	14000	-0.271180	14000	0.201665	14000	0.008838
K	19000	-0.014327	19000	0.007653	19000	0.000335
Ca	20000	-0.051166	20000	0.026664	20000	0.001169
Ti	22000	-0.004604	22000	0.002009	22000	0.000088
Mn55	25055	-0.000715	25055	0.000272	25055	0.000012
Fe	26000	-0.056285	26000	0.021050	26000	0.000923
Elemental						
O	8000	-0.513715	8000	0.670604	8000	0.029391
Na	11000	-0.006140	11000	0.005578	11000	0.000244

Mg	12000	-0.013304	12000	0.011432	12000	0.000501
Al	13000	-0.068564	13000	0.053073	13000	0.002326
Si	14000	-0.271180	14000	0.201665	14000	0.008838
K	19000	-0.014327	19000	0.007653	19000	0.000335
Ca	20000	-0.051166	20000	0.026664	20000	0.001169
Ti	22000	-0.004604	22000	0.002009	22000	0.000088
Mn	25000	-0.000715	25000	0.000272	25000	0.000012
Fe	26000	-0.056285	26000	0.021050	26000	0.000923
Comments and References						
Weight fractions based on Table 11.7 of Principles of Radiation Shielding by A.B. Chilton, J.K. Shultis, and R.E. Faw, Prentise-Hall, 1984. Density same as for typical western U.S. earth adjusted to 5.5 to match correction in the MCNP Primer (LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009).						

117. Ethane

Formula = C2H6 Molecular Weight (g/mole) = 30.069050
Density (g/cm3) = 0.001253 Total Atom Weight (atoms/b-cm) = 2.010E-04

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.201079	1001	0.749914	1001	0.000151
H2	1002	-0.000046	1002	0.000086	1002	0.000000
C	6000	-0.798868	6000	0.250000	6000	0.000050
Elemental						
H	1000	-0.201132	1000	0.750000	1000	0.000151
C	6000	-0.798868	6000	0.250000	6000	0.000050
Comments and References						
Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=152.						

118. Ethyl Acetate

Formula = C4H8O2 Molecular Weight (g/mole) = 88.105000
Density (g/cm3) = 0.901 Total Atom Weight (atoms/b-cm) = 8.622E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.091501	1001	0.571363	1001	0.049262

H2	1002	-0.000021	1002	0.000066	1002	0.000006
C	6000	-0.545286	6000	0.285714	6000	0.024634
O16	8016	-0.362205	8016	0.142510	8016	0.012287
O17	8017	-0.000147	8017	0.000054	8017	0.000005
O18	8018	-0.000838	8018	0.000293	8018	0.000025
Elemental						
H	1000	-0.091525	1000	0.571429	1000	0.049268
C	6000	-0.545286	6000	0.285714	6000	0.024634
O	8000	-0.363189	8000	0.142857	8000	0.012317

Comments and References

Formula and density = 0.901 g/cm3 at 20C from http://www.matweb.com/search/DataSheet.aspx?MatGUID=c634566b56e04467bbfc09ffd3434ebb&ckck=1.

119. Ethyl Alcohol

Formula = C2H6O Molecular Weight (g/mole) = 46.068450
Density (g/cm3) = 0.7893 Total Atom Weight (atoms/b-cm) = 9.286E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. Formula and data from NIH PubChem https://pubchem.ncbi.nlm.nih.gov/compound/702The data below is calcualted from the input formula Also called Ethanol (http://en.wikipedia.org/wiki/Ethanol).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.131245	1001	0.666590	1001	0.061900
H2	1002	-0.000030	1002	0.000077	1002	0.000007
C	6000	-0.521424	6000	0.222222	6000	0.020636
O16	8016	-0.346355	8016	0.110841	8016	0.010293
O17	8017	-0.000140	8017	0.000042	8017	0.000004
O18	8018	-0.000801	8018	0.000228	8018	0.000021
Elemental						
H	1000	-0.131280	1000	0.666667	1000	0.061907
C	6000	-0.521424	6000	0.222222	6000	0.020636
O	8000	-0.347296	8000	0.111111	8000	0.010318

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=153. Formula from p.3-232 of CRC Handbook of Chemistry and Physics, 89th ed (http://www.hbcpnetbase.com/). Table 51.120 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960).

120. Ethylene

Formula = C2H4 Molecular Weight (g/mole) = 28.053100
Density (g/cm3) = 0.001174 Total Atom Weight (atoms/b-cm) = 1.510E-04

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.143686	1001	0.666590	1001	0.000101
H2	1002	-0.000033	1002	0.000077	1002	0.000000
C	6000	-0.856276	6000	0.333333	6000	0.000050
Elemental						
H	1000	-0.143724	1000	0.666667	1000	0.000101
C	6000	-0.856276	6000	0.333333	6000	0.000050

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=155. Formula and density (0.5678 g/cm3) in CRC Handbook of Chemistry and Physics, 89th edition, page 3-244.

121. Ethylene Glycol

Formula = C2H6O2 Molecular Weight (g/mole) = 62.067850
Density (g/cm3) = 1.114 Total Atom Weight (atoms/b-cm) = 1.081E-01

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.097414	1001	0.599931	1001	0.064844
H2	1002	-0.000022	1002	0.000069	1002	0.000007
C	6000	-0.387015	6000	0.200000	6000	0.021617
O16	8016	-0.514150	8016	0.199514	8016	0.021565
O17	8017	-0.000208	8017	0.000076	8017	0.000008
O18	8018	-0.001189	8018	0.000410	8018	0.000044
Elemental						
H	1000	-0.097439	1000	0.600000	1000	0.064852
C	6000	-0.387015	6000	0.200000	6000	0.021617
O	8000	-0.515546	8000	0.200000	8000	0.021617

Comments and References

Density = 1.114 g/cm3 at 20C and formula from http://www.matweb.com/search/DataSheet.aspx?MatGUID=5e94ad885e9f4c82a50146ae8cb34801. Also at NIH PubChem https://pubchem.ncbi.nlm.nih.gov/compound/174Table 51.120 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.

122. Explosive Compound, AN

Formula = N2H4O3 Molecular Weight (g/mole) = 80.043810
Density (g/cm3) = 1.72 Total Atom Weight (atoms/b-cm) = 1.165E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.050358	1001	0.444393	1001	0.051756
H2	1002	-0.000012	1002	0.000051	1002	0.000006
N14	7014	-0.348612	7014	0.221413	7014	0.025787
N15	7015	-0.001364	7015	0.000809	7015	0.000094
O16	8016	-0.598024	8016	0.332523	8016	0.038727
O17	8017	-0.000242	8017	0.000127	8017	0.000015
O18	8018	-0.001383	8018	0.000683	8018	0.000080
Elemental						
H	1000	-0.050371	1000	0.444444	1000	0.051762
N	7000	-0.349980	7000	0.222222	7000	0.025881
O	8000	-0.599649	8000	0.333333	8000	0.038822

Comments and References

AN = Ammonium Nitrate, Abbreviation and formula from p.12 of Modern Methods and Applications in Analysis of Explosives, Jehuda Yinon and Shmuel Zitrin, John Wiley & Sons, Inc., New York, 1993. Formula and density (1.72 g/cm3) from CRC Handbook of Chemistry and Physics, 89th edition, Page 4-47 http://en.wikipedia.org/wiki/Ammonium_nitrate. Also density = 1.72 g/cm3 at http://www.matweb.com/search/DataSheet.aspx?MatGUID=646f6adaf15e46d48ff2d9a3a8311da0.

123. Explosive Compound, EGDN

Formula = C2H4N2O6 Molecular Weight (g/mole) = 152.063210
Density (g/cm3) = 1.49 Total Atom Weight (atoms/b-cm) = 8.261E-02

Formula verified from Wikipedia reference. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.026508	1001	0.285681	1001	0.023601
H2	1002	-0.000006	1002	0.000033	1002	0.000003
C	6000	-0.157969	6000	0.142857	6000	0.011802
N14	7014	-0.183504	7014	0.142337	7014	0.011759
N15	7015	-0.000718	7015	0.000520	7015	0.000043

O16	8016	-0.629581	8016	0.427530	8016	0.035319
O17	8017	-0.000255	8017	0.000163	8017	0.000013
O18	8018	-0.001456	8018	0.000879	8018	0.000073
Elemental						
H	1000	-0.026515	1000	0.285714	1000	0.023603
C	6000	-0.157969	6000	0.142857	6000	0.011802
N	7000	-0.184224	7000	0.142857	7000	0.011802
O	8000	-0.631292	8000	0.428571	8000	0.035405
Comments and References						
Abbreviation and formula from p. 11 of Modern Methods and Applications in Analysis of Explosives, Jehuda Yinon and Shmuel Zitrin, John Wiley & Sons, New York, 1993. Formula and density from CRC Handbook of Chemistry and Physics, 89th edition, page 3-232. Also see http://en.wikipedia.org/wiki/EGDNhttps://pubs.acs.org/doi/pdf/10.1021/ie50203a027 for average density of 14.9						

124. Explosive Compound, HMX

Formula = C4H8N8O8 Molecular Weight (g/mole) = 296.156240
Density (g/cm3) = 1.91 Total Atom Weight (atoms/b-cm) = 1.087E-01

The density and formula were verified from wikepedia reference. Previous density used was 1.89 The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.027221	1001	0.285681	1001	0.031067
H2	1002	-0.000006	1002	0.000033	1002	0.000004
C	6000	-0.162220	6000	0.142857	6000	0.015535
N14	7014	-0.376885	7014	0.284674	7014	0.030958
N15	7015	-0.001475	7015	0.001040	7015	0.000113
O16	8016	-0.431017	8016	0.285020	8016	0.030995
O17	8017	-0.000174	8017	0.000109	8017	0.000012
O18	8018	-0.000997	8018	0.000586	8018	0.000064
Elemental						
H	1000	-0.027228	1000	0.285714	1000	0.031071
C	6000	-0.162220	6000	0.142857	6000	0.015535
N	7000	-0.378364	7000	0.285714	7000	0.031071
O	8000	-0.432188	8000	0.285714	8000	0.031071
Comments and References						
Abbreviation, names, and formula from p. 6 of Modern Methods and Applications in Analysis of Explosives Jehuda Yinon and Shmuel Zitrin, John Wiley & Sons, Inc., New York, 1993. Density = 1.89 g/cm3 from Table 7.1 of Explosive Effects and Applications by J. A. Zudas, et al, Springer, 2002.Also see http://en.wikipedia.org/wiki/HMX.						

125. Explosive Compound, NC

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.49 Total Atom Weight (atoms/b-cm) = 8.647E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The chemical formula is apparently uncertain due to the complexity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.029208	1001	0.300729	1001	0.026005
H2	1002	-0.000007	1002	0.000035	1002	0.000003
C	6000	-0.271296	6000	0.234387	6000	0.020268
N14	7014	-0.120802	7014	0.089517	7014	0.007741
N15	7015	-0.000473	7015	0.000327	7015	0.000028
O16	8016	-0.576645	8016	0.374094	8016	0.032349
O17	8017	-0.000233	8017	0.000143	8017	0.000012
O18	8018	-0.001333	8018	0.000769	8018	0.000066
Elemental						
H	1000	-0.029216	1000	0.300764	1000	0.026008
C	6000	-0.271296	6000	0.234387	6000	0.020268
N	7000	-0.121276	7000	0.089844	7000	0.007769
O	8000	-0.578212	8000	0.375006	8000	0.032428

Comments and References

Density = 1.49 g/cm3 and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=138. General reference: Modern Methods and Applications in Analysis of Explosives, Jehuda Yinon and Shmuel Zitrin, p. 13, John Wiley & Sons, Inc., New York, 1993.

126. Explosive Compound, NG

Formula = C3H5N3O9 Molecular Weight (g/mole) = 227.086840
Density (g/cm3) = 1.6 Total Atom Weight (atoms/b-cm) = 8.486E-02

The formula and density were verified from the wikepedia reference.The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.022188	1001	0.249971	1001	0.021213
H2	1002	-0.000005	1002	0.000029	1002	0.000002
C	6000	-0.158670	6000	0.150000	6000	0.012729
N14	7014	-0.184319	7014	0.149454	7014	0.012683
N15	7015	-0.000721	7015	0.000546	7015	0.000046
O16	8016	-0.632376	8016	0.448906	8016	0.038095
O17	8017	-0.000256	8017	0.000171	8017	0.000015
O18	8018	-0.001462	8018	0.000923	8018	0.000078

Elemental						
H	1000	-0.022194	1000	0.250000	1000	0.021215
C	6000	-0.158670	6000	0.150000	6000	0.012729
N	7000	-0.185042	7000	0.150000	7000	0.012729
O	8000	-0.634094	8000	0.450000	8000	0.038188
Comments and References						
Nitroglycerin, Trinitroglycerol, Glycerol Trinitrate, etc. from http://en.wikipedia.org/wiki/Nitroglycerin. Abbreviation and formula from p.8 of Modern Methods and Applications in Analysis of Explosives, Jehuda Yinon and Shmuel Zitrin, John Wiley & Sons, Inc., New York, 1993. Density = 1.6 g/cm3 from Knovel Critial Tables, 2nd edition, 2008.						

127. Explosive Compound, PETN

Formula = C5H8N4O12 Molecular Weight (g/mole) = 316.137020
Density (g/cm3) = 1.77 Total Atom Weight (atoms/b-cm) = 9.778E-02

The formula and density were verified form the Wikepedia reference. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.025501	1001	0.275830	1001	0.026970
H2	1002	-0.000006	1002	0.000032	1002	0.000003
C	6000	-0.189959	6000	0.172414	6000	0.016859
N14	7014	-0.176532	7014	0.137429	7014	0.013438
N15	7015	-0.000691	7015	0.000502	7015	0.000049
O16	8016	-0.605663	8016	0.412787	8016	0.040362
O17	8017	-0.000245	8017	0.000157	8017	0.000015
O18	8018	-0.001401	8018	0.000848	8018	0.000083
Elemental						
H	1000	-0.025507	1000	0.275862	1000	0.026974
C	6000	-0.189959	6000	0.172414	6000	0.016859
N	7000	-0.177225	7000	0.137931	7000	0.013487
O	8000	-0.607309	8000	0.413793	8000	0.040460
Comments and References						
https://en.wikipedia.org/wiki/Pentaerythritol_tetranitrate Abbreviation and formula from p. 9 - 10 of Modern Methods and Applications in Analysis of Explosives, Jehuda Yinon and Shmuel Zitrin, John Wiley, New York, 1993. Density = 1.773 g/cm3 from Knovel Critial Tables, 2nd edition, 2008. Density = 1.76 g/cm3 in Table 7.1 of Explosive Effects and Applications, J. A. Zudas, et al, Springer, 2002.						

128. Explosive Compound, RDX

Formula = C3H6N6O6 Molecular Weight (g/mole) = 222.117180
Density (g/cm3) = 1.858 Total Atom Weight (atoms/b-cm) = 1.058E-01

The density and formula are form the wikepedia reference. Density is changed to current reference, previous value was 1.82. The following data was calculated from the input formula.Chemical name: Cyclotrimethylenetrinitramine or 1,3,5-Tinitro-1,3,5-triazacyclohexane. Commonly known as cyclonite, hexogen, or T4 (http://en.wikipedia.org/wiki/RDX).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.027221	1001	0.285681	1001	0.030221
H2	1002	-0.000006	1002	0.000033	1002	0.000003
C	6000	-0.162220	6000	0.142857	6000	0.015112
N14	7014	-0.376885	7014	0.284674	7014	0.030115
N15	7015	-0.001475	7015	0.001040	7015	0.000110
O16	8016	-0.431017	8016	0.285020	8016	0.030152
O17	8017	-0.000174	8017	0.000109	8017	0.000011
O18	8018	-0.000997	8018	0.000586	8018	0.000062
Elemental						
H	1000	-0.027228	1000	0.285714	1000	0.030225
C	6000	-0.162220	6000	0.142857	6000	0.015112
N	7000	-0.378364	7000	0.285714	7000	0.030225
O	8000	-0.432188	8000	0.285714	8000	0.030225

Comments and References

Abbreviation and formula from p.5 of Modern Methods and Applications in Analysis of Explosives, Jehuda Yinon and Shmuel Zitrin, John Wiley & Sons, Inc., New York, 1993. Density = 1.82 g/cm3 from Yaws' Handbook of Physical Properties for Hydrocarbons and Chemicals, by C. L. Yaws, Knovel, 2008. Density = 1.77 g/cm3 in Table 7.1 of Explosive Effects and Applications, J. A. Zudas, et al, Springer, 2002.

129. Explosive Compound, TNT

Formula = C7H5N3O6 Molecular Weight (g/mole) = 227.131040
Density (g/cm3) = 1.654 Total Atom Weight (atoms/b-cm) = 9.209E-02

The formula and density verified from the wikepedia reference. Chemical name: 2,4,6-trinitrotoluene (http://en.wikipedia.org/wiki/Trinitrotoluene). The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.022183	1001	0.238068	1001	0.021925
H2	1002	-0.000005	1002	0.000027	1002	0.000003
C	6000	-0.370157	6000	0.333333	6000	0.030698

N14	7014	-0.184283	7014	0.142337	7014	0.013108
N15	7015	-0.000721	7015	0.000520	7015	0.000048
O16	8016	-0.421502	8016	0.285020	8016	0.026249
O17	8017	-0.000171	8017	0.000109	8017	0.000010
O18	8018	-0.000975	8018	0.000586	8018	0.000054
Elemental						
H	1000	-0.022189	1000	0.238095	1000	0.021927
C	6000	-0.370157	6000	0.333333	6000	0.030698
N	7000	-0.185006	7000	0.142857	7000	0.013156
O	8000	-0.422648	8000	0.285714	8000	0.026312

Comments and References

Name and formula from p.3 of Modern Methods and Applications in Analysis of Explosives, Jehuda Yinon and Shmuel Zitrin, John Wiley & Sons, Inc., New York, 1993. Density = 1.654 g/cm3 from Knovel Critial Tables, 2nd edition, 2008. Density = 1.63 g/cm3 in Table 7.1 of Explosive Effects and Applications, J. A. Zudas, et al, Springer, 2002.

130. Eye Lens (ICRP)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.1 Total Atom Weight (atoms/b-cm) = 1.055E-01

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.099243	1001	0.618248	1001	0.065232
H2	1002	-0.000023	1002	0.000071	1002	0.000008
C	6000	-0.193710	6000	0.101260	6000	0.010684
N14	7014	-0.053062	7014	0.023791	7014	0.002510
N15	7015	-0.000208	7015	0.000087	7015	0.000009
O16	8016	-0.651980	8016	0.255919	8016	0.027002
O17	8017	-0.000264	8017	0.000097	8017	0.000010
O18	8018	-0.001508	8018	0.000526	8018	0.000055
Elemental						
H	1000	-0.099269	1000	0.618320	1000	0.065239
C	6000	-0.193710	6000	0.101260	6000	0.010684
N	7000	-0.053270	7000	0.023878	7000	0.002519
O	8000	-0.653751	8000	0.256542	8000	0.027068

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=156. See also The International Commission on Radiological Protection, ICRP PUBLICATION 89, Basic Anatomical and Physiological Data for Use in Radiological Protection: Refence Values, J. Valentin, Editor, 2003 ICRP Published by Elsevier Science Ltd., which gives a density from 1.022 to 1.030.

131. Felt

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.185 Total Atom Weight (atoms/b-cm) = 1.272E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.044188	1001	0.383999	1001	0.004885
H2	1002	-0.000010	1002	0.000044	1002	0.000001
C	6000	-0.434600	6000	0.316908	6000	0.004031
N14	7014	-0.175810	7014	0.109958	7014	0.001399
N15	7015	-0.000688	7015	0.000402	7015	0.000005
O16	8016	-0.343766	8016	0.188230	8016	0.002394
O17	8017	-0.000139	8017	0.000072	8017	0.000001
O18	8018	-0.000795	8018	0.000387	8018	0.000005
Elemental						
H	1000	-0.044200	1000	0.384044	1000	0.004885
C	6000	-0.434600	6000	0.316908	6000	0.004031
N	7000	-0.176500	7000	0.110360	7000	0.001404
O	8000	-0.344700	8000	0.188689	8000	0.002400

Comments and References

Density and weight fractions from page II.F.1-3 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf).

132. Ferric Oxide

Formula = Fe2O3 Molecular Weight (g/mole) = 159.688200
Density (g/cm3) = 5.2 Total Atom Weight (atoms/b-cm) = 9.805E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Can also be called iron oxide (CRC Handbook of Chemistry and Physics, 89th edition, page 4-69).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.299760	8016	0.598542	8016	0.058688
O17	8017	-0.000121	8017	0.000228	8017	0.000022
O18	8018	-0.000693	8018	0.001230	8018	0.000121
Fe	26000	-0.699426	26000	0.400000	26000	0.039220
Elemental						
O	8000	-0.300574	8000	0.600000	8000	0.058831

Fe	26000	-0.699426	26000	0.400000	26000	0.039220
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=157. Formula from Table 51.11 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.						

133. Ferrous Sulfate Dosimeter Solution

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	1.024		Total Atom Weight (atoms/b-cm) = 1.003E-01			
The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. Assumes a mixture of H2O:FeSO4. Also called standard Fricke solution.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.108230	1001	0.659934	1001	0.066224
H2	1002	-0.000025	1002	0.000076	1002	0.000008
N14	7014	-0.000027	7014	0.000012	7014	0.000001
N15	7015	-0.000000	7015	0.000000	7015	0.000000
O16	8016	-0.876255	8016	0.336655	8016	0.033783
O17	8017	-0.000355	8017	0.000128	8017	0.000013
O18	8018	-0.002026	8018	0.000692	8018	0.000069
Na23	11023	-0.000022	11023	0.000006	11023	0.000001
S	16000	-0.012968	16000	0.002485	16000	0.000249
Cl35	17035	-0.000025	17035	0.000004	17035	0.000000
Cl37	17037	-0.000009	17037	0.000001	17037	0.000000
Fe	26000	-0.000054	26000	0.000006	26000	0.000001
Elemental						
H	1000	-0.108259	1000	0.660010	1000	0.066232
N	7000	-0.000027	7000	0.000012	7000	0.000001
O	8000	-0.878636	8000	0.337475	8000	0.033865
Na	11000	-0.000022	11000	0.000006	11000	0.000001
S	16000	-0.012968	16000	0.002485	16000	0.000249
Cl	17000	-0.000034	17000	0.000006	17000	0.000001
Fe	26000	-0.000054	26000	0.000006	26000	0.000001
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=160.						

134. Fertilizer (Muriate of Potash)

Formula =		Molecular Weight (g/mole) =	
Density (g/cm3) =	1.121	Total Atom Weight (atoms/b-cm) = 1.827E-02	

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. Also called Muriate of Potash. Combination of 'Evergro' and 'Agrium'.Weight fractions are adjusted so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.000050	1001	0.001833	1001	0.000033
H2	1002	-0.000000	1002	0.000000	1002	0.000000
O16	8016	-0.000716	8016	0.001654	8016	0.000030
O17	8017	-0.000000	8017	0.000001	8017	0.000000
O18	8018	-0.000002	8018	0.000003	8018	0.000000
Na23	11023	-0.008487	11023	0.013642	11023	0.000249
Mg	12000	-0.000206	12000	0.000313	12000	0.000006
S	16000	-0.000159	16000	0.000183	16000	0.000003
Cl35	17035	-0.357144	17035	0.377421	17035	0.006895
Cl37	17037	-0.120797	17037	0.120759	17037	0.002206
K	19000	-0.511852	19000	0.483783	19000	0.008838
Ca	20000	-0.000276	20000	0.000254	20000	0.000005
Br79	35079	-0.000165	35079	0.000077	35079	0.000001
Br81	35081	-0.000165	35081	0.000075	35081	0.000001
Elemental						
H	1000	-0.000050	1000	0.001833	1000	0.000033
O	8000	-0.000718	8000	0.001658	8000	0.000030
Na	11000	-0.008487	11000	0.013642	11000	0.000249
Mg	12000	-0.000206	12000	0.000313	12000	0.000006
S	16000	-0.000159	16000	0.000183	16000	0.000003
Cl	17000	-0.477922	17000	0.498180	17000	0.009101
K	19000	-0.511852	19000	0.483783	19000	0.008838
Ca	20000	-0.000276	20000	0.000254	20000	0.000005
Br	35000	-0.000330	35000	0.000153	35000	0.000003

Comments and References

Reference: Pallet Load of Potash as NORM by E.R. Siciliano (Feb. 2006), https://www.nutrien.com/sites/default/files/products/datasheet/POT_SS_FER_GRA285.pdf Density = 1.121 g/cm3 is for the average bulk tap density from this reference, was 1.27. The loose density is 1.09 to 1.153 g/cm3.

135. Fiberglass, Type C

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.54 Total Atom Weight (atoms/b-cm) = 7.502E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions	Atom Fractions	Atom Densities

Isotopic						
B10	5010	-0.003424	5010	0.006971	5010	0.000523
B11	5011	-0.015151	5011	0.028061	5011	0.002105
O16	8016	-0.477334	8016	0.608489	8016	0.045648
O17	8017	-0.000193	8017	0.000232	8017	0.000017
O18	8018	-0.001104	8018	0.001250	8018	0.000094
Na23	11023	-0.059171	11023	0.052479	11023	0.003937
Mg	12000	-0.018037	12000	0.015131	12000	0.001135
Al27	13027	-0.021107	13027	0.015950	13027	0.001197
Si	14000	-0.302924	14000	0.219923	14000	0.016498
S	16000	-0.000399	16000	0.000254	16000	0.000019
Ca	20000	-0.099757	20000	0.050751	20000	0.003807
Fe	26000	-0.001395	26000	0.000509	26000	0.000038
Elemental						
B	5000	-0.018579	5000	0.035032	5000	0.002628
O	8000	-0.478631	8000	0.609971	8000	0.045760
Na	11000	-0.059171	11000	0.052479	11000	0.003937
Mg	12000	-0.018037	12000	0.015131	12000	0.001135
Al	13000	-0.021107	13000	0.015950	13000	0.001197
Si	14000	-0.302924	14000	0.219923	14000	0.016498
S	16000	-0.000399	16000	0.000254	16000	0.000019
Ca	20000	-0.099757	20000	0.050751	20000	0.003807
Fe	26000	-0.001395	26000	0.000509	26000	0.000038

Comments and References

Composition from Fiberglass Compositions and Their Comparative Properties in Handbook of Reinforcement for Plastics, JV Milewski and HS Katz, 1987 available at https://www.scribd.com/document/362989801/glass-strength-and-properties-pdf Average density from http://www.matweb.com/search/datasheet.aspx?MatGUID=462fd1da8ad245b2ad40093889016448, https://www.build-on-prince.com/glass-fiber.html Density is 2.56 for the fiber only. In a composite material, the volume fractions for fiber and the polymer must also be taken into account. See Tables 12-26, Materials Data Book, by E.R. Parker, McGraw-Hill, 1967, for resins used to bond fiberglass.

136. Fiberglass, Type E

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.57 Total Atom Weight (atoms/b-cm) = 7.460E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.004202	5010	0.008706	5010	0.000649
B11	5011	-0.018596	5011	0.035043	5011	0.002614

O16	8016	-0.470671	8016	0.610482	8016	0.045543
O17	8017	-0.000191	8017	0.000233	8017	0.000017
O18	8018	-0.001088	8018	0.001255	8018	0.000094
F19	9019	-0.004895	9019	0.005345	9019	0.000399
Na23	11023	-0.007262	11023	0.006553	11023	0.000489
Mg	12000	-0.014759	12000	0.012598	12000	0.000940
Al27	13027	-0.072536	13027	0.055773	13027	0.004161
Si	14000	-0.247102	14000	0.182532	14000	0.013617
K	19000	-0.008127	19000	0.004312	19000	0.000322
Ca	20000	-0.143428	20000	0.074245	20000	0.005539
Ti	22000	-0.004400	22000	0.001907	22000	0.000142
Fe	26000	-0.002739	26000	0.001018	26000	0.000076
Elemental						
B	5000	-0.022803	5000	0.043748	5000	0.003264
O	8000	-0.471950	8000	0.611969	8000	0.045654
F	9000	-0.004895	9000	0.005345	9000	0.000399
Na	11000	-0.007262	11000	0.006553	11000	0.000489
Mg	12000	-0.014759	12000	0.012598	12000	0.000940
Al	13000	-0.072536	13000	0.055773	13000	0.004161
Si	14000	-0.247102	14000	0.182532	14000	0.013617
K	19000	-0.008127	19000	0.004312	19000	0.000322
Ca	20000	-0.143428	20000	0.074245	20000	0.005539
Ti	22000	-0.004400	22000	0.001907	22000	0.000142
Fe	26000	-0.002739	26000	0.001018	26000	0.000076

Comments and References

Composition from Fiberglass Compositions and Their Comparative Properties in Handbook of Reinforcement for Plastics, JV Milewski and HS Katz, 1987 available at https://www.scribd.com/document/362989801/glass-strength-and-properties-pdf Average density also from http://www.matweb.com/search/datasheet.aspx?MatGUID=d9c18047c49147a2a7c0b0bb1743e812 Also see https://www.build-on-prince.com/glass-fiber.html which gives density of 2.54. Density is for the fiber only. In a composite material, the volume fractions for fiber and the polymer must also be taken into account. See Tables 12-26, Materials Data Book, by E.R. Parker, McGraw-Hill, 1967, for resins used to bond fiberglass.

137. Fiberglass, Type R

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.52 Total Atom Weight (atoms/b-cm) = 7.346E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.485405	8016	0.626951	8016	0.046055

O17	8017	-0.000197	8017	0.000239	8017	0.000018
O18	8018	-0.001122	8018	0.001288	8018	0.000095
Mg	12000	-0.036183	12000	0.030755	12000	0.002259
Al27	13027	-0.132313	13027	0.101309	13027	0.007442
Si	14000	-0.280457	14000	0.206302	14000	0.015155
Ca	20000	-0.064322	20000	0.033156	20000	0.002436
Elemental						
O	8000	-0.486724	8000	0.628478	8000	0.046167
Mg	12000	-0.036183	12000	0.030755	12000	0.002259
Al	13000	-0.132313	13000	0.101309	13000	0.007442
Si	14000	-0.280457	14000	0.206302	14000	0.015155
Ca	20000	-0.064322	20000	0.033156	20000	0.002436
Comments and References						
Composition from Fiberglass Compositions and Their Comparative Properties in Handbook of Reinforcement for Plastics, JV Milewski and HS Katz, 1987 available at https://www.scribd.com/document/362989801/glass-strength-and-properties-pdf Density from https://www.build-on-prince.com/glass-fiber.html. Density is for the fiber only. In a composite material, the volume fractions for fiber and the polymer must also be taken into account. See Tables 12-26, Materials Data Book, by E.R. Parker, McGraw-Hill, 1967, for resins used to bond fiberglass.						

138. Freon-12

Formula = CF2Cl2 Molecular Weight (g/mole) = 120.910406 Density (g/cm3) = 1.12 Total Atom Weight (atoms/b-cm) = 2.789E-02						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.099335	6000	0.200000	6000	0.005578
F19	9019	-0.314256	9019	0.400000	9019	0.011157
Cl35	17035	-0.438215	17035	0.303040	17035	0.008452
Cl37	17037	-0.148218	17037	0.096960	17037	0.002704
Elemental						
C	6000	-0.099335	6000	0.200000	6000	0.005578
F	9000	-0.314256	9000	0.400000	9000	0.011157
Cl	17000	-0.586409	17000	0.400000	17000	0.011157
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=161. NIH PubChem pubchem.ncbi.nlm.nih.gov lists dichlorodifluoromethane with densities of 1.35 and 1.486 g/cm3 at 59°F and -29.8°C.						

139. Freon-12B2

Formula = CF2Br2 Molecular Weight (g/mole) = 209.815406
Density (g/cm3) = 1.8 Total Atom Weight (atoms/b-cm) = 2.583E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.057244	6000	0.200000	6000	0.005166
F19	9019	-0.181096	9019	0.400000	9019	0.010333
Br79	35079	-0.381323	35079	0.202760	35079	0.005238
Br81	35081	-0.380333	35081	0.197240	35081	0.005095
Elemental						
C	6000	-0.057244	6000	0.200000	6000	0.005166
F	9000	-0.181096	9000	0.400000	9000	0.010333
Br	35000	-0.761660	35000	0.400000	35000	0.010333

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=162. NIH PubChem lists pubchem.ncbi.nlm.nih.gov difluorodibromomethane with densities of 2.29 and 2.3063 g/cm3 at 59°F and 15°F.NIH PubChem lists pubchem.ncbi.nlm.nih.gov difluorodibromomethane lists a density for gas as 8.7 kg/m3.

140. Freon-13

Formula = CF3Cl Molecular Weight (g/mole) = 104.457309
Density (g/cm3) = 0.95 Total Atom Weight (atoms/b-cm) = 2.738E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.114981	6000	0.200000	6000	0.005477
F19	9019	-0.545632	9019	0.600000	9019	0.016431
Cl35	17035	-0.253619	17035	0.151520	17035	0.004149
Cl37	17037	-0.085782	17037	0.048480	17037	0.001328
Elemental						
C	6000	-0.114981	6000	0.200000	6000	0.005477
F	9000	-0.545632	9000	0.600000	9000	0.016431
Cl	17000	-0.339387	17000	0.200000	17000	0.005477

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=163. NIH PubChem pubchem.ncbi.nlm.nih.gov lists chlorotrifluoromethane with densities of 1.3 relative to water.

141. Freon-13B1

Formula = CF3Br		Molecular Weight (g/mole) = 148.909809			
Density (g/cm3) = 1.5		Total Atom Weight (atoms/b-cm) = 3.033E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.080657	6000	0.200000	6000	0.006066
F19	9019	-0.382750	9019	0.600000	9019	0.018199
Br79	35079	-0.268644	35079	0.101380	35079	0.003075
Br81	35081	-0.267946	35081	0.098620	35081	0.002991
Elemental						
C	6000	-0.080657	6000	0.200000	6000	0.006066
F	9000	-0.382750	9000	0.600000	9000	0.018199
Br	35000	-0.536593	35000	0.200000	35000	0.006066
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=164. NIH PubChem pubchem.ncbi.nlm.nih.gov lists bromotrifluoromethane with densities of 1.5 relative to water and 1.58 g/ml at 20°C.						

142. Freon-13I1

Formula = CF3I		Molecular Weight (g/mole) = 195.910279			
Density (g/cm3) = 1.8		Total Atom Weight (atoms/b-cm) = 2.766E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.061307	6000	0.200000	6000	0.005533
F19	9019	-0.290925	9019	0.600000	9019	0.016599
I127	53127	-0.647768	53127	0.200000	53127	0.005533
Elemental						
C	6000	-0.061307	6000	0.200000	6000	0.005533
F	9000	-0.290925	9000	0.600000	9000	0.016599
I	53000	-0.647768	53000	0.200000	53000	0.005533
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=165. NIH PubChem pubchem.ncbi.nlm.nih.gov calls this trifluoroiodomethane.						

143. GAGG(CE)

Formula = Gd3Al2Ga3O12		Molecular Weight (g/mole) = 926.874876
Density (g/cm3) = 6.63	Total Atom Weight (atoms/b-cm) = 8.615E-02	

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Gd	64000	-0.508969	64000	0.150000	64000	0.012923
Al27	13027	-0.058220	13027	0.100000	13027	0.008615
Ga	31000	-0.225671	31000	0.150000	31000	0.012923
O16	8016	-0.206579	8016	0.598542	8016	0.051567
O17	8017	-0.000084	8017	0.000228	8017	0.000020
O18	8018	-0.000478	8018	0.001230	8018	0.000106
Elemental						
Gd	64000	-0.508969	64000	0.150000	64000	0.012923
Al	13000	-0.058220	13000	0.100000	13000	0.008615
Ga	31000	-0.225671	31000	0.150000	31000	0.012923
O	8000	-0.207140	8000	0.600000	8000	0.051692
Comments and References						
Density from doi:10.3390/cryst9090480 and formula from https://www.x-zlab.com/product/gagg-scintillation-crystal//						

144. Gadolinium

Formula = Gd Molecular Weight (g/mole) = 157.250000
Density (g/cm3) = 7.9004 Total Atom Weight (atoms/b-cm) = 3.026E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Gd	64000	-1.000000	64000	1.000000	64000	0.030256
Elemental						
Gd	64000	-1.000000	64000	1.000000	64000	0.030256
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=064.						

145. Gadolinium Aluminum Galium Oxide - 0.5 atom% Cerium doped

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 6.6 Total Atom Weight (atoms/b-cm) = 8.490E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Gd	64000	-0.501351	64000	0.149250	64000	0.012672
Al27	13027	-0.057349	13027	0.099500	13027	0.008448
Ga	31000	-0.222294	31000	0.149250	31000	0.012672

O16	8016	-0.203487	8016	0.595549	8016	0.050565
O17	8017	-0.000082	8017	0.000227	8017	0.000019
O18	8018	-0.000471	8018	0.001224	8018	0.000104
Ce136	58136	-0.000027	58136	0.000009	58136	0.000001
Ce138	58138	-0.000037	58138	0.000013	58138	0.000001
Ce140	58140	-0.013217	58140	0.004423	58140	0.000375
Ce142	58142	-0.001685	58142	0.000556	58142	0.000047
Elemental						
Gd	64000	-0.501351	64000	0.149250	64000	0.012672
Al	13000	-0.057349	13000	0.099500	13000	0.008448
Ga	31000	-0.222294	31000	0.149250	31000	0.012672
O	8000	-0.204040	8000	0.597000	8000	0.050688
Ce	58000	-0.014966	58000	0.005000	58000	0.000425
Comments and References						
Formula is Gd3Al2Ga3O12(Ce) but the formula isn't used in the calculation due to the Ce dopant Material properties taken from https://www.epic-crystal.com/oxide-scintillators/gagg-ce-scintillator.html Dopant (aka Activator) added at 0.5 atom percent						

146. Gadolinium Oxysulfide

Formula = Gd2O2S Molecular Weight (g/mole) = 378.566300
Density (g/cm3) = 7.44 Total Atom Weight (atoms/b-cm) = 5.918E-02

NIH PubChem pubchem.ncbi.nlm.nih.gov calls the above formula 'digadolinium dioxide sulfide' and lists the formula for 'gadolinium oxysulfide' as Gd4O3S3.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.084297	8016	0.399028	8016	0.023613
O17	8017	-0.000034	8017	0.000152	8017	0.000009
O18	8018	-0.000195	8018	0.000820	8018	0.000049
S	16000	-0.084708	16000	0.200000	16000	0.011835
Gd	64000	-0.830766	64000	0.400000	64000	0.023671
Elemental						
O	8000	-0.084526	8000	0.400000	8000	0.023671
S	16000	-0.084708	16000	0.200000	16000	0.011835
Gd	64000	-0.830766	64000	0.400000	64000	0.023671
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=166. Formula from Table 1A of Ceramic Scintillators by C. Greskovich & S. Duclos, Annual Review of Material Science, 1997, 27:69-88.Acronyms from en.wikipedia.org/wiki/Gadolinium_oxysulfide.						

147. Gadolinium Silicate (GSO)

Formula = Gd2SiO5 Molecular Weight (g/mole) = 422.582000
Density (g/cm3) = 6.71 Total Atom Weight (atoms/b-cm) = 7.650E-02

NIH PubChem pubchem.ncbi.nlm.nih.gov calls the above 'gadolinium oxyorthosilicate' and lists the formula for 'gadolinium silicate ' as Gd2O9Si3. When Gd2SiO5 is used as a scintillator, there is usually doping of cerium in the 0.1-1.0% range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.188792	8016	0.623481	8016	0.047695
O17	8017	-0.000076	8017	0.000238	8017	0.000018
O18	8018	-0.000437	8018	0.001281	8018	0.000098
Si	14000	-0.066460	14000	0.125000	14000	0.009562
Gd	64000	-0.744235	64000	0.250000	64000	0.019125
Elemental						
O	8000	-0.189305	8000	0.625000	8000	0.047812
Si	14000	-0.066460	14000	0.125000	14000	0.009562
Gd	64000	-0.744235	64000	0.250000	64000	0.019125

Comments and References

Density = 6.71 g/cm3 for GSO from page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000. Formula from M. Tanaka, et al., Applications of Cerium-Doped Gadolinium Silicate Gd2SiO5:Ce Scintillator to Calorimeters in High Radiation Environment at citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.30.4620. MatWeb Material Property Data www.matweb.com has same chemical formula and density, 6.71 g/cc.

148. Gafchromic Sensor (GS)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.3 Total Atom Weight (atoms/b-cm) = 1.248E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.089676	1001	0.558012	1001	0.069661
H2	1002	-0.000021	1002	0.000064	1002	0.000008
C	6000	-0.605800	6000	0.316313	6000	0.039487
N14	7014	-0.111761	7014	0.050052	7014	0.006248
N15	7015	-0.000437	7015	0.000183	7015	0.000023
O16	8016	-0.191779	8016	0.075192	8016	0.009387
O17	8017	-0.000078	8017	0.000029	8017	0.000004
O18	8018	-0.000443	8018	0.000155	8018	0.000019
Elemental						
H	1000	-0.089700	1000	0.558077	1000	0.069669
C	6000	-0.605800	6000	0.316313	6000	0.039487

N	7000	-0.112200	7000	0.050235	7000	0.006271
O	8000	-0.192300	8000	0.075375	8000	0.009410
Comments and References						
physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html						

149. Gallium Arsenide

Formula = GaAs Molecular Weight (g/mole) = 144.644595
Density (g/cm3) = 5.31 Total Atom Weight (atoms/b-cm) = 4.422E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ga	31000	-0.482030	31000	0.500000	31000	0.022108
As75	33075	-0.517970	33075	0.500000	33075	0.022108
Elemental						
Ga	31000	-0.482030	31000	0.500000	31000	0.022108
As	33000	-0.517970	33000	0.500000	33000	0.022108
Comments and References						
Density from physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html MatWeb Material Property Data www.matweb.com has density of 5.316 g/cc.NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 5.31 and 5.3176 g/cm3 from different sources.						

150. Gasoline

Formula = C8H18 Molecular Weight (g/mole) = 114.228350
Density (g/cm3) = 0.721 Total Atom Weight (atoms/b-cm) = 9.883E-02

It is a mixture consisting almost exclusively of hydrocarbons(compounds with only C and H) in four series: paraffins (CnH2n+2), olefins (CnH2n), cycloparaffins (CnH2n), and aromatics (CnH2n-6). There are probably several hundred such compounds in any one gasoline. The paraffins in gasoline have 4 to 12 carbon atoms (Petroleum Products Handbook V. B. Guthrie, editor, 1960, McGraw-Hill)

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.158794	1001	0.692228	1001	0.068412
H2	1002	-0.000036	1002	0.000080	1002	0.000008
C	6000	-0.841164	6000	0.307692	6000	0.030409
Elemental						
H	1000	-0.158836	1000	0.692308	1000	0.068420
C	6000	-0.841164	6000	0.307692	6000	0.030409

Comments and References
Formula based on average of C8H18 per Table 51.101, Reactor Handbook 2nd ed, Vol.1, 1960. Density = 0.721 g/cm3 from Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers E. A. Avallone, editor, 1996. Density = 0.737 g/cm3 at www.simetric.co.uk/si_liquids.htm and www.engineeringtoolbox.com/liquids-densities-d_743.html. Density = 0.70 to 0.77 g/cm3 in Table 7.4 of Handbook of Petroleum Product Analysis by James G. Speight, 2002, John Wiley & Sons. Density = 0.70 to 0.74 in Table 51.102 of Reactor Handbook, 2nd edition, Vol. 1, Materials, C.R. Tipton, 1960.Weight fractions from Table 7.1.8 of Mark's Standard Handbook for Mechanical Engineers, Avallone 1996.

151. Germanium, High Purity

Formula = Ge Molecular Weight (g/mole) = 72.630000
Density (g/cm3) = 5.323 Total Atom Weight (atoms/b-cm) = 4.414E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ge70	32070	-0.198037	32070	0.205700	32070	0.009079
Ge72	32072	-0.271824	32072	0.274500	32072	0.012115
Ge73	32073	-0.077813	32073	0.077500	32073	0.003421
Ge74	32074	-0.371489	32074	0.365000	32074	0.016110
Ge76	32076	-0.080803	32076	0.077300	32076	0.003412
Elemental						
Ge	32000	-1.000000	32000	1.000000	32000	0.044136

Comments and References
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=032.

152. Glass Scintillator, Li Doped (GS1, GS2, GS3)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.66 Total Atom Weight (atoms/b-cm) = 8.231E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.001826	3006	0.005909	3006	0.000486
Li7	3007	-0.025938	3007	0.071949	3007	0.005922
O16	8016	-0.476645	8016	0.579956	8016	0.047736
O17	8017	-0.000193	8017	0.000221	8017	0.000018
O18	8018	-0.001102	8018	0.001192	8018	0.000098
Mg	12000	-0.144729	12000	0.115886	12000	0.009539
Al27	13027	-0.058217	13027	0.041992	13027	0.003456
Si	14000	-0.257089	14000	0.178152	14000	0.014664

Ce136	58136	-0.000061	58136	0.000009	58136	0.000001
Ce138	58138	-0.000084	58138	0.000012	58138	0.000001
Ce140	58140	-0.030161	58140	0.004196	58140	0.000345
Ce142	58142	-0.003844	58142	0.000527	58142	0.000043
Elemental						
Li	3000	-0.027874	3000	0.077858	3000	0.006408
O	8000	-0.477940	8000	0.581369	8000	0.047852
Mg	12000	-0.144729	12000	0.115886	12000	0.009539
Al	13000	-0.058217	13000	0.041992	13000	0.003456
Si	14000	-0.257089	14000	0.178152	14000	0.014664
Ce	58000	-0.034151	58000	0.004743	58000	0.000390
Comments and References						
Weight fractions derived from 'pe2bz.philpem.me.uk/Comm01/- - Ion-Photon-RF/- - Scintillation/Site-005/g_scint.htm' which lists the weight percents of the components at the time of melt as SiO2/MgO/Al2O3/Li2O/Ce2O3 55/24/11/6/4 with density of 2.66 g/mL. Density=2.6 on page 548 of Knoll for type NE902 = GS2.						

153. Glass Scintillator, Li Doped (GS10, GS20, GS30)

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	2.5		Total Atom Weight (atoms/b-cm) = 8.643E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.005479	3006	0.015868	3006	0.001371
Li7	3007	-0.077814	3007	0.193196	3007	0.016698
O16	8016	-0.499719	8016	0.544220	8016	0.047037
O17	8017	-0.000202	8017	0.000207	8017	0.000018
O18	8018	-0.001156	8018	0.001118	8018	0.000097
Mg	12000	-0.024121	12000	0.017287	12000	0.001494
Al27	13027	-0.095264	13027	0.061502	13027	0.005316
Si	14000	-0.261764	14000	0.162355	14000	0.014032
Ce136	58136	-0.000061	58136	0.000008	58136	0.000001
Ce138	58138	-0.000084	58138	0.000011	58138	0.000001
Ce140	58140	-0.030161	58140	0.003755	58140	0.000325
Ce142	58142	-0.003844	58142	0.000472	58142	0.000041
Elemental						
Li	3000	-0.083623	3000	0.209064	3000	0.018069
O	8000	-0.501077	8000	0.545546	8000	0.047151
Mg	12000	-0.024121	12000	0.017287	12000	0.001494
Al	13000	-0.095264	13000	0.061502	13000	0.005316
Si	14000	-0.261764	14000	0.162355	14000	0.014032
Ce	58000	-0.034151	58000	0.004246	58000	0.000367
Comments and References						

Weight fractions derived from 'pe2bz.philpem.me.uk/Comm01/- - Ion-Photon-RF/- - Scintillation/Site-005/g_scint.htm' which lists the weight percents of the components at the time of melt as SiO2/MgO/Al2O3/Li2O/Ce2O3 56/4/18/18/4 with density of 2.50 g/mL. Density=2.48 for type NE905 = GS20 on page 548 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000.

154. Glass Scintillator, Li Doped (GSF1, GSF2, and GSF3)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.42 Total Atom Weight (atoms/b-cm) = 7.860E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.003050	3006	0.009403	3006	0.000739
Li7	3007	-0.043316	3007	0.114481	3007	0.008998
O16	8016	-0.504444	8016	0.584798	8016	0.045962
O17	8017	-0.000204	8017	0.000223	8017	0.000018
O18	8018	-0.001167	8018	0.001202	8018	0.000094
Na23	11023	-0.017840	11023	0.014389	11023	0.001131
Al27	13027	-0.095455	13027	0.065600	13027	0.005156
Si	14000	-0.313809	14000	0.207188	14000	0.016284
Ce136	58136	-0.000037	58136	0.000005	58136	0.000000
Ce138	58138	-0.000051	58138	0.000007	58138	0.000001
Ce140	58140	-0.018132	58140	0.002403	58140	0.000189
Ce142	58142	-0.002311	58142	0.000302	58142	0.000024
Elemental						
Li	3000	-0.046550	3000	0.123884	3000	0.009737
O	8000	-0.505815	8000	0.586222	8000	0.046074
Na	11000	-0.017840	11000	0.014389	11000	0.001131
Al	13000	-0.095455	13000	0.065600	13000	0.005156
Si	14000	-0.313809	14000	0.207188	14000	0.016284
Ce	58000	-0.020531	58000	0.002717	58000	0.000214

Comments and References

Weight fractions derived from 'pe2bz.philpem.me.uk/Comm01/- - Ion-Photon-RF/- - Scintillation/Site-005/g_scint.htm' which lists the weight percents of the components at the time of melt as SiO2/Al2O3/Li2O/NaO2/Ce2O3 67/18/10/2.4/2.4 with density of 2.42 g/mL.

155. Glass Scintillator, Li Doped (KG1, KG2, KG3)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.42 Total Atom Weight (atoms/b-cm) = 8.560E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.006393	3006	0.018093	3006	0.001549
Li7	3007	-0.090783	3007	0.220283	3007	0.018857
O16	8016	-0.512458	8016	0.545435	8016	0.046692
O17	8017	-0.000207	8017	0.000208	8017	0.000018
O18	8018	-0.001185	8018	0.001121	8018	0.000096
Si	14000	-0.345902	14000	0.209674	14000	0.017949
Ce136	58136	-0.000077	58136	0.000010	58136	0.000001
Ce138	58138	-0.000105	58138	0.000013	58138	0.000001
Ce140	58140	-0.037701	58140	0.004588	58140	0.000393
Ce142	58142	-0.004805	58142	0.000576	58142	0.000049
Elemental						
Li	3000	-0.097560	3000	0.238376	3000	0.020406
O	8000	-0.513850	8000	0.546763	8000	0.046806
Si	14000	-0.345902	14000	0.209674	14000	0.017949
Ce	58000	-0.042688	58000	0.005187	58000	0.000444
Comments and References						
Weight fractions derived from 'pe2bz.philpem.me.uk/Comm01/- - Ion-Photon-RF/- - Scintillation/Site-005/g_scint.htm' which lists the weight percents of the components at the time of melt as SiO2/Li2O/Ce2O3 74/21/5 with density of 2.42 g/mL. Density=2.674 for type NE908 = KG2 on page 548 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000.						

156. Glass, Borosilicate (Pyrex Glass)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.23 Total Atom Weight (atoms/b-cm) = 7.064E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.007382	5010	0.014016	5010	0.000990
B11	5011	-0.032672	5011	0.056417	5011	0.003985
O16	8016	-0.538099	8016	0.639544	8016	0.045179
O17	8017	-0.000218	8017	0.000244	8017	0.000017
O18	8018	-0.001244	8018	0.001314	8018	0.000093
Na23	11023	-0.028191	11023	0.023311	11023	0.001647
Al27	13027	-0.011644	13027	0.008204	13027	0.000580
Si	14000	-0.377219	14000	0.255335	14000	0.018037
K	19000	-0.003321	19000	0.001615	19000	0.000114
Elemental						
B	5000	-0.040064	5000	0.070433	5000	0.004976
O	8000	-0.539561	8000	0.641102	8000	0.045289
Na	11000	-0.028191	11000	0.023311	11000	0.001647
Al	13000	-0.011644	13000	0.008204	13000	0.000580

Si	14000	-0.377219	14000	0.255335	14000	0.018037
K	19000	-0.003321	19000	0.001615	19000	0.000114
Comments and References						
Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=169.						

157. Glass, Foam

Formula =		Molecular Weight (g/mole) =				
Density (g/cm3) =	0.128	Total Atom Weight (atoms/b-cm) = 4.086E-03				
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.001000	1001	0.018715	1001	0.000076
H2	1002	-0.000000	1002	0.000002	1002	0.000000
B10	5010	-0.002764	5010	0.005208	5010	0.000021
B11	5011	-0.012233	5011	0.020963	5011	0.000086
O16	8016	-0.532553	8016	0.628157	8016	0.002567
O17	8017	-0.000216	8017	0.000239	8017	0.000001
O18	8018	-0.001232	8018	0.001291	8018	0.000005
Na23	11023	-0.161000	11023	0.132123	11023	0.000540
Si	14000	-0.279000	14000	0.187420	14000	0.000766
S	16000	-0.010000	16000	0.005883	16000	0.000024
Elemental						
H	1000	-0.001000	1000	0.018717	1000	0.000076
B	5000	-0.015000	5000	0.026170	5000	0.000107
O	8000	-0.534000	8000	0.629687	8000	0.002573
Na	11000	-0.161000	11000	0.132123	11000	0.000540
Si	14000	-0.279000	14000	0.187420	14000	0.000766
S	16000	-0.010000	16000	0.005883	16000	0.000024
Comments and References						
Criticality Handbook, Volume I, ARH-600, Page II.F.1-3. (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf)						

158. Glass, Lead

Formula =		Molecular Weight (g/mole) =				
Density (g/cm3) =	6.22	Total Atom Weight (atoms/b-cm) = 6.177E-02				
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.156029	8016	0.591511	8016	0.036540
O17	8017	-0.000063	8017	0.000225	8017	0.000014

O18	8018	-0.000361	8018	0.001216	8018	0.000075
Si	14000	-0.080866	14000	0.174595	14000	0.010785
Ti	22000	-0.008092	22000	0.010251	22000	0.000633
As75	33075	-0.002651	33075	0.002146	33075	0.000133
Pb	82000	-0.751938	82000	0.220056	82000	0.013594
Elemental						
O	8000	-0.156453	8000	0.592952	8000	0.036629
Si	14000	-0.080866	14000	0.174595	14000	0.010785
Ti	22000	-0.008092	22000	0.010251	22000	0.000633
As	33000	-0.002651	33000	0.002146	33000	0.000133
Pb	82000	-0.751938	82000	0.220056	82000	0.013594
Comments and References						
Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=170.						

159. Glass, Plate

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	2.4		Total Atom Weight (atoms/b-cm) = 6.878E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.458555	8016	0.602388	8016	0.041435
O17	8017	-0.000186	8017	0.000229	8017	0.000016
O18	8018	-0.001060	8018	0.001238	8018	0.000085
Na23	11023	-0.096441	11023	0.088144	11023	0.006063
Si	14000	-0.336553	14000	0.251795	14000	0.017320
Ca	20000	-0.107205	20000	0.056205	20000	0.003866
Elemental						
O	8000	-0.459800	8000	0.603856	8000	0.041536
Na	11000	-0.096441	11000	0.088144	11000	0.006063
Si	14000	-0.336553	14000	0.251795	14000	0.017320
Ca	20000	-0.107205	20000	0.056205	20000	0.003866
Comments and References						
Density = 2.40 g/cm3 and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=171. See Tables 12-16 and 12-17, Materials Data Book, by E.R. Parker, McGraw-Hill, 1967, for other types of glass. Density = 2.56 g/cm3 in Table 7.5 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996.						

160. Glycerol

Formula =	C3H8O3	Molecular Weight (g/mole) = 92.093800	
Density (g/cm3) =	1.2613	Total Atom Weight (atoms/b-cm) = 1.155E-01	

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.087538	1001	0.571362	1001	0.065975
H2	1002	-0.000020	1002	0.000066	1002	0.000008
C	6000	-0.391251	6000	0.214286	6000	0.024743
O16	8016	-0.519776	8016	0.213765	8016	0.024683
O17	8017	-0.000210	8017	0.000081	8017	0.000009
O18	8018	-0.001202	8018	0.000439	8018	0.000051
Elemental						
H	1000	-0.087561	1000	0.571428	1000	0.065983
C	6000	-0.391251	6000	0.214286	6000	0.024743
O	8000	-0.521188	8000	0.214286	8000	0.024743

Comments and References

Density = 1.2613 from physics.nist.gov/cgi-bin/Star/compos.pl?matno=174. MatWeb Material Property Data www.matweb.com lists 'Glycerin (HOCH2(CHOH)CH2O2CCH3; Glycerol)' with a density = 1.2613 g/cm3 at 20C. NIH PubChem pubchem.ncbi.nlm.nih.gov lists glycerol, CH2OH-CHOH-CH2OH, densities of 1.26, 1.261 and 1.2613 g/cc at different temperatures from different sources. Also called glycerin (en.wikipedia.org/wiki/Glycerin). Formula from p.3-268 of CRC Handbook of Chemistry and Physics, 89th ed (www.hbcpnetbase.com) and Table 51.120 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960).

161. Gold

Formula = Au Molecular Weight (g/mole) = 196.966569
Density (g/cm3) = 19.32 Total Atom Weight (atoms/b-cm) = 5.907E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Au197	79197	-1.000000	79197	1.000000	79197	0.059070
Elemental						
Au	79000	-1.000000	79000	1.000000	79000	0.059070

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=079.

162. Gypsum (Plaster of Paris)

Formula = Ca1S1O6H4 Molecular Weight (g/mole) = 172.173800
Density (g/cm3) = 2.32 Total Atom Weight (atoms/b-cm) = 9.738E-02

Gypsum is the primary component of wallboard or drywall.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.023411	1001	0.333295	1001	0.032455
H2	1002	-0.000005	1002	0.000038	1002	0.000004
O16	8016	-0.556044	8016	0.498785	8016	0.048570
O17	8017	-0.000225	8017	0.000190	8017	0.000019
O18	8018	-0.001286	8018	0.001025	8018	0.000100
S	16000	-0.186251	16000	0.083333	16000	0.008115
Ca	20000	-0.232776	20000	0.083333	20000	0.008115
Elemental						
H	1000	-0.023418	1000	0.333333	1000	0.032459
O	8000	-0.557555	8000	0.500000	8000	0.048688
S	16000	-0.186251	16000	0.083333	16000	0.008115
Ca	20000	-0.232776	20000	0.083333	20000	0.008115

Comments and References

Density = 2.32 g/cm3 from physics.nist.gov/cgi-bin/Star/compos.pl?matno=176. MatWeb Material Property Data www.matweb.com lists density = 2.32 g/cm3 and formula. There is a significant variation in densities listed for different types of gypsum. For example, density = 1.12 to 2.79 at www.simetric.co.uk/si_materials.htm.Gypsum is the primary component of wallboard or drywall. Density of wallboard = 43 lb/ft3 = 0.69 g/cm3 in Table 35-1, Engineering Materials Handbook, C.L. Mantell, 1958. Density = 0.75 g/cm3 in Table 7.5 of Radiation Shielding by J.K. Shultis and R.E. Faw, Prentise-Hall, 1996.

163. He-3 Proportional Gas

Formula = He Molecular Weight (g/mole) = 3.016029
Density (g/cm3) = 0.0001252645124733361 Total Atom Weight (atoms/b-cm) = 2.500E-05

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
He3	2003	-1.000000	2003	1.000000	2003	0.000025
Elemental						
He	2003	-1.000000	2003	1.000000	2003	0.000025

Comments and References

This density is calculated for T = 20 C and P = 1 atmosphere using a Van der Waals equation of state.

164. He-4 Gas Detector

Formula = He			Molecular Weight (g/mole) = 4.002603			
Density (g/cm3) = 0.03			Total Atom Weight (atoms/b-cm) = 4.514E-03			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
He4	2004	-1.000000	2004	1.000000	2004	0.004514
Elemental						
He	2004	-1.000000	2004	1.000000	2004	0.004514
Comments and References						
Density at 200 bar from https://inis.iaea.org/collection/NCLCollectionStore/_Public/48/103/48103866.pdf Pressures may vary, literature shows a range from 150 to 200 barr, pressures of 150 and 180 bar of 150 and 180 bar are also mentioned in https://www.researchgate.net/publication/322361348_Timing_Characterization_of_Helium-4_Fast_Neutron_Detector_with_EJ-309_Organic_Liquid_Scintillator.						

165. Helium, Natural

Formula = He			Molecular Weight (g/mole) = 4.002602			
Density (g/cm3) = 0.000166322			Total Atom Weight (atoms/b-cm) = 2.500E-05			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
He3	2003	-0.000001	2003	0.000001	2003	0.000000
He4	2004	-0.999999	2004	0.999999	2004	0.000025
Elemental						
He	2000	-1.000000	2000	1.000000	2000	0.000025
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=002.						

166. Hydrogen

Formula = H2			Molecular Weight (g/mole) = 2.015950			
Density (g/cm3) = 8.3748e-05			Total Atom Weight (atoms/b-cm) = 5.000E-05			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.999736	1001	0.999885	1001	0.000050
H2	1002	-0.000230	1002	0.000115	1002	0.000000
Elemental						

H	1000	-1.000000	1000	1.000000	1000	0.000050
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=001.						

167. Incoloy Alloy 800

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.94 Total Atom Weight (atoms/b-cm) = 8.672E-02

Weight fractions for Al, Ti, Cr, and Ni set at the average of the allowed range. Weight fractions for C, Si, S, Mn and Cu assumed to be 65% of their upper limits. Weight fraction of Fe was set above its lower limit value so that the total sums to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000650	6000	0.002984	6000	0.000259
Al27	13027	-0.003750	13027	0.007663	13027	0.000665
Si	14000	-0.006500	14000	0.012761	14000	0.001107
S	16000	-0.000097	16000	0.000167	16000	0.000014
Ti	22000	-0.003750	22000	0.004320	22000	0.000375
Cr	24000	-0.210000	24000	0.222684	24000	0.019312
Mn55	25055	-0.009750	25055	0.009785	25055	0.000849
Fe	26000	-0.435628	26000	0.430102	26000	0.037299
Ni	28000	-0.325000	28000	0.305305	28000	0.026477
Cu	29000	-0.004875	29000	0.004230	29000	0.000367
Elemental						
C	6000	-0.000650	6000	0.002984	6000	0.000259
Al	13000	-0.003750	13000	0.007663	13000	0.000665
Si	14000	-0.006500	14000	0.012761	14000	0.001107
S	16000	-0.000097	16000	0.000167	16000	0.000014
Ti	22000	-0.003750	22000	0.004320	22000	0.000375
Cr	24000	-0.210000	24000	0.222684	24000	0.019312
Mn	25000	-0.009750	25000	0.009785	25000	0.000849
Fe	26000	-0.435628	26000	0.430102	26000	0.037299
Ni	28000	-0.325000	28000	0.305305	28000	0.026477
Cu	29000	-0.004875	29000	0.004230	29000	0.000367

Comments and References

Density and weight fractions from MatWeb Material Property Data www.matweb.com. Weight fractions for Al, Ti, Cr, and Ni set at the average of the allowed range. Weight fractions for C, Si, S, Mn and Cu assumed to be 65% of their upper limits. Weight fraction of Fe was set above its lower limit value so that the total sums to unity.

168. Inconel Alloy 600

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8.47 Total Atom Weight (atoms/b-cm) = 8.965E-02

Weight fractions for Cr and Fe set at the average of the allowed range. Weight fractions for C, Si, S, Mn and Cu assumed to be 65% of their upper limits. Weight fraction of Ni was set above its lower limit value so that the total sums to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000975	6000	0.004618	6000	0.000414
Si	14000	-0.003250	14000	0.006584	14000	0.000590
S	16000	-0.000097	16000	0.000172	16000	0.000015
Cr	24000	-0.155000	24000	0.169596	24000	0.015205
Mn55	25055	-0.006500	25055	0.006731	25055	0.000603
Fe	26000	-0.080000	26000	0.081501	26000	0.007307
Ni	28000	-0.750928	28000	0.727888	28000	0.065259
Cu	29000	-0.003250	29000	0.002910	29000	0.000261
Elemental						
C	6000	-0.000975	6000	0.004618	6000	0.000414
Si	14000	-0.003250	14000	0.006584	14000	0.000590
S	16000	-0.000097	16000	0.000172	16000	0.000015
Cr	24000	-0.155000	24000	0.169596	24000	0.015205
Mn	25000	-0.006500	25000	0.006731	25000	0.000603
Fe	26000	-0.080000	26000	0.081501	26000	0.007307
Ni	28000	-0.750928	28000	0.727888	28000	0.065259
Cu	29000	-0.003250	29000	0.002910	29000	0.000261

Comments and References

Density and weight fractions from MatWeb Material Property Data www.matweb.com. Weight fractions for Cr and Fe set at the average of the allowed range. Weight fractions for C, Si, S, Mn and Cu assumed to be 65% of their upper limits. Weight fraction of Ni was set above its lower limit value so that the total sums to unity.

169. Inconel Alloy 625

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8.44 Total Atom Weight (atoms/b-cm) = 8.635E-02

Weight fractions for Cr, Nb and Mo set at the average of the allowed range. Weight fraction for Ni set at the minimum value of 0.58. Weight fractions for C, Al, Si, P, S, TI, Mn, Fe, and Co set be 98.99117% of their upper limits so that all wt. fractions sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000990	6000	0.004852	6000	0.000419
Al27	13027	-0.003960	13027	0.008639	13027	0.000746

Si	14000	-0.004950	14000	0.010374	14000	0.000896
P31	15031	-0.000148	15031	0.000281	15031	0.000024
S	16000	-0.000148	16000	0.000272	16000	0.000023
Ti	22000	-0.003960	22000	0.004869	22000	0.000420
Cr	24000	-0.215000	24000	0.243380	24000	0.021017
Mn55	25055	-0.004950	25055	0.005303	25055	0.000458
Fe	26000	-0.049495	26000	0.052167	26000	0.004505
Co59	27059	-0.009899	27059	0.009887	27059	0.000854
Ni	28000	-0.580000	28000	0.581642	28000	0.050226
Nb93	41093	-0.036500	41093	0.023124	41093	0.001997
Mo	42000	-0.090000	42000	0.055210	42000	0.004768
Elemental						
C	6000	-0.000990	6000	0.004852	6000	0.000419
Al	13000	-0.003960	13000	0.008639	13000	0.000746
Si	14000	-0.004950	14000	0.010374	14000	0.000896
P	15000	-0.000148	15000	0.000281	15000	0.000024
S	16000	-0.000148	16000	0.000272	16000	0.000023
Ti	22000	-0.003960	22000	0.004869	22000	0.000420
Cr	24000	-0.215000	24000	0.243380	24000	0.021017
Mn	25000	-0.004950	25000	0.005303	25000	0.000458
Fe	26000	-0.049495	26000	0.052167	26000	0.004505
Co	27000	-0.009899	27000	0.009887	27000	0.000854
Ni	28000	-0.580000	28000	0.581642	28000	0.050226
Nb	41000	-0.036500	41000	0.023124	41000	0.001997
Mo	42000	-0.090000	42000	0.055210	42000	0.004768
Comments and References						
Density and weight fractions from MatWeb Material Property Data www.matweb.com. Weight fractions for Cr, Nb and Mo set at the average of the allowed range. Weight fraction for Ni set at the minimum value of 0.58. Weight fractions for C, Al, Si, P, S, TI, Mn, Fe, and Co set be 98.99117% of their upper limits so that all wt. fractions sum to unity.Similar weight fractions also in the technical bulletin from www.specialmetals.com/assets/smc/documents/smw/fm625.pdf						

170. Inconel Alloy 718

Formula =		Molecular Weight (g/mole) =				
Density (g/cm3) =	8.19	Total Atom Weight (atoms/b-cm) = 8.547E-02				
Weight fractions for Al, Ti, Cr, Fe, Ni, Nb and Mo set at the average of the allowed range. Weight fractions for B, C, Si, P, S, Mn, Co and Cu set to be 91% of their upper limits so that all wt. fractions sum to unity.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.000010	5010	0.000058	5010	0.000005
B11	5011	-0.000045	5011	0.000235	5011	0.000020

C	6000	-0.000728	6000	0.003498	6000	0.000299
Al27	13027	-0.005000	13027	0.010694	13027	0.000914
Si	14000	-0.003184	14000	0.006542	14000	0.000559
P31	15031	-0.000136	15031	0.000253	15031	0.000022
S	16000	-0.000136	16000	0.000245	16000	0.000021
Ti	22000	-0.009000	22000	0.010850	22000	0.000927
Cr	24000	-0.190000	24000	0.210869	24000	0.018023
Mn55	25055	-0.003184	25055	0.003344	25055	0.000286
Fe	26000	-0.170000	26000	0.175669	26000	0.015014
Ni	28000	-0.525000	28000	0.516178	28000	0.044117
Co59	27059	-0.009098	27059	0.008909	27059	0.000761
Cu	29000	-0.002729	29000	0.002478	29000	0.000212
Nb93	41093	-0.051250	41093	0.031833	41093	0.002721
Mo	42000	-0.030500	42000	0.018344	42000	0.001568
Elemental						
B	5000	-0.000055	5000	0.000294	5000	0.000025
C	6000	-0.000728	6000	0.003498	6000	0.000299
Al	13000	-0.005000	13000	0.010694	13000	0.000914
Si	14000	-0.003184	14000	0.006542	14000	0.000559
P	15000	-0.000136	15000	0.000253	15000	0.000022
S	16000	-0.000136	16000	0.000245	16000	0.000021
Ti	22000	-0.009000	22000	0.010850	22000	0.000927
Cr	24000	-0.190000	24000	0.210869	24000	0.018023
Mn	25000	-0.003184	25000	0.003344	25000	0.000286
Fe	26000	-0.170000	26000	0.175669	26000	0.015014
Ni	28000	-0.525000	28000	0.516178	28000	0.044117
Co	27000	-0.009098	27000	0.008909	27000	0.000761
Cu	29000	-0.002729	29000	0.002478	29000	0.000212
Nb	41000	-0.051250	41000	0.031833	41000	0.002721
Mo	42000	-0.030500	42000	0.018344	42000	0.001568
Comments and References						
Density and weight fractions from MatWeb Material Property Data www.matweb.com. Weight fractions for Al, Ti, Cr, Fe, Ni, Nb and Mo set at the average of the allowed range. Weight fractions for B, C, Si, P, S, Mn, Co and Cu set to be 91% of their upper limits so that all wt. fractions sum to unity.Similar weight fractions also in the technical bulletin from www.specialmetals.com/assets/smc/documents/smw/fm718.pdf.						

171. Indium

Formula = In		Molecular Weight (g/mole) = 114.818000			
Density (g/cm3) = 7.31		Total Atom Weight (atoms/b-cm) = 3.834E-02			
	Weight Fractions		Atom Fractions		Atom Densities
Isotopic					
In	49000	-1.000000	49000	1.000000	49000	0.038341

Elemental						
In	49000	-1.000000	49000	1.000000	49000	0.038341
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=049.						

172. Iron

Formula = Fe Molecular Weight (g/mole) = 55.845000
Density (g/cm3) = 7.874 Total Atom Weight (atoms/b-cm) = 8.491E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Fe	26000	-1.000000	26000	1.000000	26000	0.084911
Elemental						
Fe	26000	-1.000000	26000	1.000000	26000	0.084911
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=026.						

173. Iron Boride (Fe2B)

Formula = Fe2B Molecular Weight (g/mole) = 122.503500
Density (g/cm3) = 7.3 Total Atom Weight (atoms/b-cm) = 1.702E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.051440	5010	0.132667	5010	0.022585
B11	5011	-0.227655	5011	0.534000	5011	0.090906
Fe	26000	-0.720841	26000	0.333333	26000	0.056745
Elemental						
B	5000	-0.279159	5000	0.666667	5000	0.113490
Fe	26000	-0.720841	26000	0.333333	26000	0.056745
Comments and References						
Formula and density from MatWeb Material Property Data www.matweb.com, http://www.matweb.com/search/DataSheet.aspx?MatGUID=b9dbb726fb444cf4b6fcde21039e98bd Also see NIH PubChem https://pubchem.ncbi.nlm.nih.gov/compound/82789 Formula for iron boride can be FeB or Fe2B. See Iron boride (FeB) for naming conventions.						

174. Iron Boride (FeB)

Formula = FeB			Molecular Weight (g/mole) = 66.658500			
Density (g/cm3) = 7.15			Total Atom Weight (atoms/b-cm) = 1.292E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.029892	5010	0.099500	5010	0.012854
B11	5011	-0.132293	5011	0.400500	5011	0.051741
Fe	26000	-0.837778	26000	0.500000	26000	0.064595
Elemental						
B	5000	-0.162222	5000	0.500000	5000	0.064595
Fe	26000	-0.837778	26000	0.500000	26000	0.064595
Comments and References						
FeB can be called ferroboride (physics.nist.gov/cgi-bin/Star/compos.pl?matno=158), ferro boron (Table 51.11 of Reactor Handbook by Tipton), or iron boride, but iron boride can also refer to Fe2B (www.matweb.com and CRC Handbook of Chemistry and Physics, 89th edition, p.4-68). Density of FeB = 7.15 g/cm3 is from physics.nist.gov/cgi-bin/Star/compos.pl?matno=158. Density of FeB ~ 7 g/cm3 on page 4-68 of CRC Handbook of Chemistry and Physics, 89th edition. Density of FeB = 7.00 g/cm3 listed by MatWeb Material Property Data www.matweb.com						

175. Iron, Armco Ingot

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) = 7.866			Total Atom Weight (atoms/b-cm) = 8.511E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000120	6000	0.000556	6000	0.000047
O16	8016	-0.001097	8016	0.003817	8016	0.000325
O17	8017	-0.000000	8017	0.000001	8017	0.000000
O18	8018	-0.000003	8018	0.000008	8018	0.000001
P31	15031	-0.000050	15031	0.000090	15031	0.000008
S	16000	-0.000250	16000	0.000434	16000	0.000037
Mn55	25055	-0.000170	25055	0.000172	25055	0.000015
Fe	26000	-0.998310	26000	0.994922	26000	0.084681
Elemental						
C	6000	-0.000120	6000	0.000556	6000	0.000047
O	8000	-0.001100	8000	0.003826	8000	0.000326
P	15000	-0.000050	15000	0.000090	15000	0.000008
S	16000	-0.000250	16000	0.000434	16000	0.000037
Mn	25000	-0.000170	25000	0.000172	25000	0.000015
Fe	26000	-0.998310	26000	0.994922	26000	0.084681

Comments and References
Weight fractions from Table 51.40, and density from Table 51.41 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.

176. Iron, Cast (gray)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.15 Total Atom Weight (atoms/b-cm) = 8.890E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.034000	6000	0.137105	6000	0.012189
Si	14000	-0.026000	14000	0.044837	14000	0.003986
P31	15031	-0.003000	15031	0.004691	15031	0.000417
S	16000	-0.001000	16000	0.001510	16000	0.000134
Mn55	25055	-0.006500	25055	0.005730	25055	0.000509
Fe	26000	-0.929500	26000	0.806127	26000	0.071667
Elemental						
C	6000	-0.034000	6000	0.137105	6000	0.012189
Si	14000	-0.026000	14000	0.044837	14000	0.003986
P	15000	-0.003000	15000	0.004691	15000	0.000417
S	16000	-0.001000	16000	0.001510	16000	0.000134
Mn	25000	-0.006500	25000	0.005730	25000	0.000509
Fe	26000	-0.929500	26000	0.806127	26000	0.071667

Comments and References
Weight fractions from Table 51.40, and density from Table 51.41 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.

177. Iron, Wrought (Byers No.1)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.7 Total Atom Weight (atoms/b-cm) = 8.346E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000810	6000	0.003747	6000	0.000313
Si	14000	-0.001599	14000	0.003163	14000	0.000264
P31	15031	-0.000628	15031	0.001127	15031	0.000094
S	16000	-0.000101	16000	0.000175	16000	0.000015
Mn55	25055	-0.000152	25055	0.000154	25055	0.000013
Fe	26000	-0.996710	26000	0.991634	26000	0.082761
Elemental						
C	6000	-0.000810	6000	0.003747	6000	0.000313

Si	14000	-0.001599	14000	0.003163	14000	0.000264
P	15000	-0.000628	15000	0.001127	15000	0.000094
S	16000	-0.000101	16000	0.000175	16000	0.000015
Mn	25000	-0.000152	25000	0.000154	25000	0.000013
Fe	26000	-0.996710	26000	0.991634	26000	0.082761
Comments and References						
Weight fractions from Table 51.40, and density from Table 51.41 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960. Table 51.40 lists 1.2 wt.% as slag. This was omitted since it is not specified what elements are in slag. The weight fractions in the table were then divided by 0.988 so that the weight fractions would sum to unity.						

178. Kaowool

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.096 Total Atom Weight (atoms/b-cm) = 2.840E-03

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.000046	5010	0.000093	5010	0.000000
B11	5011	-0.000202	5011	0.000374	5011	0.000001
O16	8016	-0.498709	8016	0.634554	8016	0.001803
O17	8017	-0.000202	8017	0.000242	8017	0.000001
O18	8018	-0.001153	8018	0.001304	8018	0.000004
Al27	13027	-0.238163	13027	0.179644	13027	0.000510
Si	14000	-0.243627	14000	0.176545	14000	0.000502
Ca	20000	-0.000715	20000	0.000363	20000	0.000001
Ti	22000	-0.010189	22000	0.004332	22000	0.000012
Fe	26000	-0.006994	26000	0.002549	26000	0.000007
Elemental						
B	5000	-0.000248	5000	0.000467	5000	0.000001
O	8000	-0.500064	8000	0.636100	8000	0.001807
Al	13000	-0.238163	13000	0.179644	13000	0.000510
Si	14000	-0.243627	14000	0.176545	14000	0.000502
Ca	20000	-0.000715	20000	0.000363	20000	0.000001
Ti	22000	-0.010189	22000	0.004332	22000	0.000012
Fe	26000	-0.006994	26000	0.002549	26000	0.000007

Comments and References

Fibers in a Kaowool insulating blanket are made from Kaolinite, which is a naturally occurring clay mineral. The density of the Kaolinite fibers is 2.65 g/cm3 on p. II.F.1-4 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf). The density of the mineral is given as 2.16-2.68 g/cm3 at en.wikipedia.org/wiki/Kaolin, and 2.6 at www.galleries.com/Minerals/By_Name.htm The density of the fibers (2.65 g/cm3) must be multiplied by the volume fraction of the fibers to get the bulk density of the blanket. Bulk densities range from 0.048 to 0.192 g/cm3 for five

examples at MatWeb Material Property Data www.matweb.com/search/DataSheet.aspx?MatGUID=cb830e74bc69422aa560a7b57494955a. Density = 0.096 g/cm3 for one example of a Kaowool blanket at this reference, and this value is the closest to the average of the five values. This reference also gives the composition for a Kaowool blanket.

179. Kapton Polyimide Film

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.42 Total Atom Weight (atoms/b-cm) = 8.723E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.026355	1001	0.256362	1001	0.022362
H2	1002	-0.000006	1002	0.000029	1002	0.000003
C	6000	-0.691133	6000	0.564121	6000	0.049208
N14	7014	-0.072984	7014	0.051095	7014	0.004457
N15	7015	-0.000286	7015	0.000187	7015	0.000016
O16	8016	-0.208668	8016	0.127894	8016	0.011156
O17	8017	-0.000084	8017	0.000049	8017	0.000004
O18	8018	-0.000483	8018	0.000263	8018	0.000023
Elemental						
H	1000	-0.026362	1000	0.256392	1000	0.022365
C	6000	-0.691133	6000	0.564121	6000	0.049208
N	7000	-0.073270	7000	0.051282	7000	0.004473
O	8000	-0.209235	8000	0.128205	8000	0.011183

Comments and References

Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=179.

180. Kennertium

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 16.8 Total Atom Weight (atoms/b-cm) = 8.122E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ni	28000	-0.090000	28000	0.191007	28000	0.015514
Cu	29000	-0.150000	29000	0.294036	29000	0.023882
W	74000	-0.760000	74000	0.514957	74000	0.041825
Elemental						
Ni	28000	-0.090000	28000	0.191007	28000	0.015514
Cu	29000	-0.150000	29000	0.294036	29000	0.023882
W	74000	-0.760000	74000	0.514957	74000	0.041825

Comments and References
Kennertium is a high density tungsten alloy for shielding.Data from page 137 of LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.

181. Kernite

Formula = Na2B4O11H8 Molecular Weight (g/mole) = 273.290738
Density (g/cm3) = 1.95 Total Atom Weight (atoms/b-cm) = 1.074E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.029499	1001	0.319963	1001	0.034372
H2	1002	-0.000007	1002	0.000037	1002	0.000004
B10	5010	-0.029164	5010	0.031840	5010	0.003420
B11	5011	-0.129071	5011	0.128160	5011	0.013767
O16	8016	-0.642234	8016	0.438931	8016	0.047152
O17	8017	-0.000260	8017	0.000167	8017	0.000018
O18	8018	-0.001485	8018	0.000902	8018	0.000097
Na23	11023	-0.168244	11023	0.080000	11023	0.008594
Elemental						
H	1000	-0.029506	1000	0.320000	1000	0.034376
B	5000	-0.158271	5000	0.160000	5000	0.017188
O	8000	-0.643979	8000	0.440000	8000	0.047266
Na	11000	-0.168244	11000	0.080000	11000	0.008594

Comments and References

Density and formula from page II.F.1-4 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf). Density 1.95 g/cm3 and formula also at MatWeb Material Property Data www.matweb.com.

182. Kerosene

Formula = C14H30 Molecular Weight (g/mole) = 198.387650
Density (g/cm3) = 0.819 Total Atom Weight (atoms/b-cm) = 1.094E-01

Kerosene is sometimes spelled kerosine. It is usually called paraffin (sometimes paraffin oil) in the UK, SE Asia, and South Africa. Kerosene is a clear liquid consisting of a mixture of hydrocarbons containing between 6 and 16 carbon atoms per molecule [Implementing Phytoremediation of Petroleum Hydrocarbons by Chris Collins (2007) in Methods in Biotechnology 23:99-108].

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.152385	1001	0.681740	1001	0.074575

H2	1002	-0.000035	1002	0.000078	1002	0.000009
C	6000	-0.847575	6000	0.318182	6000	0.034806
Elemental						
H	1000	-0.152425	1000	0.681818	1000	0.074583
C	6000	-0.847575	6000	0.318182	6000	0.034806
Comments and References						
Average composition (near C14H30 wt. fractions and density (0.819 g/cm3 at 16C) from Table 51.104 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.Density also 0.819 g/cm3 in Table 7.1.8 of Mark's Standard Handbook for Mechanical Engineers, 10th edition. Density = 0.817 g/cm3 at www.simetric.co.uk/siliquids.htm. Density = 0.820 at www.engineeringtoolbox.com/liquids-densities-d_743.html and 0.810 g/cm3 at physics.info/density. Density = 0.77 to 0.82 g/cm3 in Table 7.4 of Handbook of Petroleum Product Analysis by James G. Speight, 2002, John Wiley & Sons. Density = 0.775 to 0.840 g/cm3 for jet kerosene at MatWeb Material Property Data www.matweb.com.						

183. Krypton

Formula = Kr			Molecular Weight (g/mole) = 83.798000			
Density (g/cm3) = 0.00347832			Total Atom Weight (atoms/b-cm) = 2.500E-05			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Kr78	36078	-0.003301	36078	0.003550	36078	0.000000
Kr80	36080	-0.021801	36080	0.022860	36080	0.000001
Kr82	36082	-0.113323	36082	0.115930	36082	0.000003
Kr83	36083	-0.113787	36083	0.115000	36083	0.000003
Kr84	36084	-0.570642	36084	0.569870	36084	0.000014
Kr86	36086	-0.177146	36086	0.172790	36086	0.000004
Elemental						
Kr	36000	-1.000000	36000	1.000000	36000	0.000025
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=036.						

184. Kynar

Formula = H2C2F2			Molecular Weight (g/mole) = 64.033956			
Density (g/cm3) = 1.79			Total Atom Weight (atoms/b-cm) = 1.010E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.031474	1001	0.333295	1001	0.033665

H2	1002	-0.000007	1002	0.000038	1002	0.000004
C	6000	-0.375132	6000	0.333333	6000	0.033668
F19	9019	-0.593385	9019	0.333333	9019	0.033668
Elemental						
H	1000	-0.031483	1000	0.333333	1000	0.033668
C	6000	-0.375132	6000	0.333333	6000	0.033668
F	9000	-0.593385	9000	0.333333	9000	0.033668
Comments and References						
Density = 1.78 to 1.80 at MatWeb Material Property Data www.matweb.com/search/DataSheet.aspx?MatGUID=8144c044f8a347739734597e0025a723. Trade name for Polyvinylidene Fluoride, abbreviated PVDF (en.wikipedia.org/wiki/Kynar).Formula = H2C2F2 from Polymer Handbook, J. Brandrup et al, 4th edition, 2005, John Wiley & Sons.						

185. Lanthanum Bromide - 0.5 wt% Cerium doped

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 5.08 Total Atom Weight (atoms/b-cm) = 3.244E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Br79	35079	-0.320699	35079	0.383214	35079	0.012432
Br81	35081	-0.319866	35081	0.372781	35081	0.012093
Ce136	58136	-0.000003	58136	0.000002	58136	0.000000
Ce138	58138	-0.000005	58138	0.000003	58138	0.000000
Ce140	58140	-0.001639	58140	0.001105	58140	0.000036
Ce142	58142	-0.000209	58142	0.000139	58142	0.000005
La138	57138	-0.000315	57138	0.000216	57138	0.000007
La139	57139	-0.357260	57139	0.242540	57139	0.007868
Elemental						
Br	35000	-0.640569	35000	0.755995	35000	0.024525
Ce	58000	-0.001856	58000	0.001249	58000	0.000041
La	57000	-0.357575	57000	0.242756	57000	0.007875
Comments and References						
Formula is LaBr3(Ce) but the formula isn't used in the calculation due to the Ce dopant Density and formula from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/lanthanum-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain Safety Data Sheets and literature at St Gobain resource library @ https://www.crystals.saint-gobain.com/document-center						

186. Lanthanum Bromide - 10 wt% Cerium and 0.10 wt% Strontium doped

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	5.08		Total Atom Weight (atoms/b-cm) = 3.232E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Br79	35079	-0.316914	35079	0.380175	35079	0.012285
Br81	35081	-0.316091	35081	0.369825	35081	0.011951
Ce136	58136	-0.000066	58136	0.000046	58136	0.000001
Ce138	58138	-0.000091	58138	0.000063	58138	0.000002
Ce140	58140	-0.032677	58140	0.022112	58140	0.000715
Ce142	58142	-0.004165	58142	0.002778	58142	0.000090
La138	57138	-0.000291	57138	0.000200	57138	0.000006
La139	57139	-0.329470	57139	0.224550	57139	0.007256
Sr84	38084	-0.000001	38084	0.000001	38084	0.000000
Sr86	38086	-0.000022	38086	0.000025	38086	0.000001
Sr87	38087	-0.000016	38087	0.000017	38087	0.000001
Sr88	38088	-0.000191	38088	0.000206	38088	0.000007
Elemental						
Br	35000	-0.633009	35000	0.750000	35000	0.024236
Ce	58000	-0.037000	58000	0.025000	58000	0.000808
La	57000	-0.329760	57000	0.224750	57000	0.007263
Sr	38000	-0.000231	38000	0.000250	38000	0.000008
Comments and References						
Formula is LaBr3(Ce, Sr) but the formula isn't used in the calculation due to the Ce, Sr dopant Density and formula from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/lanthanum-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain Safety Data Sheets and literature at St Gobain resource library @ https://www.crystals.saint-gobain.com/document-center						

187. Lanthanum Bromide - 10 wt% Cerium doped

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	5.08		Total Atom Weight (atoms/b-cm) = 3.228E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Br79	35079	-0.316063	35079	0.379513	35079	0.012252
Br81	35081	-0.315242	35081	0.369181	35081	0.011919
Ce136	58136	-0.000066	58136	0.000046	58136	0.000001
Ce138	58138	-0.000090	58138	0.000062	58138	0.000002
Ce140	58140	-0.032308	58140	0.021883	58140	0.000706

Ce142	58142	-0.004118	58142	0.002750	58142	0.000089
La138	57138	-0.000293	57138	0.000201	57138	0.000006
La139	57139	-0.331817	57139	0.226364	57139	0.007308
Elemental						
Br	35000	-0.631308	35000	0.748693	35000	0.024171
Ce	58000	-0.036582	58000	0.024741	58000	0.000799
La	57000	-0.332110	57000	0.226566	57000	0.007314
Comments and References						
Formula is LaBr3(Ce) but the formula isn't used in the calculation due to the Ce dopant Density and formula from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/lanthanum-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain Safety Data Sheets and literature at St Gobain resource library @ https://www.crystals.saint-gobain.com/document-center						

188. Lanthanum Bromide - 5 wt% Cerium doped

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	5.08		Total Atom Weight (atoms/b-cm) = 3.229E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Br79	35079	-0.316012	35079	0.379431	35079	0.012250
Br81	35081	-0.315192	35081	0.369101	35081	0.011917
Ce136	58136	-0.000033	58136	0.000023	58136	0.000001
Ce138	58138	-0.000045	58138	0.000031	58138	0.000001
Ce140	58140	-0.016151	58140	0.010939	58140	0.000353
Ce142	58142	-0.002059	58142	0.001375	58142	0.000044
La138	57138	-0.000309	57138	0.000212	57138	0.000007
La139	57139	-0.350195	57139	0.238888	57139	0.007713
Elemental						
Br	35000	-0.631208	35000	0.748531	35000	0.024167
Ce	58000	-0.018288	58000	0.012368	58000	0.000399
La	57000	-0.350504	57000	0.239101	57000	0.007719
Comments and References						
Formula is LaBr3(Ce) but the formula isn't used in the calculation due to the Ce dopant Density and formula from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/lanthanum-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain Safety Data Sheets and literature at St Gobain resource library @ https://www.crystals.saint-gobain.com/document-center						

189. Lead

Formula = Pb			Molecular Weight (g/mole) = 207.200000			
Density (g/cm3) = 11.35			Total Atom Weight (atoms/b-cm) = 3.299E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pb	82000	-1.000000	82000	1.000000	82000	0.032988
Elemental						
Pb	82000	-1.000000	82000	1.000000	82000	0.032988
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=082.						

190. Lead Iodide

Formula = PbI2			Molecular Weight (g/mole) = 461.008940			
Density (g/cm3) = 6.16			Total Atom Weight (atoms/b-cm) = 2.414E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pb	82000	-0.449449	82000	0.333333	82000	0.008047
I127	53127	-0.550551	53127	0.666667	53127	0.016094
Elemental						
Pb	82000	-0.449449	82000	0.333333	82000	0.008047
I	53000	-0.550551	53000	0.666667	53000	0.016094
Comments and References						
Density and formula from https://www.americanelements.com/clyc-ce-scintillation-crystal						

191. Lead Tungstate (PWO)

Formula = PbWO4			Molecular Weight (g/mole) = 455.037600			
Density (g/cm3) = 8.24			Total Atom Weight (atoms/b-cm) = 6.543E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.140261	8016	0.665046	8016	0.043515
O17	8017	-0.000057	8017	0.000253	8017	0.000017
O18	8018	-0.000324	8018	0.001367	8018	0.000089
W	74000	-0.404011	74000	0.166667	74000	0.010905
Pb	82000	-0.455347	82000	0.166667	82000	0.010905
Elemental						

O	8000	-0.140642	8000	0.666666	8000	0.043621
W	74000	-0.404011	74000	0.166667	74000	0.010905
Pb	82000	-0.455347	82000	0.166667	82000	0.010905
Comments and References						
MatWeb Material Property Data www.matweb.com lists density of 8.28 g/cm3NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 8.24 g/cu cm (stolizite); 8.46 g/cu cm (raspite) from other sources.						

192. Lithium

Formula = Li Molecular Weight (g/mole) = 6.967500
Density (g/cm3) = 0.534 Total Atom Weight (atoms/b-cm) = 4.616E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.065525	3006	0.075900	3006	0.003503
Li7	3007	-0.930533	3007	0.924100	3007	0.042651
Elemental						
Li	3000	-1.000000	3000	1.000000	3000	0.046155
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=003.						

193. Lithium Amide

Formula = LiNH2 Molecular Weight (g/mole) = 22.990305
Density (g/cm3) = 1.178 Total Atom Weight (atoms/b-cm) = 1.234E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.087664	1001	0.499943	1001	0.061707
H2	1002	-0.000020	1002	0.000058	1002	0.000007
Li6	3006	-0.019858	3006	0.018975	3006	0.002342
Li7	3007	-0.282010	3007	0.231025	3007	0.028515
N14	7014	-0.606868	7014	0.249090	7014	0.030745
N15	7015	-0.002375	7015	0.000910	7015	0.000112
Elemental						
H	1000	-0.087687	1000	0.500000	1000	0.061714
Li	3000	-0.303063	3000	0.250000	3000	0.030857
N	7000	-0.609250	7000	0.250000	7000	0.030857
Comments and References						

Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=183. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-71.MatWeb Material Property Data www.matweb.com lists density of 1.18 g/cm3 NIH PubChem pubchem.ncbi.nlm.nih.gov lists density of 1.18 g/cm3.

194. Lithium Fluoride

Formula = LiF Molecular Weight (g/mole) = 25.965903
Density (g/cm3) = 2.635 Total Atom Weight (atoms/b-cm) = 1.222E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.017583	3006	0.037950	3006	0.004638
Li7	3007	-0.249692	3007	0.462050	3007	0.056474
F19	9019	-0.731667	9019	0.500000	9019	0.061112
Elemental						
Li	3000	-0.268333	3000	0.500000	3000	0.061112
F	9000	-0.731667	9000	0.500000	9000	0.061112

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=185. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-72. MatWeb Material Property Data www.matweb.com lists densities of 2.60 and 2.64 g/cm3NIH PubChem pubchem.ncbi.nlm.nih.gov lists density of 2.64 g/cm3.

195. Lithium Gadolinium Borate (LGB)

Formula = Li6GdB3O9 Molecular Weight (g/mole) = 367.374149
Density (g/cm3) = 3.5 Total Atom Weight (atoms/b-cm) = 1.090E-01

Li is Li-6, B is B-10, Gd and O are natural.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.098240	3006	0.315789	3006	0.034424
B10	5010	-0.081766	5010	0.157895	5010	0.017212
O16	8016	-0.390894	8016	0.472533	8016	0.051511
O17	8017	-0.000158	8017	0.000180	8017	0.000020
O18	8018	-0.000904	8018	0.000971	8018	0.000106
Gd	64000	-0.428038	64000	0.052632	64000	0.005737
Elemental						
Li	3006	-0.098240	3006	0.315789	3006	0.034424
B	5010	-0.081766	5010	0.157895	5010	0.017212
O	8000	-0.391956	8000	0.473684	8000	0.051636
Gd	64000	-0.428038	64000	0.052632	64000	0.005737

Comments and References
'Lithium gadolinium borate in plastic scintillator as an antineutrino detection material', Peter C. Nelson, Monterey, CA, Naval Postgraduate School https://core.ac.uk/download/pdf/36698968.pdf

196. Lithium Hydride

Formula = LiH Molecular Weight (g/mole) = 7.975475
Density (g/cm3) = 0.82 Total Atom Weight (atoms/b-cm) = 1.238E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.126351	1001	0.499943	1001	0.061910
H2	1002	-0.000029	1002	0.000058	1002	0.000007
Li6	3006	-0.057244	3006	0.037950	3006	0.004699
Li7	3007	-0.812928	3007	0.462050	3007	0.057217
Elemental						
H	1000	-0.126384	1000	0.500000	1000	0.061917
Li	3000	-0.873616	3000	0.500000	3000	0.061917

Comments and References

Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=186. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-72. Density = 0.70 g/cm3 for pressed power (Table 51.14, Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960). NIH PubChem pubchem.ncbi.nlm.nih.gov lists density of 0.76-0.77, 0.78, and 0.8 g/cm3 from different sources.

197. Lithium Iodide (high density)

Formula = LiI Molecular Weight (g/mole) = 133.871970
Density (g/cm3) = 4.08 Total Atom Weight (atoms/b-cm) = 3.671E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.003410	3006	0.037950	3006	0.001393
Li7	3007	-0.048431	3007	0.462050	3007	0.016961
I127	53127	-0.947954	53127	0.500000	53127	0.018354
Elemental						
Li	3000	-0.052046	3000	0.500000	3000	0.018354
I	53000	-0.947954	53000	0.500000	53000	0.018354

Comments and References

Density = 4.08 g/cm3 from page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000.MatWeb Material Property Data www.matweb.com lists density of 4.06 g/cm3.

198. Lithium Iodide (low density)

Formula = LiI Molecular Weight (g/mole) = 133.871970
Density (g/cm3) = 3.494 Total Atom Weight (atoms/b-cm) = 3.144E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.003410	3006	0.037950	3006	0.001193
Li7	3007	-0.048431	3007	0.462050	3007	0.014525
I127	53127	-0.947954	53127	0.500000	53127	0.015718
Elemental						
Li	3000	-0.052046	3000	0.500000	3000	0.015718
I	53000	-0.947954	53000	0.500000	53000	0.015718

Comments and References

physics.nist.gov/cgi-bin/Star/compos.pl?matno=187 lists density of 3.494 g/cm3.

199. Lithium Oxide

Formula = Li2O Molecular Weight (g/mole) = 29.934400
Density (g/cm3) = 2.013 Total Atom Weight (atoms/b-cm) = 1.215E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.030503	3006	0.050600	3006	0.006147
Li7	3007	-0.433180	3007	0.616067	3007	0.074847
O16	8016	-0.533034	8016	0.332523	8016	0.040399
O17	8017	-0.000216	8017	0.000127	8017	0.000015
O18	8018	-0.001233	8018	0.000683	8018	0.000083
Elemental						
Li	3000	-0.465518	3000	0.666667	3000	0.080994
O	8000	-0.534482	8000	0.333333	8000	0.040497

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=188. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-72. MatWeb Material Property Data www.matweb.com lists density of 2.013 g/cm3.

200. Lithium Tetraborate

Formula = Li2B4O7 Molecular Weight (g/mole) = 169.184800
Density (g/cm3) = 2.44 Total Atom Weight (atoms/b-cm) = 1.129E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Li6	3006	-0.005397	3006	0.011677	3006	0.001318
Li7	3007	-0.076644	3007	0.142169	3007	0.016052
B10	5010	-0.047110	5010	0.061231	5010	0.006913
B11	5011	-0.208493	5011	0.246462	5011	0.027827
O16	8016	-0.660179	8016	0.537153	8016	0.060649
O17	8017	-0.000267	8017	0.000205	8017	0.000023
O18	8018	-0.001527	8018	0.001104	8018	0.000125
Elemental						
Li	3000	-0.082366	3000	0.153846	3000	0.017370
B	5000	-0.255661	5000	0.307692	5000	0.034741
O	8000	-0.661973	8000	0.538462	8000	0.060796

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=189. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-72. NIH PubChem pubchem.ncbi.nlm.nih.gov lists this material as 'dilithium tetraborate' without a density.

201. Lucite

Formula = C5O2H8 Molecular Weight (g/mole) = 100.115600
Density (g/cm3) = 1.19 Total Atom Weight (atoms/b-cm) = 1.074E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.080524	1001	0.533272	1001	0.057258
H2	1002	-0.000019	1002	0.000061	1002	0.000007
C	6000	-0.599836	6000	0.333333	6000	0.035790
O16	8016	-0.318752	8016	0.133009	8016	0.014281
O17	8017	-0.000129	8017	0.000051	8017	0.000005
O18	8018	-0.000737	8018	0.000273	8018	0.000029
Elemental						
H	1000	-0.080545	1000	0.533333	1000	0.057265
C	6000	-0.599836	6000	0.333333	6000	0.035790
O	8000	-0.319619	8000	0.133333	8000	0.014316

Comments and References

Density = 1.19 g/cm3 from physics.nist.gov/cgi-bin/Star/compos.pl?matno=223.

202. Lutetium Aluminum Garnet (LuAG)

Formula = Al5Lu3O12			Molecular Weight (g/mole) = 851.800890			
Density (g/cm3) = 6.73			Total Atom Weight (atoms/b-cm) = 9.516E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.224786	8016	0.598542	8016	0.056958
O17	8017	-0.000091	8017	0.000228	8017	0.000022
O18	8018	-0.000520	8018	0.001230	8018	0.000117
Al27	13027	-0.158379	13027	0.250000	13027	0.023790
Lu175	71175	-0.600120	71175	0.146102	71175	0.013903
Lu176	71176	-0.016105	71176	0.003899	71176	0.000371
Elemental						
O	8000	-0.225396	8000	0.600000	8000	0.057096
Al	13000	-0.158379	13000	0.250000	13000	0.023790
Lu	71000	-0.616225	71000	0.150000	71000	0.014274
Comments and References						
The formula is listed as Al5Lu3O12 at en.wikipedia.org/wiki/LuAGAlso at 'Preparation and characterization of nanoscale lutetium aluminum garnet (LuAG) powders doped by Eu3+' by Dominik Uhlicha, et al. Optical Materials 29, 1505-1509 (2007). Density from MatWeb Material Property Data www.matweb.com.						

203. Lutetium Iodide

Formula = LuI3			Molecular Weight (g/mole) = 555.680210			
Density (g/cm3) = 5.6			Total Atom Weight (atoms/b-cm) = 2.428E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Lu175	71175	-0.306641	71175	0.243503	71175	0.005911
Lu176	71176	-0.008229	71176	0.006497	71176	0.000158
I127	53127	-0.685130	53127	0.750000	53127	0.018207
Elemental						
Lu	71000	-0.314870	71000	0.250000	71000	0.006069
I	53000	-0.685130	53000	0.750000	53000	0.018207
Comments and References						
Density and formula from https://www.americanelements.com/lutetium-iodide-13813-45-1						

204. Lutetium Orthoaluminate (LuAP)

Formula = LuAlO3			Molecular Weight (g/mole) = 249.946538			
Density (g/cm3) = 8.4			Total Atom Weight (atoms/b-cm) = 1.012E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.191514	8016	0.598542	8016	0.060569
O17	8017	-0.000078	8017	0.000228	8017	0.000023
O18	8018	-0.000443	8018	0.001230	8018	0.000124
Al27	13027	-0.107949	13027	0.200000	13027	0.020239
Lu175	71175	-0.681722	71175	0.194802	71175	0.019713
Lu176	71176	-0.018295	71176	0.005198	71176	0.000526
Elemental						
O	8000	-0.192034	8000	0.600000	8000	0.060716
Al	13000	-0.107949	13000	0.200000	13000	0.020239
Lu	71000	-0.700017	71000	0.200000	71000	0.020239
Comments and References						
Density from page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000. 'Luminescence properties and scintillation mechanisms of cerium- and praseodymium-doped lutetium orthoaluminate', C Dujardin et. al., Journal of Physics: Condensed Matter, Vol. 9, #24, June 1997.						

205. Lutetium Oxyorthosilicate (LSO)

Formula = Lu2SiO5			Molecular Weight (g/mole) = 458.015600			
Density (g/cm3) = 7.4			Total Atom Weight (atoms/b-cm) = 7.784E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.174187	8016	0.623481	8016	0.048531
O17	8017	-0.000071	8017	0.000238	8017	0.000018
O18	8018	-0.000403	8018	0.001281	8018	0.000100
Si	14000	-0.061319	14000	0.125000	14000	0.009730
Lu175	71175	-0.744054	71175	0.243503	71175	0.018954
Lu176	71176	-0.019968	71176	0.006497	71176	0.000506
Elemental						
O	8000	-0.174660	8000	0.625000	8000	0.048649
Si	14000	-0.061319	14000	0.125000	14000	0.009730
Lu	71000	-0.764021	71000	0.250000	71000	0.019460
Comments and References						
Density from page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley & Sons, 2000. Formula and density in Guohoa Ren, et al., Scintillation Characteristics of Luterium Oxyorthosilicate (Lu2SiO5:Ce) Crystals Doped with Cerium						

Ions at www.sciencedirect.com, 'Large Size LSO and LYSO Crystals for Future High Energy Physics Experiments' Jianaing Chen et. al., IEEE Transactions on Nuclear Science, Vol. 54. No. 3, June 2007.

206. Lutetium Yttrium OxyorthoSilicate: 0.5 atom% Cerium (LYSO)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.25 Total Atom Weight (atoms/b-cm) = 7.7144E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.175325	8016	0.620364	8016	0.047857
O17	8017	-0.000071	8017	0.000236	8017	0.000018
O18	8018	-0.000405	8018	0.001275	8018	0.000098
Si	14000	-0.061720	14000	0.124375	14000	0.009595
Y89	39089	-0.019538	39089	0.012438	39089	0.000959
Lu175	71175	-0.711469	71175	0.230171	71175	0.017756
Lu176	71176	-0.019093	71176	0.006142	71176	0.000474
Ce136	58136	-0.000022	58136	0.000009	58136	0.000001
Ce138	58138	-0.000031	58138	0.000013	58138	0.000001
Ce140	58140	-0.010932	58140	0.004423	58140	0.000341
Ce142	58142	-0.001393	58142	0.000556	58142	0.000043
Elemental						
O	8000	-0.175801	8000	0.621875	8000	0.047974
Si	14000	-0.061720	14000	0.124375	14000	0.009595
Y	39000	-0.019538	39000	0.012438	39000	0.000959
Lu	71000	-0.730562	71000	0.236313	71000	0.018230
Ce	58000	-0.012379	58000	0.005000	58000	0.000386

Comments and References

Formula is Lu(1.9)Y(0.1)SiO5:Ce but the formula isn't used in the calculation due to the Ce dopant. Material properties taken from https://www.epic-crystal.com/oxide-scintillators/yso-ce-scintillator.html, Dopant (aka Activator) added at 0.5 atom percent. Base formula of Lu[2(1-x)]Y(x)SiO5:Ce is given in 'Large Size LSO and LYSO Crystals for Future High Energy Physics Experiments' Jianaing Chen et. al., IEEE Transactions on Nuclear Science, Vol. 54. No. 3, June 2007. Variations of this formula exist, Saint Gobain's website lists Lu(1.8)Y(0.2)SiO5:Ce https://www.crystals.saint-gobain.com/products/LYSO-Scintillator.

207. Magnesium

Formula = Mg Molecular Weight (g/mole) = 24.305500
Density (g/cm3) = 1.74 Total Atom Weight (atoms/b-cm) = 4.311E-02

	Weight Fractions	Atom Fractions	Atom Densities
Isotopic			

Mg	12000	-1.000000	12000	1.000000	12000	0.043112
Elemental						
Mg	12000	-1.000000	12000	1.000000	12000	0.043112
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=012.						

208. Magnesium Oxide

Formula = MgO Molecular Weight (g/mole) = 40.304900
Density (g/cm3) = 3.58 Total Atom Weight (atoms/b-cm) = 1.070E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.395884	8016	0.498785	8016	0.053360
O17	8017	-0.000160	8017	0.000190	8017	0.000020
O18	8018	-0.000915	8018	0.001025	8018	0.000110
Mg	12000	-0.603041	12000	0.500000	12000	0.053490
Elemental						
O	8000	-0.396959	8000	0.500000	8000	0.053490
Mg	12000	-0.603041	12000	0.500000	12000	0.053490
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=194. MatWeb Material Property Data www.matweb.com lists density of 3.58 g/cm3. NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 3.58 and 3.6 g/cm3.						

209. Magnesium Tetraborate

Formula = MgB4O7 Molecular Weight (g/mole) = 179.555300
Density (g/cm3) = 2.53 Total Atom Weight (atoms/b-cm) = 1.018E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
B10	5010	-0.044389	5010	0.066333	5010	0.006754
B11	5011	-0.196451	5011	0.267000	5011	0.027187
O16	8016	-0.622050	8016	0.581917	8016	0.059254
O17	8017	-0.000252	8017	0.000222	8017	0.000023
O18	8018	-0.001438	8018	0.001196	8018	0.000122
Mg	12000	-0.135365	12000	0.083333	12000	0.008485
Elemental						
B	5000	-0.240895	5000	0.333333	5000	0.033942
O	8000	-0.623740	8000	0.583334	8000	0.059398
Mg	12000	-0.135365	12000	0.083333	12000	0.008485

Comments and References
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=195. Formula from www.chemicalregister.com/Magnesium_tetraborate/Suppliers/pid32346.htm#. Also called Magnesium Borate.

210. Masonite

Formula = C6H10O5 Molecular Weight (g/mole) = 162.140350
Density (g/cm3) = 1.3 Total Atom Weight (atoms/b-cm) = 1.014E-01

Masonite is a type of hardboard (en.wikipedia.org/wiki/Masonite). Masonite is produced from by-product wood chips reduced to cellulose fibers by high-pressure steam (Table 51.114 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960) so cellulose (C6H10O5) is used for the formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.062150	1001	0.476136	1001	0.048278
H2	1002	-0.000014	1002	0.000055	1002	0.000006
C	6000	-0.444452	6000	0.285714	6000	0.028970
O16	8016	-0.492044	8016	0.237517	8016	0.024083
O17	8017	-0.000199	8017	0.000090	8017	0.000009
O18	8018	-0.001138	8018	0.000488	8018	0.000049
Elemental						
H	1000	-0.062167	1000	0.476190	1000	0.048284
C	6000	-0.444452	6000	0.285714	6000	0.028970
O	8000	-0.493381	8000	0.238095	8000	0.024142

Comments and References

Masonite is a type of hardboard (en.wikipedia.org/wiki/Masonite). Table 51.114 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960) Masonite is produced from by-product wood chips reduced to cellulose fibers by high-pressure steam so cellulose (C6H10O5) is used for the formula. Density = 1.3 g/cm3 from this ref. Density also from page II.F.1-5 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf). www.hudsonhighland.com/fiberboardchart.htm lists the average density of Masonite as about 79 to 80 lb/ft3, which averages to 1.27 g/cm3.

211. Melamine

Formula = C3H6N6 Molecular Weight (g/mole) = 126.120780
Density (g/cm3) = 1.573 Total Atom Weight (atoms/b-cm) = 1.127E-01

	Weight Fractions	Atom Fractions	Atom Densities
Isotopic			

H1	1001	-0.047940	1001	0.399954	1001	0.045060
H2	1002	-0.000011	1002	0.000046	1002	0.000005
C	6000	-0.285693	6000	0.200000	6000	0.022533
N14	7014	-0.663750	7014	0.398544	7014	0.044901
N15	7015	-0.002598	7015	0.001456	7015	0.000164
Elemental						
H	1000	-0.047953	1000	0.400000	1000	0.045066
C	6000	-0.285693	6000	0.200000	6000	0.022533
N	7000	-0.666354	7000	0.400000	7000	0.045066
Comments and References						
NIH PubChem (https://pubchem.ncbi.nlm.nih.gov/compound/7955)						

212. Melamine Formaldehyde

Formula = C5H7N6 Molecular Weight (g/mole) = 151.149955
Density (g/cm3) = 1.35 Total Atom Weight (atoms/b-cm) = 9.682E-02

It is a hard thermosetting plastic often used for kitchen utensils and plates (Melmac), and is the main constituent of formica and laminate flooring (en.wikipedia.org/wiki/Melamine_resin).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.046669	1001	0.388844	1001	0.037647
H2	1002	-0.000011	1002	0.000045	1002	0.000004
C	6000	-0.397307	6000	0.277778	6000	0.026893
N14	7014	-0.553838	7014	0.332120	7014	0.032155
N15	7015	-0.002167	7015	0.001213	7015	0.000117
Elemental						
H	1000	-0.046681	1000	0.388889	1000	0.037651
C	6000	-0.397307	6000	0.277778	6000	0.026893
N	7000	-0.556012	7000	0.333333	7000	0.032272
Comments and References						
Density and formula from Table 51.2 of Reactor Handbook 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.						

213. Mercuric Iodide

Formula = HgI2 Molecular Weight (g/mole) = 454.400940
Density (g/cm3) = 6.36 Total Atom Weight (atoms/b-cm) = 2.529E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						

I127	53127	-0.558557	53127	0.666667	53127	0.016858
Hg	80000	-0.441443	80000	0.333333	80000	0.008429
Elemental						
I	53000	-0.558557	53000	0.666667	53000	0.016858
Hg	80000	-0.441443	80000	0.333333	80000	0.008429
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=196. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-76, for Mercury (II) Iodide. MatWeb Material Property Data www.matweb.com lists density of 6.28 g/cm3 for 'mercury (II) iodide'.						

214. Mercury

Formula = Hg			Molecular Weight (g/mole) = 200.592000			
Density (g/cm3) = 13.546			Total Atom Weight (atoms/b-cm) = 4.067E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Hg	80000	-1.000000	80000	1.000000	80000	0.040668
Elemental						
Hg	80000	-1.000000	80000	1.000000	80000	0.040668
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=080.						

215. Methane

Formula = CH4			Molecular Weight (g/mole) = 16.042500			
Density (g/cm3) = 0.000667151			Total Atom Weight (atoms/b-cm) = 1.250E-04			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.251260	1001	0.799908	1001	0.000100
H2	1002	-0.000058	1002	0.000092	1002	0.000000
C	6000	-0.748674	6000	0.200000	6000	0.000025
Elemental						
H	1000	-0.251326	1000	0.800000	1000	0.000100
C	6000	-0.748674	6000	0.200000	6000	0.000025
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=197. MatWeb Material Property Data www.matweb.com lists a density of 0.5547 g/cm3 for liquid.NIH PubChem						

pubchem.ncbi.nlm.nih.gov lists densities of 0.415-0.45 g/cm3 and 0.422 g/cm3 at very cold temperatures as well as 0.7168 g/liter at 0-4° C.

216. Methanol

Formula = CH4O Molecular Weight (g/mole) = 32.041900
Density (g/cm3) = 0.7914 Total Atom Weight (atoms/b-cm) = 8.924E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.125799	1001	0.666589	1001	0.059489
H2	1002	-0.000029	1002	0.000077	1002	0.000007
C	6000	-0.374840	6000	0.166667	6000	0.014874
O16	8016	-0.497974	8016	0.166262	8016	0.014838
O17	8017	-0.000202	8017	0.000063	8017	0.000006
O18	8018	-0.001152	8018	0.000342	8018	0.000030
Elemental						
H	1000	-0.125832	1000	0.666666	1000	0.059496
C	6000	-0.374840	6000	0.166667	6000	0.014874
O	8000	-0.499327	8000	0.166667	8000	0.014874

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=198. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 3-326.Also called methyl alcohol (Table 51.120 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960). MatWeb Material Property Data www.matweb.com lists densities of 0.7913, 0.7914 and 0.791 – 0.793 g/cm3 for different manufacture's methanol (methyl alcohol). NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 0.7866, 0.79, 0.792, and 0.8100 g/cm3 at different temperatures from different sources.

217. Methylene Chloride

Formula = CH2Cl2 Molecular Weight (g/mole) = 84.929550
Density (g/cm3) = 1.3266 Total Atom Weight (atoms/b-cm) = 4.703E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.023730	1001	0.399954	1001	0.018811
H2	1002	-0.000005	1002	0.000046	1002	0.000002
C	6000	-0.141418	6000	0.200000	6000	0.009407
Cl35	17035	-0.623868	17035	0.303040	17035	0.014253
Cl37	17037	-0.211011	17037	0.096960	17037	0.004560
Elemental						
H	1000	-0.023737	1000	0.400000	1000	0.018813

C	6000	-0.141418	6000	0.200000	6000	0.009407
Cl	17000	-0.834845	17000	0.400000	17000	0.018813
Comments and References						
Formula and density from MatWeb www.matweb.com. Densities of 1.318-1.329 g/cm3 are also listed. Formula and density also in CRC Handbook of Chemistry and Physics, 89th edition (www.hbcpnetbase.com), page 3-156. NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 1.3, 1.322, 1.3255, and 1.33 g/cm3 from different sources.						

218. Molybdenum

Formula = Mo			Molecular Weight (g/mole) = 95.950000			
Density (g/cm3) = 10.22			Total Atom Weight (atoms/b-cm) = 6.414E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Mo	42000	-1.000000	42000	1.000000	42000	0.064144
Elemental						
Mo	42000	-1.000000	42000	1.000000	42000	0.064144
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=042. MatWeb Material Property Data www.matweb.com lists density 10.22 g/cm3. NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 10.2 and 10.28 g/cm3 from different sources.						

219. Monosodium Titanate, MST

Formula = NaTi2O5H			Molecular Weight (g/mole) = 199.728744			
Density (g/cm3) = 1			Total Atom Weight (atoms/b-cm) = 2.714E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.005045	1001	0.111098	1001	0.003015
H2	1002	-0.000001	1002	0.000013	1002	0.000000
O16	8016	-0.399443	8016	0.554206	8016	0.015039
O17	8017	-0.000162	8017	0.000211	8017	0.000006
O18	8018	-0.000924	8018	0.001139	8018	0.000031
Na23	11023	-0.115105	11023	0.111111	11023	0.003015
Ti	22000	-0.479320	22000	0.222222	22000	0.006030
Elemental						
H	1000	-0.005047	1000	0.111111	1000	0.003015
O	8000	-0.400528	8000	0.555556	8000	0.015076
Na	11000	-0.115105	11000	0.111111	11000	0.003015
Ti	22000	-0.479320	22000	0.222222	22000	0.006030

Comments and References
Formula from www.osti.gov/bridge/purl.cover.jsp?purl=/881358-Y9ExpG/. MST is normally used in a solution: WSRC-TR-2000-00142, Phase V Simulant Testing of MonosodiumTitanate Adsorption Kinetics, by D. T. Hobbs, M. S. Blume, and H. L. Thacker, Westinghouse Savannah River CompanyTitanate Adsorption Kinetics by D. T. Hobbs, et al, Westinghouse Savannah River Company. Since it is not used as a solid and a reference for the density as a solid could not be located, 1.0 g/cm3 was assumed.

220. Mortar

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.97 Total Atom Weight (atoms/b-cm) = 5.790E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Al27	13027	-0.232525	13027	0.176573	13027	0.010224
Ca	20000	-0.002186	20000	0.001118	20000	0.000065
O16	8016	-0.486782	8016	0.623554	8016	0.036105
O17	8017	-0.000197	8017	0.000238	8017	0.000014
O18	8018	-0.001126	8018	0.001281	8018	0.000074
Fe	26000	-0.011408	26000	0.004185	26000	0.000242
K	19000	-0.007616	19000	0.003991	19000	0.000231
Na23	11023	-0.020418	11023	0.018197	11023	0.001054
Si	14000	-0.229189	14000	0.167202	14000	0.009681
Ti	22000	-0.008553	22000	0.003661	22000	0.000212
Elemental						
Al	13000	-0.232525	13000	0.176573	13000	0.010224
Ca	20000	-0.002186	20000	0.001118	20000	0.000065
O	8000	-0.488105	8000	0.625073	8000	0.036193
Fe	26000	-0.011408	26000	0.004185	26000	0.000242
K	19000	-0.007616	19000	0.003991	19000	0.000231
Na	11000	-0.020418	11000	0.018197	11000	0.001054
Si	14000	-0.229189	14000	0.167202	14000	0.009681
Ti	22000	-0.008553	22000	0.003661	22000	0.000212

Comments and References

Composition and density are from MatWeb at http://www.matweb.com/search/DataSheet.aspx?MatGUID=9bc4f6f6a2e9463cbf4633a9fa412c25 and https://www.sheffield-pottery.com/Blakbond-Mortar-for-IFB-Soft-Bricks-and-Hard-Brick-p/ncblackbond.htm Density of 2.162 g/cm3 is given at https://www.aqua-calc.com/page/density-table/substance/cement-coma-and-blank-mortar

221. Muscle Equivalent-Liquid, with sucrose

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	1.11		Total Atom Weight (atoms/b-cm) = 1.052E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.098208	1001	0.619185	1001	0.065138
H2	1002	-0.000023	1002	0.000071	1002	0.000007
C	6000	-0.156214	6000	0.082644	6000	0.008694
N14	7014	-0.035312	7014	0.016024	7014	0.001686
N15	7015	-0.000138	7015	0.000059	7015	0.000006
O16	8016	-0.708177	8016	0.281331	8016	0.029596
O17	8017	-0.000287	8017	0.000107	8017	0.000011
O18	8018	-0.001638	8018	0.000578	8018	0.000061
Elemental						
H	1000	-0.098234	1000	0.619257	1000	0.065146
C	6000	-0.156214	6000	0.082644	6000	0.008694
N	7000	-0.035451	7000	0.016082	7000	0.001692
O	8000	-0.710101	8000	0.282017	8000	0.029668
Comments and References						
Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=203.						

222. Muscle Equivalent-Liquid, without sucrose

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	1.07		Total Atom Weight (atoms/b-cm) = 1.032E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101942	1001	0.631801	1001	0.065178
H2	1002	-0.000023	1002	0.000073	1002	0.000007
C	6000	-0.120058	6000	0.062437	6000	0.006441
N14	7014	-0.035312	7014	0.015751	7014	0.001625
N15	7015	-0.000138	7015	0.000058	7015	0.000006
O16	8016	-0.740510	8016	0.289176	8016	0.029832
O17	8017	-0.000300	8017	0.000110	8017	0.000011
O18	8018	-0.001712	8018	0.000594	8018	0.000061
Elemental						
H	1000	-0.101969	1000	0.631874	1000	0.065186
C	6000	-0.120058	6000	0.062437	6000	0.006441
N	7000	-0.035451	7000	0.015809	7000	0.001631
O	8000	-0.742522	8000	0.289880	8000	0.029905

Comments and References
Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=204.

223. Muscle, Skeletal

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.04 Total Atom Weight (atoms/b-cm) = 9.911E-02

Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.100610	1001	0.630851	1001	0.062523
H2	1002	-0.000023	1002	0.000073	1002	0.000007
C	6000	-0.107830	6000	0.056734	6000	0.005623
N14	7014	-0.027572	7014	0.012443	7014	0.001233
N15	7015	-0.000108	7015	0.000045	7015	0.000005
O16	8016	-0.752728	8016	0.297389	8016	0.029474
O17	8017	-0.000305	8017	0.000113	8017	0.000011
O18	8018	-0.001741	8018	0.000611	8018	0.000061
Na23	11023	-0.000750	11023	0.000206	11023	0.000020
Mg	12000	-0.000190	12000	0.000049	12000	0.000005
P31	15031	-0.001800	15031	0.000367	15031	0.000036
S	16000	-0.002410	16000	0.000475	16000	0.000047
Cl35	17035	-0.000590	17035	0.000107	17035	0.000011
Cl37	17037	-0.000200	17037	0.000034	17037	0.000003
K	19000	-0.003020	19000	0.000488	19000	0.000048
Ca	20000	-0.000030	20000	0.000005	20000	0.000000
Fe	26000	-0.000040	26000	0.000005	26000	0.000000
Zn	30000	-0.000050	30000	0.000005	30000	0.000000
Elemental						
H	1000	-0.100637	1000	0.630924	1000	0.062531
C	6000	-0.107830	6000	0.056734	6000	0.005623
N	7000	-0.027680	7000	0.012488	7000	0.001238
O	8000	-0.754773	8000	0.298113	8000	0.029546
Na	11000	-0.000750	11000	0.000206	11000	0.000020
Mg	12000	-0.000190	12000	0.000049	12000	0.000005
P	15000	-0.001800	15000	0.000367	15000	0.000036
S	16000	-0.002410	16000	0.000475	16000	0.000047
Cl	17000	-0.000790	17000	0.000141	17000	0.000014
K	19000	-0.003020	19000	0.000488	19000	0.000048
Ca	20000	-0.000030	20000	0.000005	20000	0.000000
Fe	26000	-0.000040	26000	0.000005	26000	0.000000
Zn	30000	-0.000050	30000	0.000005	30000	0.000000

Comments and References
Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=201.

224. Muscle, Striated

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.04 Total Atom Weight (atoms/b-cm) = 1.001E-01

Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101970	1001	0.633019	1001	0.063368
H2	1002	-0.000023	1002	0.000073	1002	0.000007
C	6000	-0.123000	6000	0.064072	6000	0.006414
N14	7014	-0.034863	7014	0.015577	7014	0.001559
N15	7015	-0.000136	7015	0.000057	7015	0.000006
O16	8016	-0.727028	8016	0.284380	8016	0.028468
O17	8017	-0.000294	8017	0.000108	8017	0.000011
O18	8018	-0.001681	8018	0.000584	8018	0.000059
Na23	11023	-0.000800	11023	0.000218	11023	0.000022
Mg	12000	-0.000200	12000	0.000051	12000	0.000005
P31	15031	-0.002000	15031	0.000404	15031	0.000040
S	16000	-0.005000	16000	0.000976	16000	0.000098
K	19000	-0.003000	19000	0.000480	19000	0.000048
Elemental						
H	1000	-0.101997	1000	0.633092	1000	0.063376
C	6000	-0.123000	6000	0.064072	6000	0.006414
N	7000	-0.035000	7000	0.015634	7000	0.001565
O	8000	-0.729003	8000	0.285073	8000	0.028537
Na	11000	-0.000800	11000	0.000218	11000	0.000022
Mg	12000	-0.000200	12000	0.000051	12000	0.000005
P	15000	-0.002000	15000	0.000404	15000	0.000040
S	16000	-0.005000	16000	0.000976	16000	0.000098
K	19000	-0.003000	19000	0.000480	19000	0.000048

Comments and References

Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=202.See also The International Commission on Radiological Protection,ICRP PUBLICATION 89, Basic Anatomical and Physiological Data for Use in Radiological Protection: Refence Values, J. Valentin, Editor, 2003 ICRP Published by Elsevier Science Ltd.

225. NE-213 Equivalent

Formula = C8H10 Molecular Weight (g/mole) = 106.164550
Density (g/cm3) = 0.874 Total Atom Weight (atoms/b-cm) = 8.924E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.905055	6000	0.444444	6000	0.039662
H1	1001	-0.094920	1001	0.555492	1001	0.049572
H2	1002	-0.000022	1002	0.000064	1002	0.000006
Elemental						
C	6000	-0.905055	6000	0.444444	6000	0.039662
H	1000	-0.094945	1000	0.555556	1000	0.049577

Comments and References

Density and formula from http://dx.doi.org/10.1016/j.apradiso.2015.06.008 and also density from https://www.southernscientific.co.uk/data/file/9/5/Table%20of%20Physical%20Constants%20of%20Scintillators.1438855290.pdf

226. Neon

Formula = Ne Molecular Weight (g/mole) = 20.179700
Density (g/cm3) = 0.000838505 Total Atom Weight (atoms/b-cm) = 2.500E-05

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ne20	10020	-0.896404	10020	0.904800	10020	0.000023
Ne21	10021	-0.002809	10021	0.002700	10021	0.000000
Ne22	10022	-0.100804	10022	0.092500	10022	0.000002
Elemental						
Ne	10000	-1.000000	10000	1.000000	10000	0.000025

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=010. MatWeb Material Property Data www.matweb.com lists density 0.000825 g/cm3.NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 0.825 g/L.

227. Nickel

Formula = Ni Molecular Weight (g/mole) = 58.693400
Density (g/cm3) = 8.902 Total Atom Weight (atoms/b-cm) = 9.134E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ni	28000	-1.000000	28000	1.000000	28000	0.091338
Elemental						
Ni	28000	-1.000000	28000	1.000000	28000	0.091338

Comments and References
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=028. MatWeb Material Property Data www.matweb.com lists density 8.88 g/cm3.NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 8.9, 8.90, and 8.908 g/cm3 from different sources.

228. Niobium

Formula = Nb Molecular Weight (g/mole) = 92.906370
Density (g/cm3) = 8.57 Total Atom Weight (atoms/b-cm) = 5.555E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Nb93	41093	-1.000000	41093	1.000000	41093	0.055550
Elemental						
Nb	41000	-1.000000	41000	1.000000	41000	0.055550

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=041. MatWeb Material Property Data www.matweb.com lists density of 8.60 g/cm3.

229. Nitrogen

Formula = N2 Molecular Weight (g/mole) = 28.013710
Density (g/cm3) = 0.00116528 Total Atom Weight (atoms/b-cm) = 5.000E-05

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
N14	7014	-0.996091	7014	0.996360	7014	0.000050
N15	7015	-0.003898	7015	0.003640	7015	0.000000
Elemental						
N	7000	-1.000000	7000	1.000000	7000	0.000050

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=007. MatWeb Material Property Data www.matweb.com lists density of 0.001145 g/cm3. NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 1.251 g/L.

230. Nylon, Dupont ELVAmide 8062

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.08 Total Atom Weight (atoms/b-cm) = 1.126E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.103482	1001	0.593285	1001	0.066781
H2	1002	-0.000024	1002	0.000068	1002	0.000008
C	6000	-0.648416	6000	0.311942	6000	0.035113
N14	7014	-0.099147	7014	0.040911	7014	0.004605
N15	7015	-0.000388	7015	0.000149	7015	0.000017
O16	8016	-0.148137	8016	0.053514	8016	0.006024
O17	8017	-0.000060	8017	0.000020	8017	0.000002
O18	8018	-0.000343	8018	0.000110	8018	0.000012
Elemental						
H	1000	-0.103509	1000	0.593353	1000	0.066789
C	6000	-0.648416	6000	0.311942	6000	0.035113
N	7000	-0.099536	7000	0.041061	7000	0.004622
O	8000	-0.148539	8000	0.053644	8000	0.006038

Comments and References

Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=208.

231. Nylon, Type 11 (Rilsan)

Formula = C11H21NO Molecular Weight (g/mole) = 183.290330
Density (g/cm3) = 1.425 Total Atom Weight (atoms/b-cm) = 1.592E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.115456	1001	0.617576	1001	0.098310
H2	1002	-0.000027	1002	0.000071	1002	0.000011
C	6000	-0.720805	6000	0.323529	6000	0.051501
N14	7014	-0.076120	7014	0.029305	7014	0.004665
N15	7015	-0.000298	7015	0.000107	7015	0.000017
O16	8016	-0.087053	8016	0.029340	8016	0.004671
O17	8017	-0.000035	8017	0.000011	8017	0.000002
O18	8018	-0.000201	8018	0.000060	8018	0.000010
Elemental						
H	1000	-0.115486	1000	0.617647	1000	0.098321
C	6000	-0.720805	6000	0.323529	6000	0.051501
N	7000	-0.076419	7000	0.029412	7000	0.004682
O	8000	-0.087290	8000	0.029412	8000	0.004682

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=211.en.wikipedia.org/wiki/Nylon_11 lists a density range of 1.03-1.05 g/cm3.

232. Nylon, Type 6 and Type 6/6

Formula = C6H11NO	Molecular Weight (g/mole) = 113.157580					
Density (g/cm3) = 1.14	Total Atom Weight (atoms/b-cm) = 1.153E-01					
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.097959	1001	0.578881	1001	0.066729
H2	1002	-0.000023	1002	0.000067	1002	0.000008
C	6000	-0.636843	6000	0.315789	6000	0.036402
N14	7014	-0.123298	7014	0.052440	7014	0.006045
N15	7015	-0.000483	7015	0.000192	7015	0.000022
O16	8016	-0.141007	8016	0.052504	8016	0.006052
O17	8017	-0.000057	8017	0.000020	8017	0.000002
O18	8018	-0.000326	8018	0.000108	8018	0.000012
Elemental						
H	1000	-0.097985	1000	0.578947	1000	0.066737
C	6000	-0.636843	6000	0.315789	6000	0.036402
N	7000	-0.123782	7000	0.052632	7000	0.006067
O	8000	-0.141390	8000	0.052632	8000	0.006067
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=209. Formula from page 138 of LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009.This nylon is an example of a polyamide, which is sometimes abbreviated PI, and has the formula (C6H11ON)n on page II.F.1-6 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf). en.wikipedia.org/wiki/Nylon shows 'Nylon 6' as NH−(CH2)5−CO. en.wikipedia.org/wiki/Nylon_11 lists a density range of Nylon 6 as 1.13-1.16 g/cm3.						

233. Nylon, Type 6/10

Formula = C8H15NO	Molecular Weight (g/mole) = 141.210680					
Density (g/cm3) = 1.14	Total Atom Weight (atoms/b-cm) = 1.215E-01					
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.107043	1001	0.599931	1001	0.072917
H2	1002	-0.000025	1002	0.000069	1002	0.000008
C	6000	-0.680436	6000	0.320000	6000	0.038894
N14	7014	-0.098803	7014	0.039854	7014	0.004844
N15	7015	-0.000387	7015	0.000146	7015	0.000018
O16	8016	-0.112995	8016	0.039903	8016	0.004850

O17	8017	-0.000046	8017	0.000015	8017	0.000002
O18	8018	-0.000261	8018	0.000082	8018	0.000010
Elemental						
H	1000	-0.107071	1000	0.600000	1000	0.072926
C	6000	-0.680436	6000	0.320000	6000	0.038894
N	7000	-0.099191	7000	0.040000	7000	0.004862
O	8000	-0.113302	8000	0.040000	8000	0.004862
Comments and References						
Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=210. en.wikipedia.org/wiki/Nylon shows 'Nylon 6,10 (or 610)' as NH−(CH2)6−NH−CO−(CH2)8−CO.						

234. Oil, Crude (Heavy, Cold Lake, Canada)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.97 Total Atom Weight (atoms/b-cm) = 1.023E-01

Crude oil is called heavy if its density is over 0.933 g/cm3. It is distinguished from light crude oil because it has a higher viscosity and a heavier molecular composition: en.wikipedia.org/wiki/Heavy_crude_oil.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.103973	1001	0.588807	1001	0.060264
H2	1002	-0.000024	1002	0.000068	1002	0.000007
C	6000	-0.837000	6000	0.397741	6000	0.040708
N14	7014	-0.003984	7014	0.001624	7014	0.000166
N15	7015	-0.000016	7015	0.000006	7015	0.000001
O16	8016	-0.010970	8016	0.003914	8016	0.000401
O17	8017	-0.000004	8017	0.000001	8017	0.000000
O18	8018	-0.000025	8018	0.000008	8018	0.000001
S	16000	-0.044000	16000	0.007831	16000	0.000802
Elemental						
H	1000	-0.104000	1000	0.588874	1000	0.060271
C	6000	-0.837000	6000	0.397741	6000	0.040708
N	7000	-0.004000	7000	0.001630	7000	0.000167
O	8000	-0.011000	8000	0.003924	8000	0.000402
S	16000	-0.044000	16000	0.007831	16000	0.000802
Comments and References						
Weight fractions from Table 4.1 of Handbook of Petroleum Analysis by James G. Speight, 2001 by John Wiley and Sons, ISBN 0-471-36167-4 on Knovel Database.Density range for heavy oil is 0.92 to 1.02 g/cm3 (meeting.helcom.fi/c/document_library/get_file?folderId=74984.pdf). The composition of this oil is very similar to Mexican crude which has a density of 0.975 g/cm3: Table 7.1.8 of Mark's Standard Handbook for Mechanical Engineers, 10th edition.						

235. Oil, Crude (Heavy, Mexican)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.975 Total Atom Weight (atoms/b-cm) = 1.031E-01

Crude oil is called heavy if its density is over 0.933 g/cm3. It is distinguished from light crude oil because it has a higher viscosity and a heavier molecular composition: en.wikipedia.org/wiki/Heavy_crude_oil. Weight fractions adjusted so that elements sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.104012	1001	0.587673	1001	0.060597
H2	1002	-0.000024	1002	0.000068	1002	0.000007
C	6000	-0.853733	6000	0.404760	6000	0.041736
S	16000	-0.042228	16000	0.007499	16000	0.000773
Elemental						
H	1000	-0.104039	1000	0.587741	1000	0.060604
C	6000	-0.853733	6000	0.404760	6000	0.041736
S	16000	-0.042228	16000	0.007499	16000	0.000773

Comments and References

Density and weight fractions from Table 7.1.8 of Mark's Standard Handbook for Mechanical Engineers, 10th edition, 1966.Other types of fuel oil are in Table 51.99 of Reactor Handbook, 2nd ed, Vol. 1, Materials, C.R. Tipton, 1960.

236. Oil, Crude (Heavy, Qayarah, Iraq)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.97 Total Atom Weight (atoms/b-cm) = 1.002E-01

Crude oil is called heavy if its density is over 0.933 g/cm3. It is distinguished from light crude oil because it has a higher viscosity and a heavier molecular composition: en.wikipedia.org/wiki/Heavy_crude_oil. Weight fractions adjusted so that elements sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101973	1001	0.589968	1001	0.059105
H2	1002	-0.000023	1002	0.000068	1002	0.000007
C	6000	-0.807000	6000	0.391776	6000	0.039249
N14	7014	-0.006973	7014	0.002903	7014	0.000291
N15	7015	-0.000027	7015	0.000011	7015	0.000001
S	16000	-0.084000	16000	0.015274	16000	0.001530
Elemental						
H	1000	-0.102000	1000	0.590036	1000	0.059112

C	6000	-0.807000	6000	0.391776	6000	0.039249
N	7000	-0.007000	7000	0.002914	7000	0.000292
S	16000	-0.084000	16000	0.015274	16000	0.001530
Comments and References						
Weight fractions from Table 4.1 of Handbook of Petroleum Analysis by James G. Speight, 2001 by John Wiley and Sons, ISBN 0-471-36167-4 on Knovel Database. Density range for heavy oil is 0.92 to 1.02 g/cm3 (meeting.helcom.fi/c/document_library/get_file?folderId=74984...pdf).						

237. Oil, Crude (Light, Texas)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.875 Total Atom Weight (atoms/b-cm) = 1.024E-01

Weight fractions adjusted so that elements sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.123214	1001	0.629305	1001	0.064422
H2	1002	-0.000028	1002	0.000072	1002	0.000007
C	6000	-0.852205	6000	0.365230	6000	0.037389
N14	7014	-0.006987	7014	0.002568	7014	0.000263
N15	7015	-0.000027	7015	0.000009	7015	0.000001
S	16000	-0.017535	16000	0.002815	16000	0.000288
Elemental						
H	1000	-0.123246	1000	0.629377	1000	0.064429
C	6000	-0.852205	6000	0.365230	6000	0.037389
N	7000	-0.007014	7000	0.002578	7000	0.000264
S	16000	-0.017535	16000	0.002815	16000	0.000288
Comments and References						
Density and weight fractions from Table 7.1.8 of Mark's Standard Handbook for Mechanical Engineers, 10th edition, 1966.Density and composition for other domestic sources of crude oil listed in Table 7.1.8 of Mark's Handbook and in Table 51.97 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.						

238. Oil, Fuel (Calif.)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.955 Total Atom Weight (atoms/b-cm) = 1.133E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Other types of fuel oil are in Table 51.99 of Reactor Handbook, 2nd ed, Vol. 1, Materials, C.R. Tipton, 1960. Weight fractions adjusted so that elements sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.125845	1001	0.633698	1001	0.071813
H2	1002	-0.000029	1002	0.000073	1002	0.000008
C	6000	-0.862308	6000	0.364359	6000	0.041291
S	16000	-0.011814	16000	0.001870	16000	0.000212
Elemental						
H	1000	-0.125878	1000	0.633771	1000	0.071821
C	6000	-0.862308	6000	0.364359	6000	0.041291
S	16000	-0.011814	16000	0.001870	16000	0.000212
Comments and References						
Density and weight fractions from Table 7.1.8 of Mark's Standard Handbook for Mechanical Engineers, 10th edition, 1966.						

239. Oil, Hydraulic

Formula = C40H33O4Cl6P Molecular Weight (g/mole) = 821.367537
Density (g/cm3) = 0.871 Total Atom Weight (atoms/b-cm) = 5.364E-02

Mineral oil is typically around 0.870 g/cm3.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.040487	1001	0.392812	1001	0.021072
H2	1002	-0.000009	1002	0.000045	1002	0.000002
C	6000	-0.584908	6000	0.476190	6000	0.025544
O16	8016	-0.077705	8016	0.047503	8016	0.002548
O17	8017	-0.000031	8017	0.000018	8017	0.000001
O18	8018	-0.000180	8018	0.000098	8018	0.000005
P31	15031	-0.037710	15031	0.011905	15031	0.000639
Cl35	17035	-0.193524	17035	0.054114	17035	0.002903
Cl37	17037	-0.065456	17037	0.017314	17037	0.000929
Elemental						
H	1000	-0.040497	1000	0.392857	1000	0.021074
C	6000	-0.584908	6000	0.476190	6000	0.025544
O	8000	-0.077916	8000	0.047619	8000	0.002554
P	15000	-0.037710	15000	0.011905	15000	0.000639
Cl	17000	-0.258969	17000	0.071429	17000	0.003832
Comments and References						
Density = 0.871 g/cm3 from MatWeb www.matweb.com 'Phillip 66 100 Super Hydraulic Oil'Formula from page II.F.1-5 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf), but its density = 1.28 g/cm3 which seems high.Density = 0.89 g/cm3 for Hy-Gard hydraulic/transmission oil (www.deere.com/en_US/parts/partsinfo/oils_and_lubricants/oil_hydraulic.html).						

Density = 0.873 g/cm3 for ESSO grade 46 anti-wear hydraulic oil (www.imperialoil.ca/.../IOCAENINDESHydraulic_Oil_AW.pdf).

240. Oil, Lard

Formula = C10H18O Molecular Weight (g/mole) = 154.248950
Density (g/cm3) = 0.915 Total Atom Weight (atoms/b-cm) = 1.036E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.117594	1001	0.620617	1001	0.064294
H2	1002	-0.000027	1002	0.000071	1002	0.000007
C	6000	-0.778650	6000	0.344828	6000	0.035723
O16	8016	-0.103443	8016	0.034399	8016	0.003564
O17	8017	-0.000042	8017	0.000013	8017	0.000001
O18	8018	-0.000239	8018	0.000071	8018	0.000007
Elemental						
H	1000	-0.117625	1000	0.620689	1000	0.064302
C	6000	-0.778650	6000	0.344828	6000	0.035723
O	8000	-0.103725	8000	0.034483	8000	0.003572

Comments and References

Density and formula from page II.F.1-5 of ARH-600 (ncsp.llnl.gov/docs/ARH600_Vol_I.pdf). MatWeb www.matweb.com also lists density of 0.915 g/cm3

241. Oxygen

Formula = O2 Molecular Weight (g/mole) = 31.998800
Density (g/cm3) = 0.00133151 Total Atom Weight (atoms/b-cm) = 5.000E-05

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.997290	8016	0.997570	8016	0.000050
O17	8017	-0.000404	8017	0.000380	8017	0.000000
O18	8018	-0.002306	8018	0.002050	8018	0.000000
Elemental						
O	8000	-1.000000	8000	1.000000	8000	0.000050

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=008. MatWeb Material Property Data www.matweb.com lists density of 0.001308 g/cm3.NIH PubChem pubchem.ncbi.nlm.nih.gov lists densities of 1.429 g/L at 0° C.

242. P-10 gas

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.001561 Total Atom Weight (atoms/b-cm) = 3.600E-05

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.010732	1001	0.285681	1001	0.000010
H2	1002	-0.000002	1002	0.000033	1002	0.000000
C	6000	-0.031979	6000	0.071429	6000	0.000003
Ar	18000	-0.957286	18000	0.642857	18000	0.000023
Elemental						
H	1000	-0.010735	1000	0.285714	1000	0.000010
C	6000	-0.031979	6000	0.071429	6000	0.000003
Ar	18000	-0.957286	18000	0.642857	18000	0.000023

Comments and References

This density is calculated for T = 20 C and P = 1 atmosphere using the ideal gas law.Formula from page 171 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley and Sons, 2000: P-10 is 90% Ar and 10% CH4. This is assumed to mean volume %.

243. P-5 gas

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.001611 Total Atom Weight (atoms/b-cm) = 3.000E-05

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.005201	1001	0.166648	1001	0.000005
H2	1002	-0.000001	1002	0.000019	1002	0.000000
C	6000	-0.015496	6000	0.041667	6000	0.000001
Ar	18000	-0.979302	18000	0.791666	18000	0.000024
Elemental						
H	1000	-0.005202	1000	0.166667	1000	0.000005
C	6000	-0.015496	6000	0.041667	6000	0.000001
Ar	18000	-0.979302	18000	0.791666	18000	0.000024

Comments and References

This density is calculated for T = 20 C and P = 1 atmosphere using the ideal gas law. Formula from page 171 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, John Wiley and Sons, 2000: P-5 is 95% Ar and 5% CH4. Assumed to mean volume %.

244. P-terphenyl

Formula = C18H14			Molecular Weight (g/mole) = 230.302450			
Density (g/cm3) = 1.28			Total Atom Weight (atoms/b-cm) = 1.071E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.061258	1001	0.437450	1001	0.046853
H2	1002	-0.000014	1002	0.000050	1002	0.000005
C	6000	-0.938726	6000	0.562500	6000	0.060247
Elemental						
H	1000	-0.061274	1000	0.437500	1000	0.046859
C	6000	-0.938726	6000	0.562500	6000	0.060247
Comments and References						
Formula and density from CRC 100th edition NIH PubChem lists densities of 1.23 and 1.234 g/cm3						

245. Palladium

Formula = Pd			Molecular Weight (g/mole) = 106.420000			
Density (g/cm3) = 12.02			Total Atom Weight (atoms/b-cm) = 6.802E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pd102	46102	-0.009767	46102	0.010200	46102	0.000694
Pd104	46104	-0.108766	46104	0.111400	46104	0.007577
Pd105	46105	-0.220121	46105	0.223300	46105	0.015189
Pd106	46106	-0.271974	46106	0.273300	46106	0.018590
Pd108	46108	-0.268290	46108	0.264600	46108	0.017998
Pd110	46110	-0.121038	46110	0.117200	46110	0.007972
Elemental						
Pd	46000	-1.000000	46000	1.000000	46000	0.068019
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=046.						

246. Paper, News print

Formula = C6H10O5			Molecular Weight (g/mole) = 162.140350			
Density (g/cm3) = 0.65			Total Atom Weight (atoms/b-cm) = 5.070E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						

H1	1001	-0.062150	1001	0.476136	1001	0.024139
H2	1002	-0.000014	1002	0.000055	1002	0.000003
C	6000	-0.444452	6000	0.285714	6000	0.014485
O16	8016	-0.492044	8016	0.237517	8016	0.012042
O17	8017	-0.000199	8017	0.000090	8017	0.000005
O18	8018	-0.001138	8018	0.000488	8018	0.000025
Elemental						
H	1000	-0.062167	1000	0.476190	1000	0.024142
C	6000	-0.444452	6000	0.285714	6000	0.014485
O	8000	-0.493381	8000	0.238095	8000	0.012071
Comments and References						
Cellulose is a natural organic compound plant cell walls. It forms the basis of paper and cardboard. PubChem.ncbi.nlm.nih.gov lists the molecular formula as (C6H10O5)n or C12H22O11 with a density range of 1.27-1.61 g/cm^3. Densities for paper are given at http://www.paperonweb.com/density.htm, the average density is used for news print paper						

247. Paper, glossy

Formula = C6H10O5 Molecular Weight (g/mole) = 162.140350
Density (g/cm3) = 1.135 Total Atom Weight (atoms/b-cm) = 8.853E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.062150	1001	0.476136	1001	0.042151
H2	1002	-0.000014	1002	0.000055	1002	0.000005
C	6000	-0.444452	6000	0.285714	6000	0.025293
O16	8016	-0.492044	8016	0.237517	8016	0.021027
O17	8017	-0.000199	8017	0.000090	8017	0.000008
O18	8018	-0.001138	8018	0.000488	8018	0.000043
Elemental						
H	1000	-0.062167	1000	0.476190	1000	0.042156
C	6000	-0.444452	6000	0.285714	6000	0.025293
O	8000	-0.493381	8000	0.238095	8000	0.021078
Comments and References						
Cellulose is a natural organic compound plant cell walls. It forms the basis of paper and cardboard. PubChem.ncbi.nlm.nih.gov lists the molecular formula as (C6H10O5)n or C12H22O11 with a density range of 1.27-1.61 g/cm^3. Densities for paper are given at http://www.paperonweb.com/density.htm the average density is used						

248. Paper, printer

Formula = C6H10O5			Molecular Weight (g/mole) = 162.140350			
Density (g/cm3) = 0.69			Total Atom Weight (atoms/b-cm) = 5.382E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.062150	1001	0.476136	1001	0.025625
H2	1002	-0.000014	1002	0.000055	1002	0.000003
C	6000	-0.444452	6000	0.285714	6000	0.015377
O16	8016	-0.492044	8016	0.237517	8016	0.012783
O17	8017	-0.000199	8017	0.000090	8017	0.000005
O18	8018	-0.001138	8018	0.000488	8018	0.000026
Elemental						
H	1000	-0.062167	1000	0.476190	1000	0.025628
C	6000	-0.444452	6000	0.285714	6000	0.015377
O	8000	-0.493381	8000	0.238095	8000	0.012814
Comments and References						
Cellulose is a natural organic compound plant cell walls. It forms the basis of paper and cardboard. PubChem.ncbi.nlm.nih.gov lists the molecular formula as (C6H10O5)n or C12H22O11 with a density range of 1.27-1.61 g/cm^3. Densities for paper are given at http://www.paperonweb.com/density.htm						

249. Photographic Emulsion, Gel in

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) = 1.2914			Total Atom Weight (atoms/b-cm) = 1.145E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.081159	1001	0.546880	1001	0.062627
H2	1002	-0.000019	1002	0.000063	1002	0.000007
C	6000	-0.416060	6000	0.235252	6000	0.026940
N14	7014	-0.110805	7014	0.053738	7014	0.006154
N15	7015	-0.000434	7015	0.000196	7015	0.000022
O16	8016	-0.379609	8016	0.161175	8016	0.018457
O17	8017	-0.000154	8017	0.000061	8017	0.000007
O18	8018	-0.000878	8018	0.000331	8018	0.000038
S	16000	-0.010880	16000	0.002304	16000	0.000264
Elemental						
H	1000	-0.081180	1000	0.546943	1000	0.062634
C	6000	-0.416060	6000	0.235252	6000	0.026940
N	7000	-0.111240	7000	0.053934	7000	0.006176
O	8000	-0.380640	8000	0.161567	8000	0.018502
S	16000	-0.010880	16000	0.002304	16000	0.000264

Comments and References
Density and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=168.

250. Photographic Emulsion, Kodak Type AA

Formula =		Molecular Weight (g/mole) =			
Density (g/cm3) =	2.2	Total Atom Weight (atoms/b-cm) = 9.105E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.030492	1001	0.440233	1001	0.040084
H2	1002	-0.000007	1002	0.000051	1002	0.000005
C	6000	-0.210700	6000	0.255260	6000	0.023242
N14	7014	-0.071818	7014	0.074627	7014	0.006795
N15	7015	-0.000281	7015	0.000273	7015	0.000025
O16	8016	-0.162758	8016	0.148062	8016	0.013481
O17	8017	-0.000066	8017	0.000056	8017	0.000005
O18	8018	-0.000376	8018	0.000304	8018	0.000028
Br79	35079	-0.111544	35079	0.020566	35079	0.001873
Br81	35081	-0.111255	35081	0.020006	35081	0.001822
Ag	47000	-0.300700	47000	0.040562	47000	0.003693
Elemental						
H	1000	-0.030500	1000	0.440284	1000	0.040089
C	6000	-0.210700	6000	0.255260	6000	0.023242
N	7000	-0.072100	7000	0.074899	7000	0.006820
O	8000	-0.163200	8000	0.148422	8000	0.013514
Br	35000	-0.222800	35000	0.040572	35000	0.003694
Ag	47000	-0.300700	47000	0.040562	47000	0.003693
Comments and References						
physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html						

251. Photographic Emulsion, Standard Nuclear

Formula =		Molecular Weight (g/mole) =			
Density (g/cm3) =	3.815	Total Atom Weight (atoms/b-cm) = 7.895E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.014096	1001	0.407026	1001	0.032134
H2	1002	-0.000003	1002	0.000047	1002	0.000004
C	6000	-0.072261	6000	0.175082	6000	0.013822
N14	7014	-0.019244	7014	0.039993	7014	0.003157

N15	7015	-0.000075	7015	0.000146	7015	0.000012
O16	8016	-0.065922	8016	0.119936	8016	0.009469
O17	8017	-0.000027	8017	0.000046	8017	0.000004
O18	8018	-0.000152	8018	0.000246	8018	0.000019
S	16000	-0.001890	16000	0.001715	16000	0.000135
Br79	35079	-0.174778	35079	0.064448	35079	0.005088
Br81	35081	-0.174324	35081	0.062694	35081	0.004950
Ag	47000	-0.474105	47000	0.127904	47000	0.010098
I127	53127	-0.003120	53127	0.000715	53127	0.000056
Elemental						
H	1000	-0.014100	1000	0.407073	1000	0.032138
C	6000	-0.072261	6000	0.175082	6000	0.013822
N	7000	-0.019320	7000	0.040139	7000	0.003169
O	8000	-0.066101	8000	0.120229	8000	0.009492
S	16000	-0.001890	16000	0.001715	16000	0.000135
Br	35000	-0.349104	35000	0.127142	35000	0.010038
Ag	47000	-0.474105	47000	0.127904	47000	0.010098
I	53000	-0.003120	53000	0.000715	53000	0.000056
Comments and References						
physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html						

252. Platinum

Formula = Pt		Molecular Weight (g/mole) = 195.084000			
Density (g/cm3) = 21.45		Total Atom Weight (atoms/b-cm) = 6.621E-02			
	Weight Fractions		Atom Fractions		Atom Densities
Isotopic					
Pt	78000	-1.000000	78000	1.000000	78000	0.066215
Elemental						
Pt	78000	-1.000000	78000	1.000000	78000	0.066215
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=078.						

253. Plutonium Bromide

Formula = PuBr3		Molecular Weight (g/mole) = 478.832966			
Density (g/cm3) = 6.75		Total Atom Weight (atoms/b-cm) = 3.396E-02			
	Weight Fractions		Atom Fractions		Atom Densities
Isotopic					
Br79	35079	-0.250633	35079	0.380175	35079	0.012910

Br81	35081	-0.249982	35081	0.369825	35081	0.012558
Pu238	94238	-0.000250	94238	0.000126	94238	0.000004
Pu239	94239	-0.466923	94239	0.233817	94239	0.007940
Pu240	94240	-0.029963	94240	0.014942	94240	0.000507
Pu241	94241	-0.001998	94241	0.000992	94241	0.000034
Pu242	94242	-0.000250	94242	0.000123	94242	0.000004
Elemental						
Br	35000	-0.500617	35000	0.750000	35000	0.025468
Pu	94238	-0.000250	94238	0.000126	94238	0.000004
Pu	94239	-0.466923	94239	0.233817	94239	0.007940
Pu	94240	-0.029963	94240	0.014942	94240	0.000507
Pu	94241	-0.001998	94241	0.000992	94241	0.000034
Pu	94242	-0.000250	94242	0.000123	94242	0.000004
Comments and References						
Density and formula from MatWeb Material Property Data www.matweb.com Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.						

254. Plutonium Carbide

Formula = PuC			Molecular Weight (g/mole) = 251.131566			
Density (g/cm3) = 13.6			Total Atom Weight (atoms/b-cm) = 6.523E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.047826	6000	0.500000	6000	0.032613
Pu238	94238	-0.000476	94238	0.000251	94238	0.000016
Pu239	94239	-0.890283	94239	0.467635	94239	0.030502
Pu240	94240	-0.057130	94240	0.029883	94240	0.001949
Pu241	94241	-0.003809	94241	0.001984	94241	0.000129
Pu242	94242	-0.000476	94242	0.000247	94242	0.000016
Elemental						
C	6000	-0.047826	6000	0.500000	6000	0.032613
Pu	94238	-0.000476	94238	0.000251	94238	0.000016
Pu	94239	-0.890283	94239	0.467635	94239	0.030502
Pu	94240	-0.057130	94240	0.029883	94240	0.001949
Pu	94241	-0.003809	94241	0.001984	94241	0.000129
Pu	94242	-0.000476	94242	0.000247	94242	0.000016
Comments and References						
B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library, Table 7.2.4. Compounds. Plutonium isotopics for						

WGPu from DOE-STD-3013-2018, Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials.' Data taken from Table B-10 'Isotopic mix and specific thermal power for various grades of plutonium oxide.

255. Plutonium Chloride

Formula = PuCl3 Molecular Weight (g/mole) = 345.475466
Density (g/cm3) = 5.71 Total Atom Weight (atoms/b-cm) = 3.981E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cl35	17035	-0.230052	17035	0.568200	17035	0.022622
Cl37	17037	-0.077810	17037	0.181800	17037	0.007238
Pu238	94238	-0.000346	94238	0.000126	94238	0.000005
Pu239	94239	-0.647161	94239	0.233817	94239	0.009309
Pu240	94240	-0.041529	94240	0.014942	94240	0.000595
Pu241	94241	-0.002769	94241	0.000992	94241	0.000039
Pu242	94242	-0.000346	94242	0.000123	94242	0.000005
Elemental						
Cl	17000	-0.307850	17000	0.750000	17000	0.029860
Pu	94238	-0.000346	94238	0.000126	94238	0.000005
Pu	94239	-0.647161	94239	0.233817	94239	0.009309
Pu	94240	-0.041529	94240	0.014942	94240	0.000595
Pu	94241	-0.002769	94241	0.000992	94241	0.000039
Pu	94242	-0.000346	94242	0.000123	94242	0.000005

Comments and References

Density and formula from MatWeb Material Property Data www.matweb.com Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.

256. Plutonium Dioxide

Formula = PuO2 Molecular Weight (g/mole) = 271.119766
Density (g/cm3) = 11.46 Total Atom Weight (atoms/b-cm) = 7.636E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.117705	8016	0.665047	8016	0.050786
O17	8017	-0.000048	8017	0.000253	8017	0.000019
O18	8018	-0.000272	8018	0.001367	8018	0.000104
Pu238	94238	-0.000441	94238	0.000167	94238	0.000013
Pu239	94239	-0.824647	94239	0.311756	94239	0.023807

Pu240	94240	-0.052919	94240	0.019922	94240	0.001521
Pu241	94241	-0.003528	94241	0.001323	94241	0.000101
Pu242	94242	-0.000441	94242	0.000165	94242	0.000013
Elemental						
O	8000	-0.118025	8000	0.666667	8000	0.050910
Pu	94238	-0.000441	94238	0.000167	94238	0.000013
Pu	94239	-0.824647	94239	0.311756	94239	0.023807
Pu	94240	-0.052919	94240	0.019922	94240	0.001521
Pu	94241	-0.003528	94241	0.001323	94241	0.000101
Pu	94242	-0.000441	94242	0.000165	94242	0.000013

Comments and References

B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, Standard Composition Library, Table 7.2.4. Compounds. Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.

257. Plutonium Fluoride (PuF3)

Formula = PuF3 Molecular Weight (g/mole) = 296.116175
Density (g/cm3) = 9.33 Total Atom Weight (atoms/b-cm) = 7.590E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
F19	9019	-0.192476	9019	0.750000	9019	0.056924
Pu238	94238	-0.000404	94238	0.000126	94238	0.000010
Pu239	94239	-0.755035	94239	0.233817	94239	0.017746
Pu240	94240	-0.048451	94240	0.014942	94240	0.001134
Pu241	94241	-0.003230	94241	0.000992	94241	0.000075
Pu242	94242	-0.000404	94242	0.000123	94242	0.000009
Elemental						
F	9000	-0.192476	9000	0.750000	9000	0.056924
Pu	94238	-0.000404	94238	0.000126	94238	0.000010
Pu	94239	-0.755035	94239	0.233817	94239	0.017746
Pu	94240	-0.048451	94240	0.014942	94240	0.001134
Pu	94241	-0.003230	94241	0.000992	94241	0.000075
Pu	94242	-0.000404	94242	0.000123	94242	0.000009

Comments and References

Density and formula from MatWeb Material Property Data www.matweb.com Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.

258. Plutonium Fluoride (PuF4)

Formula = PuF4			Molecular Weight (g/mole) = 315.114578			
Density (g/cm3) = 7.1			Total Atom Weight (atoms/b-cm) = 6.784E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
F19	9019	-0.241162	9019	0.800000	9019	0.054275
Pu238	94238	-0.000379	94238	0.000100	94238	0.000007
Pu239	94239	-0.709514	94239	0.187054	94239	0.012690
Pu240	94240	-0.045530	94240	0.011953	94240	0.000811
Pu241	94241	-0.003035	94241	0.000794	94241	0.000054
Pu242	94242	-0.000379	94242	0.000099	94242	0.000007
Elemental						
F	9000	-0.241162	9000	0.800000	9000	0.054275
Pu	94238	-0.000379	94238	0.000100	94238	0.000007
Pu	94239	-0.709514	94239	0.187054	94239	0.012690
Pu	94240	-0.045530	94240	0.011953	94240	0.000811
Pu	94241	-0.003035	94241	0.000794	94241	0.000054
Pu	94242	-0.000379	94242	0.000099	94242	0.000007
Comments and References						
Density and formula from MatWeb Material Property Data www.matweb.com Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.						

259. Plutonium Fluoride (PuF6)

Formula = PuF6			Molecular Weight (g/mole) = 353.111384			
Density (g/cm3) = 5.08			Total Atom Weight (atoms/b-cm) = 6.065E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
F19	9019	-0.322817	9019	0.857143	9019	0.051982
Pu238	94238	-0.000339	94238	0.000072	94238	0.000004
Pu239	94239	-0.633166	94239	0.133610	94239	0.008103
Pu240	94240	-0.040631	94240	0.008538	94240	0.000518
Pu241	94241	-0.002709	94241	0.000567	94241	0.000034
Pu242	94242	-0.000339	94242	0.000071	94242	0.000004
Elemental						
F	9000	-0.322817	9000	0.857143	9000	0.051982
Pu	94238	-0.000339	94238	0.000072	94238	0.000004

Pu	94239	-0.633166	94239	0.133610	94239	0.008103
Pu	94240	-0.040631	94240	0.008538	94240	0.000518
Pu	94241	-0.002709	94241	0.000567	94241	0.000034
Pu	94242	-0.000339	94242	0.000071	94242	0.000004
Comments and References						
Density and formula from MatWeb Material Property Data www.matweb.com Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.						

260. Plutonium Iodide

Formula = PuI3			Molecular Weight (g/mole) = 619.834376			
Density (g/cm3) = 6.92			Total Atom Weight (atoms/b-cm) = 2.689E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
I127	53127	-0.614218	53127	0.750000	53127	0.020170
Pu238	94238	-0.000193	94238	0.000126	94238	0.000003
Pu239	94239	-0.360706	94239	0.233817	94239	0.006288
Pu240	94240	-0.023147	94240	0.014942	94240	0.000402
Pu241	94241	-0.001543	94241	0.000992	94241	0.000027
Pu242	94242	-0.000193	94242	0.000123	94242	0.000003
Elemental						
I	53000	-0.614218	53000	0.750000	53000	0.020170
Pu	94238	-0.000193	94238	0.000126	94238	0.000003
Pu	94239	-0.360706	94239	0.233817	94239	0.006288
Pu	94240	-0.023147	94240	0.014942	94240	0.000402
Pu	94241	-0.001543	94241	0.000992	94241	0.000027
Pu	94242	-0.000193	94242	0.000123	94242	0.000003
Comments and References						
Density and formula from MatWeb Material Property Data hwww.matweb.com Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 'Isotopic mix and specific thermal power for various grades of plutonium oxide.						

261. Plutonium Nitrate

Formula = PuN4O12			Molecular Weight (g/mole) = 487.141186			
Density (g/cm3) = 2.447			Total Atom Weight (atoms/b-cm) = 5.142E-02			
	Weight Fractions		Atom Fractions		Atom Densities	

Isotopic						
N14	7014	-0.114563	7014	0.234438	7014	0.012056
N15	7015	-0.000448	7015	0.000856	7015	0.000044
O16	8016	-0.393054	8016	0.704167	8016	0.036212
O17	8017	-0.000159	8017	0.000268	8017	0.000014
O18	8018	-0.000909	8018	0.001447	8018	0.000074
Pu238	94238	-0.000245	94238	0.000030	94238	0.000002
Pu239	94239	-0.458960	94239	0.055016	94239	0.002829
Pu240	94240	-0.029452	94240	0.003516	94240	0.000181
Pu241	94241	-0.001963	94241	0.000233	94241	0.000012
Pu242	94242	-0.000245	94242	0.000029	94242	0.000001
Elemental						
N	7000	-0.115013	7000	0.235294	7000	0.012100
O	8000	-0.394121	8000	0.705882	8000	0.036300
Pu	94238	-0.000245	94238	0.000030	94238	0.000002
Pu	94239	-0.458960	94239	0.055016	94239	0.002829
Pu	94240	-0.029452	94240	0.003516	94240	0.000181
Pu	94241	-0.001963	94241	0.000233	94241	0.000012
Pu	94242	-0.000245	94242	0.000029	94242	0.000001
Comments and References						
B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, Standard Composition Library, Table 7.2.4. Compounds. Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.						

262. Plutonium Nitride

Formula = PuN		Molecular Weight (g/mole) = 253.127821			
Density (g/cm3) = 14.25		Total Atom Weight (atoms/b-cm) = 6.780E-02			
	Weight Fractions		Atom Fractions		Atom Densities
Isotopic					
N14	7014	-0.055119	7014	0.498180	7014	0.033779
N15	7015	-0.000216	7015	0.001820	7015	0.000123
Pu238	94238	-0.000472	94238	0.000251	94238	0.000017
Pu239	94239	-0.883262	94239	0.467635	94239	0.031708
Pu240	94240	-0.056680	94240	0.029883	94240	0.002026
Pu241	94241	-0.003779	94241	0.001984	94241	0.000135
Pu242	94242	-0.000472	94242	0.000247	94242	0.000017
Elemental						
N	7000	-0.055335	7000	0.500000	7000	0.033902
Pu	94238	-0.000472	94238	0.000251	94238	0.000017

Pu	94239	-0.883262	94239	0.467635	94239	0.031708
Pu	94240	-0.056680	94240	0.029883	94240	0.002026
Pu	94241	-0.003779	94241	0.001984	94241	0.000135
Pu	94242	-0.000472	94242	0.000247	94242	0.000017
Comments and References						
B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, Standard Composition Library, Table 7.2.4. Compounds. Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.						

263. Plutonium Oxide (Pu2O3)

Formula = Pu2O3	Molecular Weight (g/mole) = 526.240132
Density (g/cm3) = 10.5	Total Atom Weight (atoms/b-cm) = 6.008E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.090963	8016	0.598542	8016	0.035960
O17	8017	-0.000037	8017	0.000228	8017	0.000014
O18	8018	-0.000210	8018	0.001230	8018	0.000074
Pu238	94238	-0.000454	94238	0.000201	94238	0.000012
Pu239	94239	-0.849719	94239	0.374108	94239	0.022476
Pu240	94240	-0.054527	94240	0.023907	94240	0.001436
Pu241	94241	-0.003635	94241	0.001587	94241	0.000095
Pu242	94242	-0.000454	94242	0.000198	94242	0.000012
Elemental						
O	8000	-0.091210	8000	0.600000	8000	0.036048
Pu	94238	-0.000454	94238	0.000201	94238	0.000012
Pu	94239	-0.849719	94239	0.374108	94239	0.022476
Pu	94240	-0.054527	94240	0.023907	94240	0.001436
Pu	94241	-0.003635	94241	0.001587	94241	0.000095
Pu	94242	-0.000454	94242	0.000198	94242	0.000012
Comments and References						
Density and formula from MatWeb Material Property Data www.matweb.com Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.						

264. Plutonium Oxide (PuO)

Formula = PuO			Molecular Weight (g/mole) = 255.120366			
Density (g/cm3) = 14			Total Atom Weight (atoms/b-cm) = 6.609E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.062543	8016	0.498785	8016	0.032967
O17	8017	-0.000025	8017	0.000190	8017	0.000013
O18	8018	-0.000145	8018	0.001025	8018	0.000068
Pu238	94238	-0.000469	94238	0.000251	94238	0.000017
Pu239	94239	-0.876363	94239	0.467635	94239	0.030908
Pu240	94240	-0.056237	94240	0.029883	94240	0.001975
Pu241	94241	-0.003749	94241	0.001984	94241	0.000131
Pu242	94242	-0.000469	94242	0.000247	94242	0.000016
Elemental						
O	8000	-0.062713	8000	0.500000	8000	0.033047
Pu	94238	-0.000469	94238	0.000251	94238	0.000017
Pu	94239	-0.876363	94239	0.467635	94239	0.030908
Pu	94240	-0.056237	94240	0.029883	94240	0.001975
Pu	94241	-0.003749	94241	0.001984	94241	0.000131
Pu	94242	-0.000469	94242	0.000247	94242	0.000016
Comments and References						
Density and formula from MatWeb Material Property Data www.matweb.com Plutonium isotopics for WGPu from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.						

265. Plutonium, Aged WGPu (A: 4-7% Pu240)

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) = 19.84			Total Atom Weight (atoms/b-cm) = 4.997E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pu238	94238	-0.000100	94238	0.000100	94238	0.000005
Pu239	94239	-0.936294	94239	0.936557	94239	0.046796
Pu240	94240	-0.059910	94240	0.059677	94240	0.002982
Pu241	94241	-0.001997	94241	0.001981	94241	0.000099
Pu242	94242	-0.000300	94242	0.000296	94242	0.000015
Am241	95241	-0.001400	95241	0.001389	95241	0.000069
Elemental						
Pu	94238	-0.000100	94238	0.000100	94238	0.000005
Pu	94239	-0.936294	94239	0.936557	94239	0.046796
Pu	94240	-0.059910	94240	0.059677	94240	0.002982

Pu	94241	-0.001997	94241	0.001981	94241	0.000099
Pu	94242	-0.000300	94242	0.000296	94242	0.000015
Am	95241	-0.001400	95241	0.001389	95241	0.000069
Comments and References						
Plutonium isotopics from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide. Density = 19.84 g/cm3 for alpha plutonium from physics.nist.gov/cgi-bin/Star/compos.pl?matno=094. There are six different phases for solid Pu at different temperatures. These have significantly different densities (Söderlind P. 2001 at http://iopscience.iop.org/0295-5075/55/4/525/fulltext). Density = 16.63 g/cm3, for molten Pu (Page 4-141 of CRC Handbook of Chemistry and Physics, 89th Edition).						

266. Plutonium, Aged WGPu (B: 10-13% Pu240)

Formula =		Molecular Weight (g/mole) =				
Density (g/cm3) =	19.84	Total Atom Weight (atoms/b-cm) = 4.995E-02				
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pu238	94238	-0.000892	94238	0.000897	94238	0.000045
Pu239	94239	-0.861837	94239	0.862406	94239	0.043075
Pu240	94240	-0.117073	94240	0.116661	94240	0.005827
Pu241	94241	-0.009913	94241	0.009837	94241	0.000491
Pu242	94242	-0.001685	94242	0.001665	94242	0.000083
Am241	95241	-0.008600	95241	0.008534	95241	0.000426
Elemental						
Pu	94238	-0.000892	94238	0.000897	94238	0.000045
Pu	94239	-0.861837	94239	0.862406	94239	0.043075
Pu	94240	-0.117073	94240	0.116661	94240	0.005827
Pu	94241	-0.009913	94241	0.009837	94241	0.000491
Pu	94242	-0.001685	94242	0.001665	94242	0.000083
Am	95241	-0.008600	95241	0.008534	95241	0.000426
Comments and References						
Plutonium isotopics from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide. Density = 19.84 g/cm3 for alpha plutonium from physics.nist.gov/cgi-bin/Star/compos.pl?matno=094. There are six different phases for solid Pu at different temperatures. These have significantly different densities (Söderlind P. 2001 at http://iopscience.iop.org/0295-5075/55/4/525/fulltext). Density = 16.63 g/cm3, for molten Pu (Page 4-141 of CRC Handbook of Chemistry and Physics, 89th Edition).						

267. Plutonium, Aged WGPu (C: 16-19% Pu240)

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	19.84		Total Atom Weight (atoms/b-cm) = 4.992E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pu238	94238	-0.002333	94238	0.002345	94238	0.000117
Pu239	94239	-0.783937	94239	0.784809	94239	0.039181
Pu240	94240	-0.165029	94240	0.164523	94240	0.008214
Pu241	94241	-0.013995	94241	0.013894	94241	0.000694
Pu242	94242	-0.006706	94242	0.006630	94242	0.000331
Am241	95241	-0.028000	95241	0.027798	95241	0.001388
Elemental						
Pu	94238	-0.002333	94238	0.002345	94238	0.000117
Pu	94239	-0.783937	94239	0.784809	94239	0.039181
Pu	94240	-0.165029	94240	0.164523	94240	0.008214
Pu	94241	-0.013995	94241	0.013894	94241	0.000694
Pu	94242	-0.006706	94242	0.006630	94242	0.000331
Am	95241	-0.028000	95241	0.027798	95241	0.001388

Comments and References

Plutonium isotopics from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide.Density = 19.84 g/cm3 for alpha plutonium from physics.nist.gov/cgi-bin/Star/compos.pl?matno=094. There are six different phases for solid Pu at different temperatures. These have significantly different densities (Söderlind P. 2001 at http://iopscience.iop.org/0295-5075/55/4/525/fulltext). Density = 16.63 g/cm3, for molten Pu (Page 4-141 of CRC Handbook of Chemistry and Physics, 89th Edition).

268. Plutonium, DOE 3013 WGPu

Formula =	Pu		Molecular Weight (g/mole) = 239.120966			
Density (g/cm3) =	19.84		Total Atom Weight (atoms/b-cm) = 4.997E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pu238	94238	-0.000500	94238	0.000502	94238	0.000025
Pu239	94239	-0.935000	94239	0.935269	94239	0.046732
Pu240	94240	-0.060000	94240	0.059767	94240	0.002986
Pu241	94241	-0.004000	94241	0.003968	94241	0.000198
Pu242	94242	-0.000500	94242	0.000494	94242	0.000025
Elemental						
Pu	94238	-0.000500	94238	0.000502	94238	0.000025
Pu	94239	-0.935000	94239	0.935269	94239	0.046732

Pu	94240	-0.060000	94240	0.059767	94240	0.002986
Pu	94241	-0.004000	94241	0.003968	94241	0.000198
Pu	94242	-0.000500	94242	0.000494	94242	0.000025
Comments and References						
Plutonium isotopics from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 of Isotopic mix and specific thermal power for various grades of plutonium oxide. Density = 19.84 g/cm3 for alpha plutonium from physics.nist.gov/cgi-bin/Star/compos.pl?matno=094. There are six different phases for solid Pu at different temperatures. These have significantly different densities (Söderlind P. 2001 at http://iopscience.iop.org/0295-5075/55/4/525/fulltext). Density = 16.63 g/cm3, for molten Pu (Page 4-141 of CRC Handbook of Chemistry and Physics, 89th Edition).						

269. Plutonium, Fuel Grade

Formula = Pu			Molecular Weight (g/mole) = 239.208701			
Density (g/cm3) = 19.84			Total Atom Weight (atoms/b-cm) = 4.995E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pu238	94238	-0.001000	94238	0.001005	94238	0.000050
Pu239	94239	-0.861000	94239	0.861564	94239	0.043033
Pu240	94240	-0.120000	94240	0.119578	94240	0.005973
Pu241	94241	-0.016000	94241	0.015877	94241	0.000793
Pu242	94242	-0.002000	94242	0.001976	94242	0.000099
Elemental						
Pu	94238	-0.001000	94238	0.001005	94238	0.000050
Pu	94239	-0.861000	94239	0.861564	94239	0.043033
Pu	94240	-0.120000	94240	0.119578	94240	0.005973
Pu	94241	-0.016000	94241	0.015877	94241	0.000793
Pu	94242	-0.002000	94242	0.001976	94242	0.000099
Comments and References						
Plutonium isotopics from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide. Density = 19.84 g/cm3 for alpha plutonium from physics.nist.gov/cgi-bin/Star/compos.pl?matno=094. There are six different phases for solid Pu at different temperatures. These have significantly different densities (Söderlind P. 2001 at http://iopscience.iop.org/0295-5075/55/4/525/fulltext). Density = 16.63 g/cm3, for molten Pu (Page 4-141 of CRC Handbook of Chemistry and Physics, 89th Edition).						

270. Plutonium, Power Grade

Formula = Pu			Molecular Weight (g/mole) = 239.584993			
Density (g/cm3) = 19.84			Total Atom Weight (atoms/b-cm) = 4.987E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pu238	94238	-0.009900	94238	0.009964	94238	0.000497
Pu239	94239	-0.623800	94239	0.625190	94239	0.031178
Pu240	94240	-0.217800	94240	0.217375	94240	0.010840
Pu241	94241	-0.118800	94241	0.118075	94241	0.005888
Pu242	94242	-0.029700	94242	0.029396	94242	0.001466
Elemental						
Pu	94238	-0.009900	94238	0.009964	94238	0.000497
Pu	94239	-0.623800	94239	0.625190	94239	0.031178
Pu	94240	-0.217800	94240	0.217375	94240	0.010840
Pu	94241	-0.118800	94241	0.118075	94241	0.005888
Pu	94242	-0.029700	94242	0.029396	94242	0.001466
Comments and References						
Plutonium isotopics from DOE-STD-3013-2018, DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. Data taken from Table B-10 Isotopic mix and specific thermal power for various grades of plutonium oxide. Density = 19.84 g/cm3 for alpha plutonium from physics.nist.gov/cgi-bin/Star/compos.pl?matno=094. There are six different phases for solid Pu at different temperatures. These have significantly different densities (Söderlind P. 2001 at http://iopscience.iop.org/0295-5075/55/4/525/fulltext). Density = 16.63 g/cm3, for molten Pu (Page 4-141 of CRC Handbook of Chemistry and Physics, 89th Edition).						

271. Plutonium, Shefelbine WGPu

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) = 19.84			Total Atom Weight (atoms/b-cm) = 4.997E-02			
The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Pu238	94238	-0.000300	94238	0.000301	94238	0.000015
Pu239	94239	-0.939200	94239	0.939451	94239	0.046942
Pu240	94240	-0.057000	94240	0.056777	94240	0.002837
Pu241	94241	-0.003000	94241	0.002976	94241	0.000149
Pu242	94242	-0.000300	94242	0.000296	94242	0.000015
Am241	95241	-0.000200	95241	0.000198	95241	0.000010
Elemental						
Pu	94238	-0.000300	94238	0.000301	94238	0.000015

Pu	94239	-0.939200	94239	0.939451	94239	0.046942
Pu	94240	-0.057000	94240	0.056777	94240	0.002837
Pu	94241	-0.003000	94241	0.002976	94241	0.000149
Pu	94242	-0.000300	94242	0.000296	94242	0.000015
Am	95241	-0.000200	95241	0.000198	95241	0.000010
Comments and References						
Preliminary Evaluation of the Characteristics of Defense Transuranic Wastes, SAND78-1850, Table 4, Sandia National Laboratory, November 1978. Density = 19.84 g/cm3 for alpha plutonium from physics.nist.gov/cgi-bin/Star/compos.pl?matno=094. There are six different phases for solid Pu at different temperatures. These have significantly different densities (Söderlind P. 2001 at http://iopscience.iop.org/0295-5075/55/4/525/fulltext). Density = 16.63 g/cm3 for molten Pu (Page 4-141 of CRC Handbook of Chemistry and Physics, 89th Edition).						

272. Polycarbonate

Formula = C16H14O3 Molecular Weight (g/mole) = 254.279450
Density (g/cm3) = 1.2 Total Atom Weight (atoms/b-cm) = 9.379E-02

Density can vary.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.055482	1001	0.424194	1001	0.039783
H2	1002	-0.000013	1002	0.000049	1002	0.000005
C	6000	-0.755741	6000	0.484848	6000	0.045472
O16	8016	-0.188250	8016	0.090688	8016	0.008505
O17	8017	-0.000076	8017	0.000035	8017	0.000003
O18	8018	-0.000435	8018	0.000186	8018	0.000017
Elemental						
H	1000	-0.055497	1000	0.424242	1000	0.039788
C	6000	-0.755741	6000	0.484848	6000	0.045472
O	8000	-0.188762	8000	0.090909	8000	0.008526
Comments and References						
Also called Makrolon or Lexan (en.wikipedia.org/wiki/Polycarbonate). Formula and density from www.polymerprocessing.com/polymers/PC.html Density and weight fractions match physics.nist.gov/cgi-bin/Star/compos.pl?matno=219. MatWeb www.matweb.com gives a density range for Acrylic/Polycarbonate Alloy of 1.12-1.29 g/cm3 and for Polycarbonate, Optical Grade 1.20-1.40 g/cm3						

273. Polyethylene Terephthalate (PET)

Formula = C10H8O4 Molecular Weight (g/mole) = 192.167400
Density (g/cm3) = 1.38 Total Atom Weight (atoms/b-cm) = 9.514E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.The term polyester as a specific material most commonly refers to polyethylene terephthalate, which is commonly abbreviated as PET or PETE. Trade names of PET products include Dacron. Mylar is biaxially-oriented polyethylene terephthalate (boPET) polyester film used for transparency and reflectivity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.041951	1001	0.363595	1001	0.034593
H2	1002	-0.000010	1002	0.000042	1002	0.000004
C	6000	-0.625008	6000	0.454545	6000	0.043246
O16	8016	-0.332128	8016	0.181376	8016	0.017257
O17	8017	-0.000134	8017	0.000069	8017	0.000007
O18	8018	-0.000768	8018	0.000373	8018	0.000035
Elemental						
H	1000	-0.041962	1000	0.363636	1000	0.034597
C	6000	-0.625008	6000	0.454545	6000	0.043246
O	8000	-0.333030	8000	0.181818	8000	0.017299

Comments and References

Density from physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html. Density = 1.40 g/cm3 physics.nist.gov/cgi-bin/Star/compos.pl?matno=222.

274. Polyethylene, Borated

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1 Total Atom Weight (atoms/b-cm) = 1.193E-01

Density can vary.Assumes a mixture of B4C in C2H4.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.125322	1001	0.627683	1001	0.074885
H2	1002	-0.000029	1002	0.000072	1002	0.000009
B10	5010	-0.018427	5010	0.009289	5010	0.001108
B11	5011	-0.081550	5011	0.037391	5011	0.004461
C	6000	-0.774645	6000	0.325564	6000	0.038841
Elemental						
H	1000	-0.125355	1000	0.627756	1000	0.074893
B	5000	-0.100000	5000	0.046680	5000	0.005569
C	6000	-0.774645	6000	0.325564	6000	0.038841

Comments and References

10.0 wt% B as B4C in polyethylene. Many manufactures produce 5 wt% with a density range from 0.92 to 1.07 g/cm3. Some manufactures make borated polyethylene ranging from 1% to 30% boron by weight. .

275. Polyethylene, Non-borated

Formula = C2H4 Molecular Weight (g/mole) = 28.053100
Density (g/cm3) = 0.93 Total Atom Weight (atoms/b-cm) = 1.198E-01

Density can vary.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.143686	1001	0.666590	1001	0.079848
H2	1002	-0.000033	1002	0.000077	1002	0.000009
C	6000	-0.856276	6000	0.333333	6000	0.039928
Elemental						
H	1000	-0.143724	1000	0.666667	1000	0.079857
C	6000	-0.856276	6000	0.333333	6000	0.039928

Comments and References

Density = 0.93 g/cm3 from physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html. High density polyethylene (HDPE) is 0.944 to 0.965 g/cm3 (www.bpf.co.uk/Plastipedia/Polymers/HDPE.aspx). Low density polyethylene (LDPE) is 0.917 to 0.930 g/cm3 (www.bpf.co.uk/Plastipedia/Polymers/LDPE.aspx). Formula www.plasticmoulding.ca/polymers/polyethylene.htm, with low-density (defined as 0.910-0.40 g/cm3) and high density (defined as anything above 0.941 g/cm3) versions having different amounts of long chains. MatWeb www.matweb.com has molded HDPE = 0.918-1.05 g/cm3 and MDPE = 0.926-0.95.Density = 0.94 g/cm3 at physics.nist.gov/cgi-bin/Star/compos.pl?matno=221.

276. Polyisocyanurate (PIR)

Formula = C15H10N2O2 Molecular Weight (g/mole) = 250.251260
Density (g/cm3) = 0.0482 Total Atom Weight (atoms/b-cm) = 3.364E-03

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.040268	1001	0.344788	1001	0.001160
H2	1002	-0.000009	1002	0.000040	1002	0.000000
C	6000	-0.719912	6000	0.517240	6000	0.001740
N14	7014	-0.111505	7014	0.068714	7014	0.000231
N15	7015	-0.000436	7015	0.000251	7015	0.000001
O16	8016	-0.127520	8016	0.068798	8016	0.000231
O17	8017	-0.000052	8017	0.000026	8017	0.000000
O18	8018	-0.000295	8018	0.000141	8018	0.000000
Elemental						
H	1000	-0.040279	1000	0.344828	1000	0.001160

C	6000	-0.719912	6000	0.517240	6000	0.001740
N	7000	-0.111942	7000	0.068966	7000	0.000232
O	8000	-0.127867	8000	0.068966	8000	0.000232
Comments and References						
Acronyms per en.wikipedia.org/wiki/Polyisocyanurate. Formula from NIST Chemistry WebBook SRD 69 (webbook.nist.gov) Density = 0.0264, 0.0288, 0.048, 0.064, and 0.096 g/cm3 from Foam Products CorporationDensity range = 33 to 320 kg/m3 from Kingspan (pipe insulation) Density = 0.0482 g/cm3 for nominal 3.0 lb/ft3 density on ISO-C1 datasheet available from Dyplast Products. Nominal densities are available at 2.0, 2.5, 3, 4, and 6 lb/ft3.						

277. Polypropylene (PP)

Formula = C3H6 Molecular Weight (g/mole) = 42.079650 Density (g/cm3) = 0.9 Total Atom Weight (atoms/b-cm) = 1.159E-01						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.143686	1001	0.666590	1001	0.077272
H2	1002	-0.000033	1002	0.000077	1002	0.000009
C	6000	-0.856276	6000	0.333333	6000	0.038640
Elemental						
H	1000	-0.143724	1000	0.666667	1000	0.077281
C	6000	-0.856276	6000	0.333333	6000	0.038640
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=225. Formula = C3H6 from Polymer Handbook, J. Brandrup et al, 4th edition, 2005, John Wiley & Sons.Wikipedia lists densities of 0.855 g/cm3 for amorphous and 0.946 g/cm3 for crystalline forms. MatWeb.com lists many varieties covering a range of densities from 0.780 to 2.80 g/cm3.						

278. Polystyrene (PS)

Formula = C8H8 Molecular Weight (g/mole) = 104.148600 Density (g/cm3) = 1.06 Total Atom Weight (atoms/b-cm) = 9.807E-02						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.077405	1001	0.499943	1001	0.049028
H2	1002	-0.000018	1002	0.000058	1002	0.000006
C	6000	-0.922574	6000	0.500000	6000	0.049034
Elemental						
H	1000	-0.077426	1000	0.500000	1000	0.049034

C	6000	-0.922574	6000	0.500000	6000	0.049034
Comments and References						
Density from physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html. Abbreviated PS (en.wikipedia.org/wiki/Polystyrene) and called Styrofoam (en.wikipedia.org/wiki/Styrofoam). Formula = C8H8 from Polymer Handbook, J. Brandrup et al, 4th edition, 2005, John Wiley & Sons.MatWeb.com lists density range of 1.03-1.10 g/cm3 for extruded polystryrene. Expanded polystryrene can be as low as 0.00170 g/cm3.						

279. Polytetrafluoroethylene (PTFE)

Formula = C2F4			Molecular Weight (g/mole) = 100.014812			
Density (g/cm3) = 2.25			Total Atom Weight (atoms/b-cm) = 8.129E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.240176	6000	0.333333	6000	0.027096
F19	9019	-0.759824	9019	0.666667	9019	0.054191
Elemental						
C	6000	-0.240176	6000	0.333333	6000	0.027096
F	9000	-0.759824	9000	0.666667	9000	0.054191
Comments and References						
Density = 2.25 g/cm3 at physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html.Density = 2.20 g/cm3 at physics.nist.gov/cgi-bin/Star/compos.pl?matno=227.Also called Teflon (en.wikipedia.org/wiki/Teflon).MatWeb.com lists densities of 0.700-3.35 g/cm3 for molded polytetrafluoroethylene.						

280. Polyurethane Foam (PUR)

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) = 0.021			Total Atom Weight (atoms/b-cm) = 1.428E-03			
Based on www.pfa.org/intouch/new_pdf/hr_IntouchV1.2.pdf, the density used for packaging is about 0.9 to 1.5 lb/ft3. An average value of 1.3 lb/ft3 = 0.021 g/cm3, so that the density being used is appropriate for packaging. Many other uses are in the 1.2 to 4.0 lb/ft3 density range, and it can go as high as about 8.0 lb/ft3.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.040991	1001	0.359982	1001	0.000514
H2	1002	-0.000009	1002	0.000041	1002	0.000000
C	6000	-0.543998	6000	0.400878	6000	0.000573
N14	7014	-0.120528	7014	0.076181	7014	0.000109
N15	7015	-0.000472	7015	0.000278	7015	0.000000

O16	8016	-0.293204	8016	0.162244	8016	0.000232
O17	8017	-0.000119	8017	0.000062	8017	0.000000
O18	8018	-0.000678	8018	0.000333	8018	0.000000
Elemental						
H	1000	-0.041001	1000	0.360023	1000	0.000514
C	6000	-0.543998	6000	0.400878	6000	0.000573
N	7000	-0.121001	7000	0.076459	7000	0.000109
O	8000	-0.294000	8000	0.162639	8000	0.000232
Comments and References						
Abbreviated PUR or PU (en.wikipedia.org/wiki/Polyurethane). Density = 0.021 g/cm3 and wt. fractions from LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009. Density = 0.00800 to 4.50 g/cm3 for unreinforced polyurethane foam at www.matweb.com/search/DataSheet.aspx?MatGUID=91d44cae736e4b36bcba94720654eeae.						

281. Polyvinyl Acetate (PVA)

Formula = C4H6O2			Molecular Weight (g/mole) = 86.089050			
Density (g/cm3) = 1.19			Total Atom Weight (atoms/b-cm) = 9.989E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.070233	1001	0.499943	1001	0.049940
H2	1002	-0.000016	1002	0.000058	1002	0.000006
C	6000	-0.558055	6000	0.333333	6000	0.033297
O16	8016	-0.370687	8016	0.166262	8016	0.016608
O17	8017	-0.000150	8017	0.000063	8017	0.000006
O18	8018	-0.000857	8018	0.000342	8018	0.000034
Elemental						
H	1000	-0.070251	1000	0.500000	1000	0.049946
C	6000	-0.558055	6000	0.333333	6000	0.033297
O	8000	-0.371694	8000	0.166667	8000	0.016649
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=229. Wikipedia says PVA is best known as wood glue or school glue.						

282. Polyvinyl Chloride (PVC)

Formula = C2H3Cl		Molecular Weight (g/mole) = 62.496625	
Density (g/cm3) = 1.406		Total Atom Weight (atoms/b-cm) = 8.129E-02	
	Weight Fractions	Atom Fractions	Atom Densities
Isotopic			

H1	1001	-0.048373	1001	0.499943	1001	0.040640
H2	1002	-0.000011	1002	0.000058	1002	0.000005
C	6000	-0.384360	6000	0.333333	6000	0.027096
Cl35	17035	-0.423901	17035	0.126267	17035	0.010264
Cl37	17037	-0.143376	17037	0.040400	17037	0.003284
Elemental						
H	1000	-0.048385	1000	0.500000	1000	0.040644
C	6000	-0.384360	6000	0.333333	6000	0.027096
Cl	17000	-0.567255	17000	0.166667	17000	0.013548
Comments and References						
Density = 1.406 g/cm3 from physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html, 1.38 g/cm3 at www.bpf.co.uk/Plastipedia/Polymers/PVC.aspx, Density range of 1.35 to 1.52 g/cm3 is listed at www.matweb.com/search/DataSheet.aspx?MatGUID=0fc1831d51e447879a5ae9ee7f3dc0bb Density of 1.30 g/cm3 at physics.nist.gov/cgi-bin/Star/compos.pl?matno=232. Density = 1.39 g/cm3 in en.wikipedia.org/wiki/Polyvinyl_chloride.						

283. Polyvinyl Toluene (PVT)

Formula = C9H10 Molecular Weight (g/mole) = 118.175150
Density (g/cm3) = 1.032 Total Atom Weight (atoms/b-cm) = 9.992E-02

Plastic scintillators are solutions of organic scintillators in a solvent which is subsequently polymerized to form a solid. Some of the common solutes are p-Terphenyl, PBD, b-PBD, PBO, POPOP. The most widely used plastic solvents are polyvinyl toluene and polystyrene (en.wikipedia.org/wiki/Plastic_scintillator), but many other materials can also be used.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.085273	1001	0.526255	1001	0.052584
H2	1002	-0.000020	1002	0.000061	1002	0.000006
C	6000	-0.914705	6000	0.473684	6000	0.047331
Elemental						
H	1000	-0.085295	1000	0.526316	1000	0.052590
C	6000	-0.914705	6000	0.473684	6000	0.047331
Comments and References						
Polyvinyl Toluene, or polyvinyltoluene, is abbreviated PVT (en.wikipedia.org/wiki/Polyvinyl_toluene).For polyvinyl toluene (PVT), density = 1.032 g/cm3 from physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html for Plastic Scintillator, Vinyltoluene.						

284. Polyvinylidene Chloride (PVDC)

Formula = C2H2Cl2 Molecular Weight (g/mole) = 96.940150
Density (g/cm3) = 1.7 Total Atom Weight (atoms/b-cm) = 6.337E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.020790	1001	0.333295	1001	0.021119
H2	1002	-0.000005	1002	0.000038	1002	0.000002
C	6000	-0.247794	6000	0.333333	6000	0.021122
Cl35	17035	-0.546572	17035	0.252533	17035	0.016002
Cl37	17037	-0.184867	17037	0.080800	17037	0.005120
Elemental						
H	1000	-0.020796	1000	0.333333	1000	0.021122
C	6000	-0.247794	6000	0.333333	6000	0.021122
Cl	17000	-0.731410	17000	0.333333	17000	0.021122

Comments and References

Abbreviated as PVDC and also called saran (en.wikipedia.org/wiki/Plastics).Density = 1.70 g/cm3 from physics.nist.gov/cgi-bin/Star/compos.pl?matno=233. Density of 1.21 and 1.2129 g/cm3 listed by NIH PubChem.Density of 1.60 g/cm3 listed by MatWeb.com

285. Potassium Aluminum Silicate

Formula = KAlSi3O8 Molecular Weight (g/mole) = 278.330038
Density (g/cm3) = 1.1 Total Atom Weight (atoms/b-cm) = 3.094E-02

This material is sometimes used to bound naturally occurring radioactive material (NORM).The density = 1.1 g/cm3 was chosen based on the maximum value for the density for clumping cat litter. See cat litter (clumping).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.458622	8016	0.613889	8016	0.018994
O17	8017	-0.000186	8017	0.000234	8017	0.000007
O18	8018	-0.001061	8018	0.001262	8018	0.000039
Al27	13027	-0.096941	13027	0.076923	13027	0.002380
Si	14000	-0.302716	14000	0.230769	14000	0.007140
K	19000	-0.140475	19000	0.076923	19000	0.002380
Elemental						
O	8000	-0.459868	8000	0.615385	8000	0.019040
Al	13000	-0.096941	13000	0.076923	13000	0.002380
Si	14000	-0.302716	14000	0.230769	14000	0.007140
K	19000	-0.140475	19000	0.076923	19000	0.002380

Comments and References

Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-82. This reference lists the density = 2.56 g/cm3. The mineral form of this compound is called microcline. The density for this mineral = 2.56 g/cm3 at webmineral.com/data/Microcline.shtml. The density = 1.1 g/cm3 was chosen based on the maximum value for the density for clumping cat litter. See cat litter (clumping).

286. Potassium Iodide

Formula = KI Molecular Weight (g/mole) = 166.002770
Density (g/cm3) = 3.13 Total Atom Weight (atoms/b-cm) = 2.271E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
K	19000	-0.235528	19000	0.500000	19000	0.011355
I127	53127	-0.764472	53127	0.500000	53127	0.011355
Elemental						
K	19000	-0.235528	19000	0.500000	19000	0.011355
I	53000	-0.764472	53000	0.500000	53000	0.011355

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=236. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-83.CRC 100th Edition lists a density of 3.13 g/cm3.

287. Potassium Oxide

Formula = K2O Molecular Weight (g/mole) = 94.196000
Density (g/cm3) = 2.32 Total Atom Weight (atoms/b-cm) = 4.450E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.169392	8016	0.332523	8016	0.014796
O17	8017	-0.000069	8017	0.000127	8017	0.000006
O18	8018	-0.000392	8018	0.000683	8018	0.000030
K	19000	-0.830148	19000	0.666667	19000	0.029664
Elemental						
O	8000	-0.169852	8000	0.333333	8000	0.014832
K	19000	-0.830148	19000	0.666667	19000	0.029664

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=237. Formula from CRC Handbook of Chemistry and Physics, 89th edition, page 4-83.CRC 100th Edition lists a density of 2.35 g/cm3.

288. Propane (gas)

Formula = C3H8 Molecular Weight (g/mole) = 44.095600 Density (g/cm3) = 0.00187939 Total Atom Weight (atoms/b-cm) = 2.820E-04						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.182823	1001	0.727189	1001	0.000205
H2	1002	-0.000042	1002	0.000084	1002	0.000000
C	6000	-0.817129	6000	0.272727	6000	0.000077
Elemental						
H	1000	-0.182871	1000	0.727273	1000	0.000205
C	6000	-0.817129	6000	0.272727	6000	0.000077
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=238. Formula from Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens, 4th Edition, 2002.						

289. Propane (liquid)

Formula = C3H8 Molecular Weight (g/mole) = 44.095600 Density (g/cm3) = 0.43 Total Atom Weight (atoms/b-cm) = 6.460E-02 NIH PubChem lists densities of 0.59, 0.493, 0.5, 0.59 g/cm3 at different temperatures.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.182823	1001	0.727189	1001	0.046975
H2	1002	-0.000042	1002	0.000084	1002	0.000005
C	6000	-0.817129	6000	0.272727	6000	0.017618
Elemental						
H	1000	-0.182871	1000	0.727273	1000	0.046980
C	6000	-0.817129	6000	0.272727	6000	0.017618
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=239. Formula from Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens, 4th Edition, 2002.						

290. Quartz

Formula = SiO2 Molecular Weight (g/mole) = 60.083800 Density (g/cm3) = 2.62 Total Atom Weight (atoms/b-cm) = 7.878E-02				
	Weight Fractions		Atom Fractions	Atom Densities
Isotopic				

O16	8016	-0.531126	8016	0.665047	8016	0.052392
O17	8017	-0.000215	8017	0.000253	8017	0.000020
O18	8018	-0.001228	8018	0.001367	8018	0.000108
Si	14000	-0.467430	14000	0.333333	14000	0.026260
Elemental						
O	8000	-0.532570	8000	0.666667	8000	0.052520
Si	14000	-0.467430	14000	0.333333	14000	0.026260
Comments and References						
Natural mineral.WebMineral.com lists density as 2.6-2.65 g/cm3 with an average=2.62 g/cm3. MatWeb.com lists density of 2.65 g/cm3. 'PubChem.ncbi.nlm.nih.gov lists densities of 2.20, 2.2, 2.3 and 2.6 g/cm3.'						

291. Quartz Glass

Formula = SiO2			Molecular Weight (g/mole) = 60.083800			
Density (g/cm3) = 2.2			Total Atom Weight (atoms/b-cm) = 6.615E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.531126	8016	0.665047	8016	0.043994
O17	8017	-0.000215	8017	0.000253	8017	0.000017
O18	8018	-0.001228	8018	0.001367	8018	0.000090
Si	14000	-0.467430	14000	0.333333	14000	0.022050
Elemental						
O	8000	-0.532570	8000	0.666667	8000	0.044101
Si	14000	-0.467430	14000	0.333333	14000	0.022050
Comments and References						
Quartz glass is made from melting SiO2 (quartz) minerals into an amorphous (non-crystalline) form of SiO2. HeliosQuartz.com lists densities of 2.2, 2.21, and 2.15 g/cm3 for its glass products. MetaGlas.de lists a density of 2.2 g/cm^3.						

292. Radiochromic Dye Film, Nylon Base (RDF: NB)

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) = 1.08			Total Atom Weight (atoms/b-cm) = 1.117E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101969	1001	0.588996	1001	0.065805
H2	1002	-0.000023	1002	0.000068	1002	0.000008
C	6000	-0.654396	6000	0.317179	6000	0.035436
N14	7014	-0.098528	7014	0.040961	7014	0.004576

N15	7015	-0.000386	7015	0.000150	7015	0.000017
O16	8016	-0.144301	8016	0.052519	8016	0.005868
O17	8017	-0.000058	8017	0.000020	8017	0.000002
O18	8018	-0.000334	8018	0.000108	8018	0.000012
Elemental						
H	1000	-0.101996	1000	0.589064	1000	0.065812
C	6000	-0.654396	6000	0.317179	6000	0.035436
N	7000	-0.098915	7000	0.041110	7000	0.004593
O	8000	-0.144693	8000	0.052647	8000	0.005882
Comments and References						
physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html						

293. Rayon

Formula = C6H10O5 Molecular Weight (g/mole) = 162.140350
Density (g/cm3) = 1.16 Total Atom Weight (atoms/b-cm) = 9.048E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.062150	1001	0.476136	1001	0.043079
H2	1002	-0.000014	1002	0.000055	1002	0.000005
C	6000	-0.444452	6000	0.285714	6000	0.025851
O16	8016	-0.492044	8016	0.237517	8016	0.021490
O17	8017	-0.000199	8017	0.000090	8017	0.000008
O18	8018	-0.001138	8018	0.000488	8018	0.000044
Elemental						
H	1000	-0.062167	1000	0.476190	1000	0.043084
C	6000	-0.444452	6000	0.285714	6000	0.025851
O	8000	-0.493381	8000	0.238095	8000	0.021542
Comments and References						
Wikiopedia (rayon) says 'Rayon is a manufactured fiber made from regenerated cellulose fiber. 'MatWeb.com lists densities of 1.14-1.19 g/cm3 for resins and 1.52 for cloth fiber.'						

294. Rock (Average of 5 types)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.662 Total Atom Weight (atoms/b-cm) = 8.048E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.Average density and weight fractions for the following 5 types of rock, i.e. a rock mixture with 20 wt.% of each of the following: basalt, granite, limestone, sandstone, and shale. This mixture of 5 rock types is used for the aggregate that is added to asphalt to make asphalt pavement. This mixture of 5 rock types may also be used for gravel with the appropriate bulk

density to account for voids between rocks.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.001369	1001	0.027049	1001	0.002177
H2	1002	-0.000000	1002	0.000003	1002	0.000000
C	6000	-0.059427	6000	0.098551	6000	0.007932
O16	8016	-0.449828	8016	0.560152	8016	0.045084
O17	8017	-0.000182	8017	0.000213	8017	0.000017
O18	8018	-0.001040	8018	0.001151	8018	0.000093
Na23	11023	-0.013988	11023	0.012119	11023	0.000975
Mg	12000	-0.033044	12000	0.027079	12000	0.002179
Al27	13027	-0.058433	13027	0.043135	13027	0.003472
Si	14000	-0.208330	14000	0.147747	14000	0.011891
P31	15031	-0.000477	15031	0.000307	15031	0.000025
S	16000	-0.009045	16000	0.005618	16000	0.000452
K	19000	-0.017022	19000	0.008671	19000	0.000698
Ca	20000	-0.108803	20000	0.054072	20000	0.004352
Ti	22000	-0.003639	22000	0.001514	22000	0.000122
Mn55	25055	-0.000454	25055	0.000165	25055	0.000013
Fe	26000	-0.034919	26000	0.012454	26000	0.001002
Elemental						
H	1000	-0.001369	1000	0.027052	1000	0.002177
C	6000	-0.059427	6000	0.098551	6000	0.007932
O	8000	-0.451051	8000	0.561516	8000	0.045194
Na	11000	-0.013988	11000	0.012119	11000	0.000975
Mg	12000	-0.033044	12000	0.027079	12000	0.002179
Al	13000	-0.058433	13000	0.043135	13000	0.003472
Si	14000	-0.208330	14000	0.147747	14000	0.011891
P	15000	-0.000477	15000	0.000307	15000	0.000025
S	16000	-0.009045	16000	0.005618	16000	0.000452
K	19000	-0.017022	19000	0.008671	19000	0.000698
Ca	20000	-0.108803	20000	0.054072	20000	0.004352
Ti	22000	-0.003639	22000	0.001514	22000	0.000122
Mn	25000	-0.000454	25000	0.000165	25000	0.000013
Fe	26000	-0.034919	26000	0.012454	26000	0.001002

Comments and References

For gravel, http://www.simetric.co.uk/si_materials.htm lists bulk density = 1.52 g/cm3for loose dry gravel, 1.68 g/cm3 for dry gravel (1/4 to 2 inch), and 2.00 g/cm3 for wet gravel (1/4 to 2 inch). Density for gravel = 1.76 g/cm3 at http://www.powderandbulk.com/resources/bulk_density/material_bulk_density_chart_g.htm. Density of gravel = 1.44 to 1.92 g/cm3 in Table 51.65 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960. Weight fractions for each of the 5 types of rock from the following: Tables 3-4 and 7.1 of Petrology, Igneous, Sedimentary, and Metamorphic by Harvey Blatt, Robert J. Tracy, and Brent E. Owens, 3rd edition, 2006,H. Blatt and E.G. Ehlers, 'Petrology Igneous, Sedimentary, and Metamorphic', W.H. Freemand and Co., 1982,Hillier, S., 2006, Appendix A. Mineralogical and chemical data, in GM Reeves, I Sims, and JC Cripps eds., Clay

materials used in construction: London, Geological Society, Engineering Geology Special Publications Volume 21, p. 449-459.Shaw D.B. & Weaver C.E. 1965. The mineralogical composition of shales. J. Sed. Pet. 35, 213-222, https://www.claysandminerals.com/materials/shales.

295. Rock, Basalt

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.01 Total Atom Weight (atoms/b-cm) = 8.718E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.483336	8016	0.628308	8016	0.054775
O17	8017	-0.000196	8017	0.000239	8017	0.000021
O18	8018	-0.001118	8018	0.001291	8018	0.000113
Na23	11023	-0.027328	11023	0.024716	11023	0.002155
Mg	12000	-0.004274	12000	0.003656	12000	0.000319
Al27	13027	-0.076189	13027	0.058713	13027	0.005119
Si	14000	-0.336170	14000	0.248880	14000	0.021697
P31	15031	-0.000523	15031	0.000351	15031	0.000031
K	19000	-0.034144	19000	0.018158	19000	0.001583
Ca	20000	-0.012985	20000	0.006737	20000	0.000587
Ti	22000	-0.001795	22000	0.000780	22000	0.000068
Mn55	25055	-0.000387	25055	0.000146	25055	0.000013
Fe	26000	-0.021555	26000	0.008025	26000	0.000700
Elemental						
O	8000	-0.484649	8000	0.629838	8000	0.054909
Na	11000	-0.027328	11000	0.024716	11000	0.002155
Mg	12000	-0.004274	12000	0.003656	12000	0.000319
Al	13000	-0.076189	13000	0.058713	13000	0.005119
Si	14000	-0.336170	14000	0.248880	14000	0.021697
P	15000	-0.000523	15000	0.000351	15000	0.000031
K	19000	-0.034144	19000	0.018158	19000	0.001583
Ca	20000	-0.012985	20000	0.006737	20000	0.000587
Ti	22000	-0.001795	22000	0.000780	22000	0.000068
Mn	25000	-0.000387	25000	0.000146	25000	0.000013
Fe	26000	-0.021555	26000	0.008025	26000	0.000700

Comments and References

The weight fractions are calculated based on the 11 compounds in basalt listed in Table 3-4 of Petrology Igneous, Sedimentary, and Metamorphic by H. Blatt, R. J. Tracy, B. E. Owens, 3rd edition, 2006, Freeman. Average density of basalt = 2.95 g/cm3 in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers by E. A. Avallone and T Baumeister III, editors, 10th edition, 1996. Density = 3.01 g/cm3 for solid basalt and 1.95 g/cm3 for broken basalt at

http://www.simetric.co.uk/si_materials.htm. Density for solid basalt = 3.09 g/cm3 is an average of basalt densities from 3 regions from page 52 of International Critical Tables of Numerical Data, Physics, Chemistry and Technology (1st Electronic Edition) edited by E.W. Washburn, 2003, Knovel online version available at http://totem.pnl.gov:2067/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=735&VerticalID=0. Density = 2.7 to 3.2 g/cm3, and bulk density = 1.58 g/cm3, in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers E. A. Avallone, editor, 1996.

296. Rock, Granite

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.69 Total Atom Weight (atoms/b-cm) = 7.372E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.441271	8016	0.606267	8016	0.044692
O17	8017	-0.000179	8017	0.000231	8017	0.000017
O18	8018	-0.001020	8018	0.001246	8018	0.000092
Na23	11023	-0.021700	11023	0.020743	11023	0.001529
Mg	12000	-0.041879	12000	0.037864	12000	0.002791
Al27	13027	-0.083935	13027	0.068362	13027	0.005039
Si	14000	-0.232811	14000	0.182167	14000	0.013429
P31	15031	-0.001476	15031	0.001047	15031	0.000077
K	19000	-0.008920	19000	0.005014	19000	0.000370
Ca	20000	-0.068974	20000	0.037820	20000	0.002788
Ti	22000	-0.011151	22000	0.005119	22000	0.000377
Mn55	25055	-0.001541	25055	0.000616	25055	0.000045
Fe	26000	-0.085142	26000	0.033504	26000	0.002470
Elemental						
O	8000	-0.442470	8000	0.607744	8000	0.044801
Na	11000	-0.021700	11000	0.020743	11000	0.001529
Mg	12000	-0.041879	12000	0.037864	12000	0.002791
Al	13000	-0.083935	13000	0.068362	13000	0.005039
Si	14000	-0.232811	14000	0.182167	14000	0.013429
P	15000	-0.001476	15000	0.001047	15000	0.000077
K	19000	-0.008920	19000	0.005014	19000	0.000370
Ca	20000	-0.068974	20000	0.037820	20000	0.002788
Ti	22000	-0.011151	22000	0.005119	22000	0.000377
Mn	25000	-0.001541	25000	0.000616	25000	0.000045
Fe	26000	-0.085142	26000	0.033504	26000	0.002470

Comments and References

The weight fractions are calculated based on the 11 compounds in granite listed in Table 3-4 of Petrology Igneous, Sedimentary, and Metamorphic by H. Blatt, R. J. Tracy, B. E. Owens, 3rd

edition, 2006, Freeman.Average density of granite = 2.64 g/cm3 in Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers by E. A. Avallone and T Baumeister III, editors, 10th edition, 1996. Density = 2.69 g/cm3 for solid granite and 1.65 g/cm3 for broken granite at http://www.simetric.co.uk/si_materials.htm. Bulk density of crushed granite = 1.55 g/cm3 at http://www.powderandbulk.com/resources/bulk_density/material_bulk_density_chart_g.htm. Density for solid granite = 3.09 g/cm3 is an average of granite densities from 8 regions from page 53 of International Critical Tables of Numerical Data, Physics, Chemistry and Technology (1st Electronic Edition) edited by E.W. Washburn, 2003, Knovel online version available at http://totem.pnl.gov:2067/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=735&VerticalID=0. Density = 2.65 g/cm3 in Table 51.64 of Reactor Handbook, 2nd edition, Vol. 1, Materials, by C. R. Tipton, 1960.

297. Rock, Limestone

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.6 Total Atom Weight (atoms/b-cm) = 7.822E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.114006	6000	0.190012	6000	0.014862
O16	8016	-0.480901	8016	0.601856	8016	0.047076
O17	8017	-0.000195	8017	0.000229	8017	0.000018
O18	8018	-0.001112	8018	0.001237	8018	0.000097
Si	14000	-0.023372	14000	0.016659	14000	0.001303
Ca	20000	-0.380414	20000	0.190007	20000	0.014862
Elemental						
C	6000	-0.114006	6000	0.190012	6000	0.014862
O	8000	-0.482208	8000	0.603322	8000	0.047191
Si	14000	-0.023372	14000	0.016659	14000	0.001303
Ca	20000	-0.380414	20000	0.190007	20000	0.014862

Comments and References

The weight fractions and densities are from H. Blatt and E.G. Ehlers, 'Petrology Igneous, Sedimentary, and Metamorphic', W.H. Freemand and Co., 1982.

298. Rock, Sandstone

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.37 Total Atom Weight (atoms/b-cm) = 7.018E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions	Atom Fractions	Atom Densities

Isotopic						
C	6000	-0.000874	6000	0.001480	6000	0.000104
O16	8016	-0.513682	8016	0.653120	8016	0.045837
O17	8017	-0.000208	8017	0.000249	8017	0.000017
O18	8018	-0.001188	8018	0.001342	8018	0.000094
Na23	11023	-0.007316	11023	0.006472	11023	0.000454
Mg	12000	-0.001620	12000	0.001355	12000	0.000095
Al27	13027	-0.020522	13027	0.015468	13027	0.001086
Si	14000	-0.421080	14000	0.304910	14000	0.021399
P31	15031	-0.000005	15031	0.000003	15031	0.000000
K	19000	-0.013509	19000	0.007027	19000	0.000493
Ca	20000	-0.008931	20000	0.004532	20000	0.000318
Ti	22000	-0.000200	22000	0.000085	22000	0.000006
Fe	26000	-0.010862	26000	0.003956	26000	0.000278
Mn55	25055	-0.000003	25055	0.000001	25055	0.000000
Elemental						
C	6000	-0.000874	6000	0.001480	6000	0.000104
O	8000	-0.515078	8000	0.654711	8000	0.045948
Na	11000	-0.007316	11000	0.006472	11000	0.000454
Mg	12000	-0.001620	12000	0.001355	12000	0.000095
Al	13000	-0.020522	13000	0.015468	13000	0.001086
Si	14000	-0.421080	14000	0.304910	14000	0.021399
P	15000	-0.000005	15000	0.000003	15000	0.000000
K	19000	-0.013509	19000	0.007027	19000	0.000493
Ca	20000	-0.008931	20000	0.004532	20000	0.000318
Ti	22000	-0.000200	22000	0.000085	22000	0.000006
Fe	26000	-0.010862	26000	0.003956	26000	0.000278
Mn	25000	-0.000003	25000	0.000001	25000	0.000000
Comments and References						
The weight fractions and densities are from H. Blatt and E.G. Ehlers, 'Petrology Igneous, Sedimentary, and Metamorphic', W.H. Freemand and Co., 1982.						

299. Rock, Shale

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 2.6 Total Atom Weight (atoms/b-cm) = 7.831E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.001483	1001	0.029414	1001	0.002303
H2	1002	-0.000000	1002	0.000003	1002	0.000000
C	6000	-0.018890	6000	0.031447	6000	0.002463
O16	8016	-0.485083	8016	0.606389	8016	0.047485

O17	8017	-0.000196	8017	0.000231	8017	0.000018
O18	8018	-0.001122	8018	0.001246	8018	0.000098
Na23	11023	-0.004276	11023	0.003719	11023	0.000291
Mg	12000	-0.006008	12000	0.004942	12000	0.000387
Al27	13027	-0.072577	13027	0.053784	13027	0.004212
Si	14000	-0.317411	14000	0.225978	14000	0.017696
P31	15031	-0.000064	15031	0.000041	15031	0.000003
S	16000	-0.009799	16000	0.006110	16000	0.000478
K	19000	-0.017193	19000	0.008792	19000	0.000689
Ca	20000	-0.029474	20000	0.014705	20000	0.001151
Ti	22000	-0.002623	22000	0.001096	22000	0.000086
Fe	26000	-0.033765	26000	0.012089	26000	0.000947
Mn55	25055	-0.000036	25055	0.000013	25055	0.000001
Elemental						
H	1000	-0.001483	1000	0.029418	1000	0.002304
C	6000	-0.018890	6000	0.031447	6000	0.002463
O	8000	-0.486400	8000	0.607866	8000	0.047601
Na	11000	-0.004276	11000	0.003719	11000	0.000291
Mg	12000	-0.006008	12000	0.004942	12000	0.000387
Al	13000	-0.072577	13000	0.053784	13000	0.004212
Si	14000	-0.317411	14000	0.225978	14000	0.017696
P	15000	-0.000064	15000	0.000041	15000	0.000003
S	16000	-0.009799	16000	0.006110	16000	0.000478
K	19000	-0.017193	19000	0.008792	19000	0.000689
Ca	20000	-0.029474	20000	0.014705	20000	0.001151
Ti	22000	-0.002623	22000	0.001096	22000	0.000086
Fe	26000	-0.033765	26000	0.012089	26000	0.000947
Mn	25000	-0.000036	25000	0.000013	25000	0.000001

Comments and References

The weight fractions and densities are from H. Blatt and E.G. Ehlers, 'Petrology Igneous, Sedimentary, and Metamorphic', W.H. Freemand and Co., 1982. Hillier, S., 2006. Appendix A. Mineralogical and chemical data, in GM Reeves, I Sims, and JC Cripps eds., Clay materials used in construction: London, Geological Society, Engineering Geology Special Publications Volume 21, p. 449-459. Shaw D.B. & Weaver C.E. 1965. The mineralogical composition of shales. J. Sed. Pet. 35, 213-222. https://www.claysandminerals.com/materials/shales.

300. Rubber, Butyl

Formula = C4H8 Molecular Weight (g/mole) = 56.106200
Density (g/cm3) = 0.92 Total Atom Weight (atoms/b-cm) = 1.185E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.143686	1001	0.666590	1001	0.078989

H2	1002	-0.000033	1002	0.000077	1002	0.000009
C	6000	-0.856276	6000	0.333333	6000	0.039499
Elemental						
H	1000	-0.143724	1000	0.666667	1000	0.078998
C	6000	-0.856276	6000	0.333333	6000	0.039499
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=242.						

301. Rubber, Natural

Formula = C5H8 Molecular Weight (g/mole) = 68.116800
Density (g/cm3) = 0.92 Total Atom Weight (atoms/b-cm) = 1.057E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.118351	1001	0.615314	1001	0.065062
H2	1002	-0.000027	1002	0.000071	1002	0.000007
C	6000	-0.881618	6000	0.384615	6000	0.040668
Elemental						
H	1000	-0.118382	1000	0.615385	1000	0.065069
C	6000	-0.881618	6000	0.384615	6000	0.040668
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=243.Formula from Table 51.11 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960. Halcyon Agri says natural rubber is made of polyisoprene (different isomers of isoprene).						

302. Rubber, Neoprene

Formula = C4H5Cl Molecular Weight (g/mole) = 88.533775
Density (g/cm3) = 1.23 Total Atom Weight (atoms/b-cm) = 8.367E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.056911	1001	0.499943	1001	0.041828
H2	1002	-0.000013	1002	0.000058	1002	0.000005
C	6000	-0.542645	6000	0.400000	6000	0.033466
Cl35	17035	-0.299235	17035	0.075760	17035	0.006339
Cl37	17037	-0.101210	17037	0.024240	17037	0.002028
Elemental						
H	1000	-0.056926	1000	0.500000	1000	0.041833
C	6000	-0.542645	6000	0.400000	6000	0.033466
Cl	17000	-0.400429	17000	0.100000	17000	0.008367

Comments and References
Density from physics.nist.gov/cgi-bin/Starcompos.pl?matno=244.Density = 1.23 g/cm3 for polychloroprene rubber from www.matweb.com/search/DataSheet.aspx?MatGUID=f3743816df954959b10cad28927578f0.

303. Rubber, Silicon

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.0185 Total Atom Weight (atoms/b-cm) = 8.227E-02

Weight fractions are adjusted so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.080695	1001	0.596959	1001	0.049110
H2	1002	-0.000019	1002	0.000069	1002	0.000006
C	6000	-0.321164	6000	0.199364	6000	0.016401
O16	8016	-0.222939	8016	0.103918	8016	0.008549
O17	8017	-0.000090	8017	0.000040	8017	0.000003
O18	8018	-0.000516	8018	0.000214	8018	0.000018
Si	14000	-0.374575	14000	0.099437	14000	0.008180
Elemental						
H	1000	-0.080716	1000	0.597028	1000	0.049116
C	6000	-0.321164	6000	0.199364	6000	0.016401
O	8000	-0.223545	8000	0.104171	8000	0.008570
Si	14000	-0.374575	14000	0.099437	14000	0.008180

Comments and References

LA-UR-09-0380, Criticality Calculations with MCNP5: A Primer by R. Brewer, LANL, Jan 2009. MatWeb lists a density of 1.12 g/cm3 for liquid silicon rubber.

304. Salt Water (T=0 C)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.209865 Total Atom Weight (atoms/b-cm) = 9.599E-02

Assumes a mixture of H2O:NaCl

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.082469	1001	0.621079	1001	0.059620
H2	1002	-0.000019	1002	0.000071	1002	0.000007
O16	8016	-0.652935	8016	0.309833	8016	0.029742
O17	8017	-0.000264	8017	0.000118	8017	0.000011
O18	8018	-0.001510	8018	0.000637	8018	0.000061

Na23	11023	-0.103378	11023	0.034130	11023	0.003276
Cl35	17035	-0.119134	17035	0.025858	17035	0.002482
Cl37	17037	-0.040295	17037	0.008273	17037	0.000794
Elemental						
H	1000	-0.082491	1000	0.621151	1000	0.059627
O	8000	-0.654709	8000	0.310588	8000	0.029815
Na	11000	-0.103378	11000	0.034130	11000	0.003276
Cl	17000	-0.159422	17000	0.034131	17000	0.003276
Comments and References						
The density of NaCl in water is calculated using Eqn. 4.3.1 from ORNL/CDIAC-74: DOE (1994) Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea WaterVersion 2 by A. G. Dickson and C Goyet, eds. (https://www.osti.gov/servlets/purl/10107773), the equation is valid from a molality in mols (NaCL)/(kg H2O) of 0.1 to concentration and temperature range of 0 to 40. This density is calculated at T = 0 C assuming a saturated solution, with 26.28 wt% salts based on page 8-116 of the Handbook of Chemistry and Physics, 89th edition.						

305. Salt Water (T=20 C)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.022394 Total Atom Weight (atoms/b-cm) = 9.977E-02

Assumes a mixture of H2O:NaCl

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.108086	1001	0.661821	1001	0.066032
H2	1002	-0.000025	1002	0.000076	1002	0.000008
O16	8016	-0.855745	8016	0.330157	8016	0.032941
O17	8017	-0.000346	8017	0.000126	8017	0.000013
O18	8018	-0.001979	8018	0.000678	8018	0.000068
Na23	11023	-0.013302	11023	0.003571	11023	0.000356
Cl35	17035	-0.015330	17035	0.002705	17035	0.000270
Cl37	17037	-0.005185	17037	0.000866	17037	0.000086
Elemental						
H	1000	-0.108114	1000	0.661897	1000	0.066039
O	8000	-0.858070	8000	0.330961	8000	0.033021
Na	11000	-0.013302	11000	0.003571	11000	0.000356
Cl	17000	-0.020514	17000	0.003571	17000	0.000356
Comments and References						
The density of NaCl in water is calculated using Eqn. 4.3.1 from ORNL/CDIAC-74: DOE (1994) Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Wateralso from https://www.crystals.saint-gobain.com/products/zns-and-lif-based-neutron-detectors, which also lists a mixture ZnS(Ag)+Li with variable Li content						

306. Sand

Formula =		Molecular Weight (g/mole) =				
Density (g/cm3) =	1.7	Total Atom Weight (atoms/b-cm) = 5.876E-02				
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.007831	1001	0.135386	1001	0.007955
H2	1002	-0.000002	1002	0.000016	1002	0.000001
C	6000	-0.003360	6000	0.004874	6000	0.000286
O16	8016	-0.534700	8016	0.582472	8016	0.034224
O17	8017	-0.000216	8017	0.000222	8017	0.000013
O18	8018	-0.001236	8018	0.001197	8018	0.000070
Na23	11023	-0.017063	11023	0.012932	11023	0.000760
Al27	13027	-0.034401	13027	0.022215	13027	0.001305
Si	14000	-0.365067	14000	0.226487	14000	0.013308
K	19000	-0.011622	19000	0.005179	19000	0.000304
Ca	20000	-0.011212	20000	0.004874	20000	0.000286
Fe	26000	-0.013289	26000	0.004146	26000	0.000244
Elemental						
H	1000	-0.007833	1000	0.135402	1000	0.007956
C	6000	-0.003360	6000	0.004874	6000	0.000286
O	8000	-0.536153	8000	0.583891	8000	0.034307
Na	11000	-0.017063	11000	0.012932	11000	0.000760
Al	13000	-0.034401	13000	0.022215	13000	0.001305
Si	14000	-0.365067	14000	0.226487	14000	0.013308
K	19000	-0.011622	19000	0.005179	19000	0.000304
Ca	20000	-0.011212	20000	0.004874	20000	0.000286
Fe	26000	-0.013289	26000	0.004146	26000	0.000244

Comments and References

Element weight fractions calculated based on 78.1 wt.% SiO2, 6.5% Al2O3, 1.9% Fe2O3, 2.8% CaCO3, 2.3% Na2O, 1.4% K2O, and 7.0% H2O from Table 51.62 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960. Density = 1.7 g/cm3 for normal sand (4 to 23 wt.% water) from www.matweb.com/search/DataSheet.aspx?MatGUID=ce6e6b2274534e35b6a14945e778e391. Use 1.65 g/cm3 for totally dry sand (www.matweb.com/search/DataSheet.aspx?MatGUID=18a1e365613b478f880e5506d6fb2ec1). Data for sand density is at www.simetric.co.uk/si_materials.htm, Table 51.61 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960, and at www.powderhandling.com.au/bulk-density-chart/.

307. Sea Water, Simple Artificial

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.023343 Total Atom Weight (atoms/b-cm) = 9.978E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.107946	1001	0.661507	1001	0.066007
H2	1002	-0.000025	1002	0.000076	1002	0.000008
O16	8016	-0.856439	8016	0.330695	8016	0.032998
O17	8017	-0.000347	8017	0.000126	8017	0.000013
O18	8018	-0.001981	8018	0.000680	8018	0.000068
Na23	11023	-0.010785	11023	0.002897	11023	0.000289
Mg	12000	-0.001284	12000	0.000326	12000	0.000033
S	16000	-0.000906	16000	0.000174	16000	0.000017
Cl35	17035	-0.014550	17035	0.002570	17035	0.000256
Cl37	17037	-0.004921	17037	0.000822	17037	0.000082
K	19000	-0.000399	19000	0.000063	19000	0.000006
Ca	20000	-0.000415	20000	0.000064	20000	0.000006
Elemental						
H	1000	-0.107974	1000	0.661583	1000	0.066015
O	8000	-0.858766	8000	0.331501	8000	0.033078
Na	11000	-0.010785	11000	0.002897	11000	0.000289
Mg	12000	-0.001284	12000	0.000326	12000	0.000033
S	16000	-0.000906	16000	0.000174	16000	0.000017
Cl	17000	-0.019471	17000	0.003392	17000	0.000338
K	19000	-0.000399	19000	0.000063	19000	0.000006
Ca	20000	-0.000415	20000	0.000064	20000	0.000006

Comments and References

Element weight fractions calculated based on 78.1 wt.% SiO2, 6.5% Al2O3, 1.9% Fe2O3, 2.8% CaCO3, 2.3% Na2O, 1.4% K2O, and 7.0% H2O from Table 51.62 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960. Density = 1.7 g/cm3 for normal sand (4 to 23 wt.% water) from www.matweb.com/search/DataSheet.aspx?MatGUID=ce6e6b2274534e35b6a14945e778e391. Use 1.65 g/cm3 for totally dry sand (www.matweb.com/search/DataSheet.aspx?MatGUID=18a1e365613b478f880e5506d6fb2ec1). Data for sand density is at www.simetric.co.uk/si_materials.htm, Table 51.61 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960, and at www.powderhandling.com.au/bulk-density-chart/.

308. Sea Water, Standard

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.023343 Total Atom Weight (atoms/b-cm) = 9.978E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.107938	1001	0.661483	1001	0.066002
H2	1002	-0.000025	1002	0.000076	1002	0.000008
B10	5010	-0.000001	5010	0.000001	5010	0.000000
B11	5011	-0.000004	5011	0.000002	5011	0.000000
C	6000	-0.000024	6000	0.000012	6000	0.000001
O16	8016	-0.856466	8016	0.330720	8016	0.032999
O17	8017	-0.000347	8017	0.000126	8017	0.000013
O18	8018	-0.001981	8018	0.000680	8018	0.000068
F19	9019	-0.000001	9019	0.000000	9019	0.000000
Na23	11023	-0.010784	11023	0.002897	11023	0.000289
Mg	12000	-0.001284	12000	0.000326	12000	0.000033
S	16000	-0.000905	16000	0.000174	16000	0.000017
Cl35	17035	-0.014461	17035	0.002554	17035	0.000255
Cl37	17037	-0.004891	17037	0.000817	17037	0.000082
K	19000	-0.000399	19000	0.000063	19000	0.000006
Ca	20000	-0.000412	20000	0.000063	20000	0.000006
Br79	35079	-0.000034	35079	0.000003	35079	0.000000
Br81	35081	-0.000033	35081	0.000003	35081	0.000000
Sr84	38084	-0.000000	38084	0.000000	38084	0.000000
Sr86	38086	-0.000001	38086	0.000000	38086	0.000000
Sr87	38087	-0.000001	38087	0.000000	38087	0.000000
Sr88	38088	-0.000007	38088	0.000000	38088	0.000000
Elemental						
H	1000	-0.107966	1000	0.661559	1000	0.066010
B	5000	-0.000005	5000	0.000003	5000	0.000000
C	6000	-0.000024	6000	0.000012	6000	0.000001
O	8000	-0.858793	8000	0.331526	8000	0.033079
F	9000	-0.000001	9000	0.000000	9000	0.000000
Na	11000	-0.010784	11000	0.002897	11000	0.000289
Mg	12000	-0.001284	12000	0.000326	12000	0.000033
S	16000	-0.000905	16000	0.000174	16000	0.000017
Cl	17000	-0.019352	17000	0.003371	17000	0.000336
K	19000	-0.000399	19000	0.000063	19000	0.000006
Ca	20000	-0.000412	20000	0.000063	20000	0.000006
Br	35000	-0.000067	35000	0.000005	35000	0.000001
Sr	38000	-0.000008	38000	0.000001	38000	0.000000
Comments and References						
From Chapter 5 of ORNL/CDIAC-74, Table 6.3. This density is calculated for T = 25 C and salinity = 35 with salinity defined in the reference as the sum of chemicals present in g/(kg solution). The density of sea water is calculated using Eqn. 4.2.2 from chapter 5 of ORNL/CDIAC-74, valid for the salinity range of 0 to 42 and temperature range 0 to 40 C.						

309. Sepiolite

Formula = Mg4Si6O23H14 Molecular Weight (g/mole) = 647.829850
Density (g/cm3) = 2.14 Total Atom Weight (atoms/b-cm) = 9.350E-02

Non-clumping cat litter is often made of zeolite, diatomaceous earth, and/or sepiolite.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.021777	1001	0.297838	1001	0.027847
H2	1002	-0.000005	1002	0.000034	1002	0.000003
O16	8016	-0.566490	8016	0.488173	8016	0.045643
O17	8017	-0.000229	8017	0.000186	8017	0.000017
O18	8018	-0.001310	8018	0.001003	8018	0.000094
Mg	12000	-0.150073	12000	0.085106	12000	0.007957
Si	14000	-0.260115	14000	0.127660	14000	0.011936
Elemental						
H	1000	-0.021783	1000	0.297872	1000	0.027850
O	8000	-0.568029	8000	0.489362	8000	0.045754
Mg	12000	-0.150073	12000	0.085106	12000	0.007957
Si	14000	-0.260115	14000	0.127660	14000	0.011936

Comments and References

Formula from webmineral.com/data/Sepiolite.shtml, and rpd.oxfordjournals.org/cgi/content/full/131/3/390. Density = 2.14 and 2.18 g/cm3 at webmineral.com/data/Sepiolite.shtml. Density = 2.08 g/cm3 at www.minersoc.org/pages/Archive-CM/Volume_34/34-4-647.pdf. NIH PubChem says 'sepiolite' refers to H4Mg2O10Si3 and H8Mg2O10Si3.AmericanElements.com says 'sepiolite' is Mg2H2(SiO3)3nH2O

310. Silciate Yttrium - 0.5 atom% Cerium

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.5 Total Atom Weight (atoms/b-cm) = 9.072E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Y89	39089	-0.423158	39089	0.142173	39089	0.012898
S	16000	-0.230094	16000	0.214332	16000	0.019445
O16	8016	-0.343468	8016	0.641432	8016	0.058193
O17	8017	-0.000139	8017	0.000244	8017	0.000022
O18	8018	-0.000794	8018	0.001318	8018	0.000120
Ce136	58136	-0.000004	58136	0.000001	58136	0.000000
Ce138	58138	-0.000006	58138	0.000001	58138	0.000000
Ce140	58140	-0.002072	58140	0.000442	58140	0.000040
Ce142	58142	-0.000264	58142	0.000056	58142	0.000005

Elemental						
Y	39000	-0.423158	39000	0.142173	39000	0.012898
S	16000	-0.230094	16000	0.214332	16000	0.019445
O	8000	-0.344402	8000	0.642995	8000	0.058334
Ce	58000	-0.002346	58000	0.000500	58000	0.000045

Comments and References

Formula is Y3Al5O12(Ce) but the formula isn't used in the calculation due to the Ce dopant Material properties taken from https://www.epic-crystal.com/oxide-scintillators/yso-ce-scintillator.html Dopant (aka Activator) added at 0.5 atom percent

311. Silicon

Formula = Si Molecular Weight (g/mole) = 28.085000
Density (g/cm3) = 2.33 Total Atom Weight (atoms/b-cm) = 4.996E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Si	14000	-1.000000	14000	1.000000	14000	0.049961
Elemental						
Si	14000	-1.000000	14000	1.000000	14000	0.049961

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=014.

312. Silicon Carbide (hexagonal)

Formula = SiC Molecular Weight (g/mole) = 40.095600
Density (g/cm3) = 3.21 Total Atom Weight (atoms/b-cm) = 9.642E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.299549	6000	0.500000	6000	0.048212
Si	14000	-0.700451	14000	0.500000	14000	0.048212
Elemental						
C	6000	-0.299549	6000	0.500000	6000	0.048212
Si	14000	-0.700451	14000	0.500000	14000	0.048212

Comments and References

Density and formula from CRC Materials Science and Engineer Handbook, 3rd Edition, by J.F. Shackelford and W. Alexander, CRC Press, 2001.CRC 100th edition (Internet Version 2019) says density of silicon carbide (hexagonal), also known as moissanite, is 3.16 g/cm3.NIH PubChem lists silicon carbide, carborundum, with densities of 3.2 and 3.23 g/cm3.

313. Silicon Dioxide (Alpha-quartz)

Formula = SiO2 Molecular Weight (g/mole) = 60.083800
Density (g/cm3) = 2.648 Total Atom Weight (atoms/b-cm) = 7.962E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.531126	8016	0.665047	8016	0.052952
O17	8017	-0.000215	8017	0.000253	8017	0.000020
O18	8018	-0.001228	8018	0.001367	8018	0.000109
Si	14000	-0.467430	14000	0.333333	14000	0.026541
Elemental						
O	8000	-0.532570	8000	0.666667	8000	0.053081
Si	14000	-0.467430	14000	0.333333	14000	0.026541

Comments and References

Density of SiO2 for alpha-quartz = 2.648 g/cm3 in CRC Handbook of Chemistry and Physics, 89th Edition (www.hbcpnetbase.com/), page 4-88, and at www.matweb.com/search/DataSheet.aspx?MatGUID=d5c906beded84f18a394afec8735c2a4. Note that there are 12 minerals listed for SiO2 at MatWeb.com. CRC 100th edition (Internet Version 2019) also states density of 2.648 g/cm3 for alpha-quartz and lists a total of five versions of SiO2.AmericanElements.com lists a density of 2533 kg/m3.

314. Silicon Dioxide (Silica)

Formula = SiO2 Molecular Weight (g/mole) = 60.083800
Density (g/cm3) = 2.32 Total Atom Weight (atoms/b-cm) = 6.976E-02

Note that there are 12 minerals listed for SiO2 at MatWeb.com.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.531126	8016	0.665047	8016	0.046393
O17	8017	-0.000215	8017	0.000253	8017	0.000018
O18	8018	-0.001228	8018	0.001367	8018	0.000095
Si	14000	-0.467430	14000	0.333333	14000	0.023253
Elemental						
O	8000	-0.532570	8000	0.666667	8000	0.046506
Si	14000	-0.467430	14000	0.333333	14000	0.023253

Comments and References

Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=245. Density of regular sand is 1.59 g/cm3, of dry sand is 1.76, and of fine sand is 2.00 g/cm3 based on www.powderhandling.com.au/bulk-density-chart/.CRC 100th edition (Internet Version 2019) also states density of 2.648 g/cm3 for alpha-quartz and lists five versions of SiO2 with densities of 2.196, 2.265, 2.334, 2.533, and 2.648 g/cm3.AmericanElements.com lists a density of 2533 kg/m3.

315. Silver

Formula = Ag			Molecular Weight (g/mole) = 107.868200			
Density (g/cm3) = 10.5			Total Atom Weight (atoms/b-cm) = 5.862E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ag	47000	-1.000000	47000	1.000000	47000	0.058620
Elemental						
Ag	47000	-1.000000	47000	1.000000	47000	0.058620
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=047.						

316. Skin (ICRP)

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) = 1.1			Total Atom Weight (atoms/b-cm) = 1.066E-01			
Based on the International Commission on Radiological Protection (ICRP).						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.100561	1001	0.619887	1001	0.066098
H2	1002	-0.000023	1002	0.000071	1002	0.000008
C	6000	-0.228250	6000	0.118062	6000	0.012589
N14	7014	-0.046239	7014	0.020514	7014	0.002187
N15	7015	-0.000181	7015	0.000075	7015	0.000008
O16	8016	-0.617325	8016	0.239771	8016	0.025567
O17	8017	-0.000250	8017	0.000091	8017	0.000010
O18	8018	-0.001428	8018	0.000493	8018	0.000053
Na23	11023	-0.000070	11023	0.000019	11023	0.000002
Mg	12000	-0.000060	12000	0.000015	12000	0.000002
P31	15031	-0.000330	15031	0.000066	15031	0.000007
S	16000	-0.001590	16000	0.000308	16000	0.000033
Cl35	17035	-0.001995	17035	0.000354	17035	0.000038
Cl37	17037	-0.000675	17037	0.000113	17037	0.000012
K	19000	-0.000850	19000	0.000135	19000	0.000014
Ca	20000	-0.000150	20000	0.000023	20000	0.000002
Fe	26000	-0.000010	26000	0.000001	26000	0.000000
Zn	30000	-0.000010	30000	0.000001	30000	0.000000
Elemental						
H	1000	-0.100588	1000	0.619958	1000	0.066106
C	6000	-0.228250	6000	0.118062	6000	0.012589

N	7000	-0.046420	7000	0.020589	7000	0.002195
O	8000	-0.619002	8000	0.240355	8000	0.025629
Na	11000	-0.000070	11000	0.000019	11000	0.000002
Mg	12000	-0.000060	12000	0.000015	12000	0.000002
P	15000	-0.000330	15000	0.000066	15000	0.000007
S	16000	-0.001590	16000	0.000308	16000	0.000033
Cl	17000	-0.002670	17000	0.000468	17000	0.000050
K	19000	-0.000850	19000	0.000135	19000	0.000014
Ca	20000	-0.000150	20000	0.000023	20000	0.000002
Fe	26000	-0.000010	26000	0.000001	26000	0.000000
Zn	30000	-0.000010	30000	0.000001	30000	0.000000
Comments and References						
Densities and weight fractions from physics.nist.gov/cgi-bin/Star/compos.pl?matno=250. See also The International Commission on Radiological Protection,ICRP PUBLICATION 89, Basic Anatomical and Physiological Data for Use in Radiological Protection: Refence Values, J. Valentin, Editor, 2003 ICRP Published by Elsevier Science Ltd.						

317. Sodium

Formula = Na			Molecular Weight (g/mole) = 22.989769			
Density (g/cm3) = 0.971			Total Atom Weight (atoms/b-cm) = 2.543E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Na23	11023	-1.000000	11023	1.000000	11023	0.025435
Elemental						
Na	11000	-1.000000	11000	1.000000	11000	0.025435
Comments and References						
Density from physics.nist.gov/cgi-bin/Star/compos.pl?matno=011.						

318. Sodium Bismuth Tungstate (NBWO)

Formula = NaBiW2O8			Molecular Weight (g/mole) = 727.645369			
Density (g/cm3) = 7.57			Total Atom Weight (atoms/b-cm) = 7.518E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.175427	8016	0.665047	8016	0.049999
O17	8017	-0.000071	8017	0.000253	8017	0.000019
O18	8018	-0.000406	8018	0.001367	8018	0.000103
Na23	11023	-0.031595	11023	0.083333	11023	0.006265

W	74000	-0.505301	74000	0.166667	74000	0.012530
Bi209	83209	-0.287201	83209	0.083333	83209	0.006265
Elemental						
O	8000	-0.175903	8000	0.666667	8000	0.050121
Na	11000	-0.031595	11000	0.083333	11000	0.006265
W	74000	-0.505301	74000	0.166667	74000	0.012530
Bi	83000	-0.287201	83000	0.083333	83000	0.006265
Comments and References						
www.advatech-uk.co.uk/nbwo.html						

319. Sodium Chloride

Formula = NaCl Molecular Weight (g/mole) = 58.441269
Density (g/cm3) = 2.17 Total Atom Weight (atoms/b-cm) = 4.472E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Na23	11023	-0.393382	11023	0.500000	11023	0.022361
Cl35	17035	-0.453317	17035	0.378800	17035	0.016941
Cl37	17037	-0.153325	17037	0.121200	17037	0.005420
Elemental						
Na	11000	-0.393382	11000	0.500000	11000	0.022361
Cl	17000	-0.606618	17000	0.500000	17000	0.022361
Comments and References						
www.matweb.com/search/DataSheet.aspx?MatGUID=472cb23059a343df924c69c25a1779ee NIH PubChem lists densities of 2.165 and 2.17 g/cm3.AmericanElements.com lists 2.16 g/cm3. WebMineral.com and CRC 100th edition list 2.17 g/cm3 for NaCl halite.						

320. Sodium Iodide - 0.2 wt% Thalium Doped

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 3.667 Total Atom Weight (atoms/b-cm) = 2.941E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Na23	11023	-0.152956	11023	0.499500	11023	0.014692
I127	53127	-0.844324	53127	0.499501	53127	0.014692
Tl203	81203	-0.000797	81203	0.000295	81203	0.000009
Tl205	81205	-0.001923	81205	0.000704	81205	0.000021
Elemental						
Na	11000	-0.152956	11000	0.499500	11000	0.014692
I	53000	-0.844324	53000	0.499501	53000	0.014692

Tl	81000	-0.002720	81000	0.000999	81000	0.000029
Comments and References						
Formula is NaI(Tl) but the formula isn't used in the calculation due to the Tl dopant Densities from physics.nist.gov/cgi-bin/Star/compos.pl?matno=252. Also page 235 of Radiation Detection and Measurement by Glenn F. Knoll, 3rd edition, 2000. MatWeb.com and NIH PubChem list density of 3.67 g/cm3. AmericanElements.com lists density of 3.70 g/cm3 for sodium iodide and 3.67 g/cm3 for ultra-dry sodium iodide. Material information from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/lanthanum-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain Safety Data Sheets and literature at St Gobain resource library @ https://www.crystals.saint-gobain.com/document-center						

321. Sodium Iodide with 8 wt% Lithium - 0.10 wt% Thalium doped

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) =	3.66		Total Atom Weight (atoms/b-cm) = 3.107E-02			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
I127	53127	-0.848388	53127	0.474211	53127	0.014735
Na23	11023	-0.142176	11023	0.438678	11023	0.013631
Li6	3006	-0.002316	3006	0.028452	3006	0.000849
Li7	3007	-0.005527	3007	0.058220	3007	0.001736
Tl203	81203	-0.000371	81203	0.000130	81203	0.000004
Tl205	81205	-0.000894	81205	0.000309	81205	0.000010
Elemental						
I	53000	-0.848388	53000	0.474211	53000	0.014735
Na	11000	-0.142176	11000	0.438678	11000	0.013631
Li	3006	-0.002316	3006	0.028452	3006	0.000849
Li	3007	-0.005527	3007	0.058220	3007	0.001736
Tl	81000	-0.001265	81000	0.000439	81000	0.000014
Comments and References						
Formula is NaIL(Tl) but the formula isn't used in the calculation due to the Tl dopant Material information from https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/lanthanum-material-data-sheet.pdf Dopant (aka Activator) added per St Gobain Safety Data Sheets and literature at St Gobain resource library @ https://www.crystals.saint-gobain.com/document-center						

322. Sodium Nitrate

Formula =	NaNO3		Molecular Weight (g/mole) = 84.994824
Density (g/cm3) =	2.261		Total Atom Weight (atoms/b-cm) = 8.010E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
N14	7014	-0.164152	7014	0.199272	7014	0.015962
N15	7015	-0.000642	7015	0.000728	7015	0.000058
O16	8016	-0.563189	8016	0.598542	8016	0.047943
O17	8017	-0.000228	8017	0.000228	8017	0.000018
O18	8018	-0.001302	8018	0.001230	8018	0.000099
Na23	11023	-0.270484	11023	0.200000	11023	0.016020
Elemental						
N	7000	-0.164797	7000	0.200000	7000	0.016020
O	8000	-0.564719	8000	0.600000	8000	0.048060
Na	11000	-0.270484	11000	0.200000	11000	0.016020
Comments and References						
Theoretical density = 2.261 g/cm3 from physics.nist.gov/cgi-bin/Star/compos.pl?matno=254. Bulk density = 1.35 g/cm3 at www.powderhandling.com.au/bulk-density-chart/. Formula from CRC Handbook of Chemistry and Physics, 89th ed., p.4-90.MatWeb.com and AmericanElements.com list density of 2.26 g/cm3. NIH PubChem lists density of 2.26 and 2.3 g/cm3. WebMineral.com lists NaNO3 as nitratine with a density range of 2.24 - 2.29 g/cm3 with an average of 2.26 g/cm3.						

323. Sodium Oxide

Formula = Na2O Molecular Weight (g/mole) = 61.978938
Density (g/cm3) = 2.27 Total Atom Weight (atoms/b-cm) = 6.617E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.257443	8016	0.332523	8016	0.022003
O17	8017	-0.000104	8017	0.000127	8017	0.000008
O18	8018	-0.000595	8018	0.000683	8018	0.000045
Na23	11023	-0.741857	11023	0.666667	11023	0.044113
Elemental						
O	8000	-0.258143	8000	0.333333	8000	0.022056
Na	11000	-0.741857	11000	0.666667	11000	0.044113
Comments and References						
Formula and density from CRC Handbook of Chemistry and Physics, 89th edition, page 4-91, and from Table 51.11 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960. MatWeb.com and AmericanElememts.com list density of 2.27 g/cm3. NIH PubChem and CRC 100th edition list density of 2.3 g/cm3.						

324. Steel, Boron Stainless

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.87 Total Atom Weight (atoms/b-cm) = 9.046E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Cr	24000	-0.194600	24000	0.196075	24000	0.017738
Ni	28000	-0.133200	28000	0.118895	28000	0.010756
B10	5010	-0.002156	5010	0.011280	5010	0.001020
B11	5011	-0.009541	5011	0.045405	5011	0.004108
C	6000	-0.000500	6000	0.002181	6000	0.000197
N14	7014	-0.000100	7014	0.000373	7014	0.000034
N15	7015	-0.000000	7015	0.000001	7015	0.000000
P31	15031	-0.000020	15031	0.000034	15031	0.000003
S	16000	-0.000030	16000	0.000049	16000	0.000004
Co59	27059	-0.000300	27059	0.000267	27059	0.000024
Si	14000	-0.006900	14000	0.012871	14000	0.001164
Mn55	25055	-0.019100	25055	0.018214	25055	0.001648
Fe	26000	-0.633550	26000	0.594355	26000	0.053768
Elemental						
Cr	24000	-0.194600	24000	0.196075	24000	0.017738
Ni	28000	-0.133200	28000	0.118895	28000	0.010756
B	5000	-0.011700	5000	0.056685	5000	0.005128
C	6000	-0.000500	6000	0.002181	6000	0.000197
N	7000	-0.000100	7000	0.000374	7000	0.000034
P	15000	-0.000020	15000	0.000034	15000	0.000003
S	16000	-0.000030	16000	0.000049	16000	0.000004
Co	27000	-0.000300	27000	0.000267	27000	0.000024
Si	14000	-0.006900	14000	0.012871	14000	0.001164
Mn	25000	-0.019100	25000	0.018214	25000	0.001648
Fe	26000	-0.633550	26000	0.594355	26000	0.053768

Comments and References

T. Lister, R. Mizia, A. Erickson, S. Birk, 'Electrochemical Corrosion Testing of Borated Stainless Steel Alloys', INL/EXT-07-12633, May 2007, https://www.nrc.gov/docs/ML0923/ML092310695.pdf, Section 2.1 Specimes - Table 1. Alloy composition and ASTM specifications (wt%). Alloy 304B4 Grade A

325. Steel, HT9 Stainless

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.874 Total Atom Weight (atoms/b-cm) = 8.604E-02

The above density is estimated to be accurate to 4 significant digits from similar

materials.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.002100	6000	0.009637	6000	0.000829
N14	7014	-0.000060	7014	0.000235	7014	0.000020
N15	7015	-0.000000	7015	0.000001	7015	0.000000
Al27	13027	-0.000300	13027	0.000613	13027	0.000053
Si	14000	-0.002100	14000	0.004121	14000	0.000355
P31	15031	-0.000080	15031	0.000142	15031	0.000012
S	16000	-0.000030	16000	0.000052	16000	0.000004
Ti	22000	-0.000100	22000	0.000115	22000	0.000010
V	23000	-0.003300	23000	0.003570	23000	0.000307
Cr	24000	-0.118000	24000	0.125077	24000	0.010761
Mn55	25055	-0.005000	25055	0.005016	25055	0.000432
Fe	26000	-0.851130	26000	0.839996	26000	0.072270
Ni	28000	-0.005100	28000	0.004789	28000	0.000412
Mo	42000	-0.010300	42000	0.005916	42000	0.000509
W	74000	-0.002400	74000	0.000720	74000	0.000062
Elemental						
C	6000	-0.002100	6000	0.009637	6000	0.000829
N	7000	-0.000060	7000	0.000236	7000	0.000020
Al	13000	-0.000300	13000	0.000613	13000	0.000053
Si	14000	-0.002100	14000	0.004121	14000	0.000355
P	15000	-0.000080	15000	0.000142	15000	0.000012
S	16000	-0.000030	16000	0.000052	16000	0.000004
Ti	22000	-0.000100	22000	0.000115	22000	0.000010
V	23000	-0.003300	23000	0.003570	23000	0.000307
Cr	24000	-0.118000	24000	0.125077	24000	0.010761
Mn	25000	-0.005000	25000	0.005016	25000	0.000432
Fe	26000	-0.851130	26000	0.839996	26000	0.072270
Ni	28000	-0.005100	28000	0.004789	28000	0.000412
Mo	42000	-0.010300	42000	0.005916	42000	0.000509
W	74000	-0.002400	74000	0.000720	74000	0.000062

Comments and References

Accelerated Irradiations for High Dose Microstructures in Fast Reactor AlloysTable 2.1. Composition of T91, HT9, 14YWT and NF616. Page 11. DOE/NEUP-12-3541

326. Steel, High Carbon (1095)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.872 Total Atom Weight (atoms/b-cm) = 8.815E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.010300	6000	0.046122	6000	0.004065
Mn55	25055	-0.005000	25055	0.004895	25055	0.000431
P31	15031	-0.000400	15031	0.000695	15031	0.000061
S	16000	-0.000500	16000	0.000839	16000	0.000074
Fe	26000	-0.983800	26000	0.947449	26000	0.083514
Elemental						
C	6000	-0.010300	6000	0.046122	6000	0.004065
Mn	25000	-0.005000	25000	0.004895	25000	0.000431
P	15000	-0.000400	15000	0.000695	15000	0.000061
S	16000	-0.000500	16000	0.000839	16000	0.000074
Fe	26000	-0.983800	26000	0.947449	26000	0.083514

Comments and References

'Active Standard ASTM A29/A29M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Grade Designations and Chemical Compositions of Carbon Steel Bars, see grade designation 1095 Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=21bc72229925455db41e3cea6bb7625a

327. Steel, Low Carbon (1008)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.872 Total Atom Weight (atoms/b-cm) = 8.526E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.001000	6000	0.004629	6000	0.000395
Mn55	25055	-0.005000	25055	0.005060	25055	0.000431
P31	15031	-0.000400	15031	0.000718	15031	0.000061
S	16000	-0.000500	16000	0.000867	16000	0.000074
Fe	26000	-0.993100	26000	0.988726	26000	0.084303
Elemental						
C	6000	-0.001000	6000	0.004629	6000	0.000395
Mn	25000	-0.005000	25000	0.005060	25000	0.000431
P	15000	-0.000400	15000	0.000718	15000	0.000061
S	16000	-0.000500	16000	0.000867	16000	0.000074
Fe	26000	-0.993100	26000	0.988726	26000	0.084303

Comments and References

Active Standard ASTM A29/A29M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought, TABLE 1 Grade Designations and Chemical Compositions of Carbon Steel Bars, see grade designation 1008 Density obtained from

http://www.matweb.com/search/DataSheet.aspx?MatGUID=e3df7e90a7d6404f8b5366fd1e6f9941

328. Steel, Medium Carbon (1045)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.872 Total Atom Weight (atoms/b-cm) = 8.651E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.005000	6000	0.022813	6000	0.001974
Mn55	25055	-0.009000	25055	0.008977	25055	0.000777
P31	15031	-0.000400	15031	0.000708	15031	0.000061
S	16000	-0.000500	16000	0.000854	16000	0.000074
Fe	26000	-0.985100	26000	0.966648	26000	0.083624
Elemental						
C	6000	-0.005000	6000	0.022813	6000	0.001974
Mn	25000	-0.009000	25000	0.008977	25000	0.000777
P	15000	-0.000400	15000	0.000708	15000	0.000061
S	16000	-0.000500	16000	0.000854	16000	0.000074
Fe	26000	-0.985100	26000	0.966648	26000	0.083624

Comments and References

'Active Standard ASTM A29/A29M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Grade Designations and Chemical Compositions of Carbon Steel Bars, see grade designation 1045 Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=20fffdaa96f14dd98f5032c4014b9587

329. Steel, Stainless 202

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.86 Total Atom Weight (atoms/b-cm) = 8.780E-02

The above density is estimated to be accurate to 3 significant digits from similar materials. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.001500	6000	0.006733	6000	0.000591
Mn55	25055	-0.087500	25055	0.085864	25055	0.007539
P31	15031	-0.000600	15031	0.001044	15031	0.000092
S	16000	-0.000300	16000	0.000504	16000	0.000044

Si	14000	-0.010000	14000	0.019196	14000	0.001685
Cr	24000	-0.180000	24000	0.186629	24000	0.016386
Ni	28000	-0.050000	28000	0.045926	28000	0.004032
N14	7014	-0.002490	7014	0.009587	7014	0.000842
N15	7015	-0.000010	7015	0.000035	7015	0.000003
Fe	26000	-0.667600	26000	0.644482	26000	0.056586
Elemental						
C	6000	-0.001500	6000	0.006733	6000	0.000591
Mn	25000	-0.087500	25000	0.085864	25000	0.007539
P	15000	-0.000600	15000	0.001044	15000	0.000092
S	16000	-0.000300	16000	0.000504	16000	0.000044
Si	14000	-0.010000	14000	0.019196	14000	0.001685
Cr	24000	-0.180000	24000	0.186629	24000	0.016386
Ni	28000	-0.050000	28000	0.045926	28000	0.004032
N	7000	-0.002500	7000	0.009622	7000	0.000845
Fe	26000	-0.667600	26000	0.644482	26000	0.056586

Comments and References

'Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Chemical Requirements. UNS Designation S20200 - Type 202.Weight fractions for Mn, Cr and Ni are set at the average of the given range. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=d92b11c51d284edfbfea21ed274d55d5

330. Steel, Stainless 302

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.86 Total Atom Weight (atoms/b-cm) = 8.715E-02

The above density is estimated to be accurate to 3 significant digits from similar materials. Uncertainties are not addressed. Weight fractions for Cr and Ni are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.001500	6000	0.006783	6000	0.000591
Mn55	25055	-0.020000	25055	0.019772	25055	0.001723
P31	15031	-0.000450	15031	0.000789	15031	0.000069
S	16000	-0.000300	16000	0.000508	16000	0.000044
Si	14000	-0.010000	14000	0.019339	14000	0.001685
Cr	24000	-0.180000	24000	0.188019	24000	0.016386
Ni	28000	-0.090000	28000	0.083282	28000	0.007258
N14	7014	-0.000996	7014	0.003863	7014	0.000337
N15	7015	-0.000004	7015	0.000014	7015	0.000001
Fe	26000	-0.696750	26000	0.677630	26000	0.059056
Elemental						

C	6000	-0.001500	6000	0.006783	6000	0.000591
Mn	25000	-0.020000	25000	0.019772	25000	0.001723
P	15000	-0.000450	15000	0.000789	15000	0.000069
S	16000	-0.000300	16000	0.000508	16000	0.000044
Si	14000	-0.010000	14000	0.019339	14000	0.001685
Cr	24000	-0.180000	24000	0.188019	24000	0.016386
Ni	28000	-0.090000	28000	0.083282	28000	0.007258
N	7000	-0.001000	7000	0.003878	7000	0.000338
Fe	26000	-0.696750	26000	0.677630	26000	0.059056
Comments and References						
'Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Chemical Requirements. UNS Designation S30200 - Type 302. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=e6ecda4597d24966bfd73ea4638beb57						

331. Steel, Stainless 304

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8.03 Total Atom Weight (atoms/b-cm) = 8.860E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Cr and Ni are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000800	6000	0.003635	6000	0.000322
Mn55	25055	-0.020000	25055	0.019870	25055	0.001760
P31	15031	-0.000450	15031	0.000793	15031	0.000070
S	16000	-0.000300	16000	0.000511	16000	0.000045
Si	14000	-0.010000	14000	0.019434	14000	0.001722
Cr	24000	-0.190000	24000	0.199443	24000	0.017671
Ni	28000	-0.095000	28000	0.088343	28000	0.007827
Fe	26000	-0.683450	26000	0.667971	26000	0.059182
Elemental						
C	6000	-0.000800	6000	0.003635	6000	0.000322
Mn	25000	-0.020000	25000	0.019870	25000	0.001760
P	15000	-0.000450	15000	0.000793	15000	0.000070
S	16000	-0.000300	16000	0.000511	16000	0.000045
Si	14000	-0.010000	14000	0.019434	14000	0.001722
Cr	24000	-0.190000	24000	0.199443	24000	0.017671
Ni	28000	-0.095000	28000	0.088343	28000	0.007827
Fe	26000	-0.683450	26000	0.667971	26000	0.059182
Comments and References						

'Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Chemical Requirements. UNS Designation S30400 - Type 304. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=abc4415b0f8b490387e3c922237098da

332. Steel, Stainless 304L

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8 Total Atom Weight (atoms/b-cm) = 8.827E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Cr and Ni are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000800	6000	0.003635	6000	0.000321
Mn55	25055	-0.020000	25055	0.019870	25055	0.001754
P31	15031	-0.000450	15031	0.000793	15031	0.000070
S	16000	-0.000300	16000	0.000511	16000	0.000045
Si	14000	-0.010000	14000	0.019434	14000	0.001715
Cr	24000	-0.190000	24000	0.199443	24000	0.017605
Ni	28000	-0.095000	28000	0.088343	28000	0.007798
Fe	26000	-0.683450	26000	0.667971	26000	0.058961
Elemental						
C	6000	-0.000800	6000	0.003635	6000	0.000321
Mn	25000	-0.020000	25000	0.019870	25000	0.001754
P	15000	-0.000450	15000	0.000793	15000	0.000070
S	16000	-0.000300	16000	0.000511	16000	0.000045
Si	14000	-0.010000	14000	0.019434	14000	0.001715
Cr	24000	-0.190000	24000	0.199443	24000	0.017605
Ni	28000	-0.095000	28000	0.088343	28000	0.007798
Fe	26000	-0.683450	26000	0.667971	26000	0.058961

Comments and References

'Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Chemical Requirements. UNS Designation S30403 - Type 304L. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=e2147b8f727343b0b0d51efe02a6127e

333. Steel, Stainless 316

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8 Total Atom Weight (atoms/b-cm) = 8.713E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Cr and Ni are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000800	6000	0.003683	6000	0.000321
Mn55	25055	-0.020000	25055	0.020128	25055	0.001754
P31	15031	-0.000450	15031	0.000803	15031	0.000070
S	16000	-0.000300	16000	0.000517	16000	0.000045
Si	14000	-0.010000	14000	0.019687	14000	0.001715
Cr	24000	-0.170000	24000	0.180771	24000	0.015751
Ni	28000	-0.120000	28000	0.113043	28000	0.009850
Mo	42000	-0.025000	42000	0.014406	42000	0.001255
Fe	26000	-0.653450	26000	0.646962	26000	0.056373
Elemental						
C	6000	-0.000800	6000	0.003683	6000	0.000321
Mn	25000	-0.020000	25000	0.020128	25000	0.001754
P	15000	-0.000450	15000	0.000803	15000	0.000070
S	16000	-0.000300	16000	0.000517	16000	0.000045
Si	14000	-0.010000	14000	0.019687	14000	0.001715
Cr	24000	-0.170000	24000	0.180771	24000	0.015751
Ni	28000	-0.120000	28000	0.113043	28000	0.009850
Mo	42000	-0.025000	42000	0.014406	42000	0.001255
Fe	26000	-0.653450	26000	0.646962	26000	0.056373

Comments and References

'Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Chemical Requirements. UNS Designation S31600 - Type 316. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=994d75c5b5814f95a2b70c94e0b865d3

334. Steel, Stainless 316L

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8 Total Atom Weight (atoms/b-cm) = 8.698E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Cr and Ni are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000300	6000	0.001384	6000	0.000120
Mn55	25055	-0.020000	25055	0.020165	25055	0.001754
P31	15031	-0.000450	15031	0.000805	15031	0.000070
S	16000	-0.000300	16000	0.000518	16000	0.000045
Si	14000	-0.010000	14000	0.019722	14000	0.001715

Cr	24000	-0.170000	24000	0.181098	24000	0.015751
Ni	28000	-0.120000	28000	0.113247	28000	0.009850
Mo	42000	-0.025000	42000	0.014432	42000	0.001255
Fe	26000	-0.653950	26000	0.648629	26000	0.056416
Elemental						
C	6000	-0.000300	6000	0.001384	6000	0.000120
Mn	25000	-0.020000	25000	0.020165	25000	0.001754
P	15000	-0.000450	15000	0.000805	15000	0.000070
S	16000	-0.000300	16000	0.000518	16000	0.000045
Si	14000	-0.010000	14000	0.019722	14000	0.001715
Cr	24000	-0.170000	24000	0.181098	24000	0.015751
Ni	28000	-0.120000	28000	0.113247	28000	0.009850
Mo	42000	-0.025000	42000	0.014432	42000	0.001255
Fe	26000	-0.653950	26000	0.648629	26000	0.056416

Comments and References

'Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Chemical Requirements. UNS Designation S31603 - Type 316L. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=530144e2752b47709a58ca8fe0849969

335. Steel, Stainless 321

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8 Total Atom Weight (atoms/b-cm) = 8.816E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Cr and Ni are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000800	6000	0.003640	6000	0.000321
Mn55	25055	-0.020000	25055	0.019894	25055	0.001754
P31	15031	-0.000450	15031	0.000794	15031	0.000070
S	16000	-0.000300	16000	0.000511	16000	0.000045
Si	14000	-0.010000	14000	0.019457	14000	0.001715
Cr	24000	-0.180000	24000	0.189172	24000	0.016678
Ni	28000	-0.105000	28000	0.097759	28000	0.008619
Fe	26000	-0.683450	26000	0.668773	26000	0.058961
Elemental						
C	6000	-0.000800	6000	0.003640	6000	0.000321
Mn	25000	-0.020000	25000	0.019894	25000	0.001754
P	15000	-0.000450	15000	0.000794	15000	0.000070
S	16000	-0.000300	16000	0.000511	16000	0.000045
Si	14000	-0.010000	14000	0.019457	14000	0.001715
Cr	24000	-0.180000	24000	0.189172	24000	0.016678

Ni	28000	-0.105000	28000	0.097759	28000	0.008619
Fe	26000	-0.683450	26000	0.668773	26000	0.058961
Comments and References						
'Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Chemical Requirements. UNS Designation S32100 - Type 321. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=5b0e95f294c04e2d87da228e8018e2ff						

336. Steel, Stainless 347

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 8 Total Atom Weight (atoms/b-cm) = 8.784E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Cr and Ni are set at the average of the given range. Nb is calculated by the average between 10×C & 1.10

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000800	6000	0.003653	6000	0.000321
Mn55	25055	-0.020000	25055	0.019968	25055	0.001754
P31	15031	-0.000450	15031	0.000797	15031	0.000070
S	16000	-0.000300	16000	0.000513	16000	0.000045
Si	14000	-0.010000	14000	0.019530	14000	0.001715
Cr	24000	-0.180000	24000	0.189877	24000	0.016678
Ni	28000	-0.105000	28000	0.098123	28000	0.008619
Nb93	41093	-0.009500	41093	0.005609	41093	0.000493
Fe	26000	-0.673950	26000	0.661930	26000	0.058141
Elemental						
C	6000	-0.000800	6000	0.003653	6000	0.000321
Mn	25000	-0.020000	25000	0.019968	25000	0.001754
P	15000	-0.000450	15000	0.000797	15000	0.000070
S	16000	-0.000300	16000	0.000513	16000	0.000045
Si	14000	-0.010000	14000	0.019530	14000	0.001715
Cr	24000	-0.180000	24000	0.189877	24000	0.016678
Ni	28000	-0.105000	28000	0.098123	28000	0.008619
Nb	41000	-0.009500	41000	0.005609	41000	0.000493
Fe	26000	-0.673950	26000	0.661930	26000	0.058141
Comments and References						
'Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought', TABLE 1 Chemical Requirements. UNS Designation S34700 - Type 347. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=cecb69a2b862447f9c748c2e22cc0210						

337. Steel, Stainless 409

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.8 Total Atom Weight (atoms/b-cm) = 8.584E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. S40900 (Type 409) has been replaced by S40910, S40920, and S40930. Material meeting the requirements of S40910, S40920, or S40930, may ... be certified as S40900. Weight fractions for Cr is set at the average of the given range. Ti is calculated by the average between 6×(C+N) & 0.5

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000300	6000	0.001367	6000	0.000117
Mn55	25055	-0.010000	25055	0.009961	25055	0.000855
P31	15031	-0.000400	15031	0.000707	15031	0.000061
S	16000	-0.000200	16000	0.000341	16000	0.000029
Si	14000	-0.010000	14000	0.019484	14000	0.001673
Cr	24000	-0.111000	24000	0.116819	24000	0.010028
Ni	28000	-0.005000	28000	0.004662	28000	0.000400
N14	7014	-0.000299	7014	0.001168	7014	0.000100
N15	7015	-0.000001	7015	0.000004	7015	0.000000
Ti	22000	-0.004300	22000	0.004916	22000	0.000422
Nb93	41093	-0.001700	41093	0.001001	41093	0.000086
Fe	26000	-0.856800	26000	0.839570	26000	0.072068
Elemental						
C	6000	-0.000300	6000	0.001367	6000	0.000117
Mn	25000	-0.010000	25000	0.009961	25000	0.000855
P	15000	-0.000400	15000	0.000707	15000	0.000061
S	16000	-0.000200	16000	0.000341	16000	0.000029
Si	14000	-0.010000	14000	0.019484	14000	0.001673
Cr	24000	-0.111000	24000	0.116819	24000	0.010028
Ni	28000	-0.005000	28000	0.004662	28000	0.000400
N	7000	-0.000300	7000	0.001172	7000	0.000101
Ti	22000	-0.004300	22000	0.004916	22000	0.000422
Nb	41000	-0.001700	41000	0.001001	41000	0.000086
Fe	26000	-0.856800	26000	0.839570	26000	0.072068

Comments and References

Active Standard ASTM A240/A240M - 18: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications, TABLE 1 Chemical Composition Requirements. UNS Designation S40910 - Type 409. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=7f38db56864e46659a38760e6de4a5db

338. Steel, Stainless 440A

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.8 Total Atom Weight (atoms/b-cm) = 8.787E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Weight fractions for C and Cr are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.006750	6000	0.030043	6000	0.002640
Mn55	25055	-0.010000	25055	0.009730	25055	0.000855
P31	15031	-0.000400	15031	0.000690	15031	0.000061
S	16000	-0.000300	16000	0.000500	16000	0.000044
Si	14000	-0.010000	14000	0.019034	14000	0.001673
Cr	24000	-0.170000	24000	0.174775	24000	0.015358
Mo	42000	-0.007500	42000	0.004178	42000	0.000367
Fe	26000	-0.795050	26000	0.761050	26000	0.066874
Elemental						
C	6000	-0.006750	6000	0.030043	6000	0.002640
Mn	25000	-0.010000	25000	0.009730	25000	0.000855
P	15000	-0.000400	15000	0.000690	15000	0.000061
S	16000	-0.000300	16000	0.000500	16000	0.000044
Si	14000	-0.010000	14000	0.019034	14000	0.001673
Cr	24000	-0.170000	24000	0.174775	24000	0.015358
Mo	42000	-0.007500	42000	0.004178	42000	0.000367
Fe	26000	-0.795050	26000	0.761050	26000	0.066874

Comments and References

Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought, TABLE 1 Chemical Requirements. UNS Designation S44002 - Type 440A. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=704ebd5797b944898f5cf39260fecce0

339. Steel, Stainless 440B

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.8 Total Atom Weight (atoms/b-cm) = 8.841E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.Weight fractions for C and Cr are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.008500	6000	0.037602	6000	0.003324
Mn55	25055	-0.010000	25055	0.009671	25055	0.000855
P31	15031	-0.000400	15031	0.000686	15031	0.000061

S	16000	-0.000300	16000	0.000497	16000	0.000044
Si	14000	-0.010000	14000	0.018918	14000	0.001673
Cr	24000	-0.170000	24000	0.173713	24000	0.015358
Mo	42000	-0.007500	42000	0.004153	42000	0.000367
Fe	26000	-0.793300	26000	0.754760	26000	0.066727
Elemental						
C	6000	-0.008500	6000	0.037602	6000	0.003324
Mn	25000	-0.010000	25000	0.009671	25000	0.000855
P	15000	-0.000400	15000	0.000686	15000	0.000061
S	16000	-0.000300	16000	0.000497	16000	0.000044
Si	14000	-0.010000	14000	0.018918	14000	0.001673
Cr	24000	-0.170000	24000	0.173713	24000	0.015358
Mo	42000	-0.007500	42000	0.004153	42000	0.000367
Fe	26000	-0.793300	26000	0.754760	26000	0.066727

Comments and References

Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought, TABLE 1 Chemical Requirements. UNS Designation S44003 - Type 440B. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=704ebd5797b944898f5cf39260fecce0

340. Steel, Stainless 440C

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 7.8 Total Atom Weight (atoms/b-cm) = 8.909E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Weight fractions for C and Cr are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.010726	6000	0.047087	6000	0.004195
Mn55	25055	-0.009978	25055	0.009576	25055	0.000853
P31	15031	-0.000399	15031	0.000679	15031	0.000061
S	16000	-0.000299	16000	0.000492	16000	0.000044
Si	14000	-0.009978	14000	0.018732	14000	0.001669
Cr	24000	-0.169618	24000	0.172001	24000	0.015323
Mo	42000	-0.007483	42000	0.004112	42000	0.000366
Fe	26000	-0.791519	26000	0.747321	26000	0.066577
Elemental						
C	6000	-0.010726	6000	0.047087	6000	0.004195
Mn	25000	-0.009978	25000	0.009576	25000	0.000853
P	15000	-0.000399	15000	0.000679	15000	0.000061
S	16000	-0.000299	16000	0.000492	16000	0.000044
Si	14000	-0.009978	14000	0.018732	14000	0.001669
Cr	24000	-0.169618	24000	0.172001	24000	0.015323

Mo	42000	-0.007483	42000	0.004112	42000	0.000366
Fe	26000	-0.791519	26000	0.747321	26000	0.066577
Comments and References						
Active Standard ASTM A276/A276M - 16: Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought, TABLE 1 Chemical Requirements. UNS Designation S44004 - Type 440C. Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=704ebd5797b944898f5cf39260fecce0						

341. Sterotex

Formula = C57O6H110 Molecular Weight (g/mole) = 891.477850
Density (g/cm3) = 0.862 Total Atom Weight (atoms/b-cm) = 1.007E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.124342	1001	0.635765	1001	0.064046
H2	1002	-0.000029	1002	0.000073	1002	0.000007
C	6000	-0.767943	6000	0.329480	6000	0.033191
O16	8016	-0.107391	8016	0.034598	8016	0.003485
O17	8017	-0.000043	8017	0.000013	8017	0.000001
O18	8018	-0.000248	8018	0.000071	8018	0.000007
Elemental						
H	1000	-0.124375	1000	0.635838	1000	0.064053
C	6000	-0.767943	6000	0.329480	6000	0.033191
O	8000	-0.107682	8000	0.034682	8000	0.003494

Comments and References

LA-10860-MS, Criticality Dimensions of Systems Containing 235U, 239Pu, and 233U by H. C. Paxton and N. L. Pruvost, 1986 revision issued July 1987, page 200.

342. Stilbene (trans-stilbene isomer)

Formula = C14H12 Molecular Weight (g/mole) = 180.244100
Density (g/cm3) = 0.9707 Total Atom Weight (atoms/b-cm) = 8.432E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.067090	1001	0.461485	1001	0.038914

H2	1002	-0.000015	1002	0.000053	1002	0.000004
C	6000	-0.932893	6000	0.538462	6000	0.045405
Elemental						
H	1000	-0.067107	1000	0.461538	1000	0.038919
C	6000	-0.932893	6000	0.538462	6000	0.045405
Comments and References						
Density and formula from https://pubchem.ncbi.nlm.nih.gov/compound/trans-Stilbene						

343. Strontium Iodide - 2.5 atom% Europium doped

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.59 Total Atom Weight (atoms/b-cm) = 2.422E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Sr84	38084	-0.001361	38084	0.001851	38084	0.000045
Sr86	38086	-0.024529	38086	0.032588	38086	0.000789
Sr87	38087	-0.017617	38087	0.023136	38087	0.000560
Sr88	38088	-0.210214	38088	0.272934	38088	0.006610
I127	53127	-0.734985	53127	0.661017	53127	0.016009
Eu	63000	-0.011284	63000	0.008475	63000	0.000205
Elemental						
Sr	38000	-0.253731	38000	0.330508	38000	0.008005
I	53000	-0.734985	53000	0.661017	53000	0.016009
Eu	63000	-0.011284	63000	0.008475	63000	0.000205
Comments and References						
Formula is SrI2(Eu) but the formula isn't used in the calculation due to the Tl dopant Material information from the 2014 disertation by Emmanuel Rowe - High Performance Doped Strontium Iodide Crystal Growth Using a Modified Bridgman Method, Virginia Commonwealth University Dopant (aka Activator) added at 2.5 atom percent as this is the optimal amount found in the disertation.						

344. Sulfuric acid

Formula = H2SO4 Molecular Weight (g/mole) = 98.081050
Density (g/cm3) = 1.84 Total Atom Weight (atoms/b-cm) = 7.908E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.020548	1001	0.285681	1001	0.022592
H2	1002	-0.000005	1002	0.000033	1002	0.000003
S	16000	-0.326949	16000	0.142857	16000	0.011298

O16	8016	-0.650729	8016	0.570040	8016	0.045080
O17	8017	-0.000263	8017	0.000217	8017	0.000017
O18	8018	-0.001505	8018	0.001171	8018	0.000093
Elemental						
H	1000	-0.020554	1000	0.285714	1000	0.022595
S	16000	-0.326949	16000	0.142857	16000	0.011298
O	8000	-0.652497	8000	0.571429	8000	0.045190
Comments and References						
Formula from https://webbook.nist.gov/cgi/cbook.cgi?ID=7664-93-9. Density of 1.840 g/ml at 25 deg C is given for a 99.99% pure H2SO4 solution at https://www.sigmaaldrich.com/catalog/product/sial/435589?lang=en&region=US and https://www.chemicalbook.com/ChemicalProductProperty_EN_CB9675634.htm. A dentisy of 1.83g/cc is given for 20 deg C at https://www.engineeringtoolbox.com/indsulfuric-acid-density-d_2163.html.						

345. Sulphur

Formula = S Molecular Weight (g/mole) = 32.067500
Density (g/cm3) = 2 Total Atom Weight (atoms/b-cm) = 3.756E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
S	16000	-1.000000	16000	1.000000	16000	0.037559
Elemental						
S	16000	-1.000000	16000	1.000000	16000	0.037559
Comments and References						
Density from https://physics.nist.gov/cgi-bin/Star/compos.pl?mode=text&matno=016						

346. TLYC

Formula = Tl2LiYCl6 Molecular Weight (g/mole) = 717.349340
Density (g/cm3) = 4.58 Total Atom Weight (atoms/b-cm) = 3.845E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Tl203	81203	-0.167052	81203	0.059040	81203	0.002270
Tl205	81205	-0.402777	81205	0.140960	81205	0.005420
Li6	3006	-0.000636	3006	0.007590	3006	0.000292
Li7	3007	-0.009038	3007	0.092410	3007	0.003553
Y89	39089	-0.123937	39089	0.100000	39089	0.003845

Cl35	17035	-0.221586	17035	0.454560	17035	0.017477
Cl37	17037	-0.074947	17037	0.145440	17037	0.005592
Elemental						
Tl	81000	-0.569829	81000	0.200000	81000	0.007690
Li	3000	-0.009713	3000	0.100000	3000	0.003845
Y	39000	-0.123937	39000	0.100000	39000	0.003845
Cl	17000	-0.296521	17000	0.600000	17000	0.023069
Comments and References						
Density and formula from http://dx.doi.org/10.1021/acs.cgd.7b00583						

347. Tantalum

Formula = Ta Molecular Weight (g/mole) = 180.947880
Density (g/cm3) = 16.654 Total Atom Weight (atoms/b-cm) = 5.543E-02

The above density is estimated to be accurate to 5 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ta180	73180	-0.000119	73180	0.000120	73180	0.000007
Ta181	73181	-0.999881	73181	0.999880	73181	0.055420
Elemental						
Ta	73000	-1.000000	73000	1.000000	73000	0.055426
Comments and References						
Density from https://physics.nist.gov/cgi-bin/Star/compos.pl?mode=text&matno=073.						

348. Thorium

Formula = Th Molecular Weight (g/mole) = 232.037700
Density (g/cm3) = 11.72 Total Atom Weight (atoms/b-cm) = 3.042E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Th232	90232	-1.000002	90232	1.000000	90232	0.030417
Elemental						
Th	90000	-1.000000	90000	1.000000	90000	0.030417
Comments and References						
Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=090.						

349. Thorium Dioxide

Formula = ThO2 Molecular Weight (g/mole) = 264.036500
Density (g/cm3) = 9.7 Total Atom Weight (atoms/b-cm) = 6.637E-02

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.120862	8016	0.665047	8016	0.044140
O17	8017	-0.000049	8017	0.000253	8017	0.000017
O18	8018	-0.000279	8018	0.001367	8018	0.000091
Th232	90232	-0.878811	90232	0.333333	90232	0.022124
Elemental						
O	8000	-0.121191	8000	0.666667	8000	0.044247
Th	90000	-0.878809	90000	0.333333	90000	0.022124

Comments and References

https://pubchem.ncbi.nlm.nih.gov/compound/Thorium-dioxide

350. Tin

Formula = Sn Molecular Weight (g/mole) = 118.710000
Density (g/cm3) = 7.31 Total Atom Weight (atoms/b-cm) = 3.708E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Sn	50000	-1.000000	50000	1.000000	50000	0.037084
Elemental						
Sn	50000	-1.000000	50000	1.000000	50000	0.037084

Comments and References

Density from https://physics.nist.gov/cgi-bin/Star/compos.pl?mode=text&matno=050

351. Tissue Equivalent, MS20

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1 Total Atom Weight (atoms/b-cm) = 8.879E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions	Atom Fractions	Atom Densities

Isotopic						
H1	1001	-0.081171	1001	0.546286	1001	0.048503
H2	1002	-0.000019	1002	0.000063	1002	0.000006
C	6000	-0.583442	6000	0.329488	6000	0.029254
N14	7014	-0.017728	7014	0.008587	7014	0.000762
N15	7015	-0.000069	7015	0.000031	7015	0.000003
O16	8016	-0.185876	8016	0.078822	8016	0.006998
O17	8017	-0.000075	8017	0.000030	8017	0.000003
O18	8018	-0.000430	8018	0.000162	8018	0.000014
Mg	12000	-0.130287	12000	0.036358	12000	0.003228
Cl35	17035	-0.000673	17035	0.000130	17035	0.000012
Cl37	17037	-0.000227	17037	0.000042	17037	0.000004
Elemental						
H	1000	-0.081192	1000	0.546349	1000	0.048508
C	6000	-0.583442	6000	0.329488	6000	0.029254
N	7000	-0.017798	7000	0.008619	7000	0.000765
O	8000	-0.186381	8000	0.079014	8000	0.007015
Mg	12000	-0.130287	12000	0.036358	12000	0.003228
Cl	17000	-0.000900	17000	0.000172	17000	0.000015
Comments and References						
Density and weight fractions from https://physics.nist.gov/cgi-bin/Star/compos.pl?mode=text&matno=200						

352. Tissue Equivalent-Gas, methane based (TEG: MB)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.001064 Total Atom Weight (atoms/b-cm) = 1.070E-04

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101842	1001	0.605170	1001	0.000065
H2	1002	-0.000023	1002	0.000070	1002	0.000000
C	6000	-0.456179	6000	0.227460	6000	0.000024
N14	7014	-0.035035	7014	0.014983	7014	0.000002
N15	7015	-0.000137	7015	0.000055	7015	0.000000
O16	8016	-0.405678	8016	0.151892	8016	0.000016
O17	8017	-0.000164	8017	0.000058	8017	0.000000
O18	8018	-0.000938	8018	0.000312	8018	0.000000
Elemental						
H	1000	-0.101869	1000	0.605240	1000	0.000065
C	6000	-0.456179	6000	0.227460	6000	0.000024
N	7000	-0.035172	7000	0.015038	7000	0.000002
O	8000	-0.406780	8000	0.152262	8000	0.000016

Comments and References
Density and weight fractions from https://physics.nist.gov/cgi-bin/Star/compos.pl?matno=263

353. Tissue Equivalent-Gas, propane based (TEG: PB)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.001826 Total Atom Weight (atoms/b-cm) = 1.870E-04

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.102645	1001	0.598874	1001	0.000112
H2	1002	-0.000024	1002	0.000069	1002	0.000000
C	6000	-0.568940	6000	0.278538	6000	0.000052
N14	7014	-0.034885	7014	0.014649	7014	0.000003
N15	7015	-0.000137	7015	0.000054	7015	0.000000
O16	8016	-0.292571	8016	0.107555	8016	0.000020
O17	8017	-0.000118	8017	0.000041	8017	0.000000
O18	8018	-0.000677	8018	0.000221	8018	0.000000
Elemental						
H	1000	-0.102672	1000	0.598943	1000	0.000112
C	6000	-0.568940	6000	0.278538	6000	0.000052
N	7000	-0.035022	7000	0.014702	7000	0.000003
O	8000	-0.293366	8000	0.107817	8000	0.000020

Comments and References
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=264.

354. Tissue, Adipose (ICRP)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.92 Total Atom Weight (atoms/b-cm) = 1.035E-01

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed. Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.119445	1001	0.634559	1001	0.065663
H2	1002	-0.000027	1002	0.000073	1002	0.000008
C	6000	-0.637240	6000	0.284071	6000	0.029395

N14	7014	-0.007939	7014	0.003035	7014	0.000314
N15	7015	-0.000031	7015	0.000011	7015	0.000001
O16	8016	-0.231703	8016	0.077560	8016	0.008026
O17	8017	-0.000094	8017	0.000030	8017	0.000003
O18	8018	-0.000536	8018	0.000159	8018	0.000016
Na23	11023	-0.000500	11023	0.000116	11023	0.000012
Mg	12000	-0.000020	12000	0.000004	12000	0.000000
P31	15031	-0.000160	15031	0.000028	15031	0.000003
S	16000	-0.000730	16000	0.000122	16000	0.000013
Cl35	17035	-0.000889	17035	0.000136	17035	0.000014
Cl37	17037	-0.000301	17037	0.000044	17037	0.000005
K	19000	-0.000320	19000	0.000044	19000	0.000005
Ca	20000	-0.000020	20000	0.000003	20000	0.000000
Fe	26000	-0.000020	26000	0.000002	26000	0.000000
Zn	30000	-0.000020	30000	0.000002	30000	0.000000
Elemental						
H	1000	-0.119477	1000	0.634632	1000	0.065671
C	6000	-0.637240	6000	0.284071	6000	0.029395
N	7000	-0.007970	7000	0.003047	7000	0.000315
O	8000	-0.232333	8000	0.077749	8000	0.008045
Na	11000	-0.000500	11000	0.000116	11000	0.000012
Mg	12000	-0.000020	12000	0.000004	12000	0.000000
P	15000	-0.000160	15000	0.000028	15000	0.000003
S	16000	-0.000730	16000	0.000122	16000	0.000013
Cl	17000	-0.001190	17000	0.000180	17000	0.000019
K	19000	-0.000320	19000	0.000044	19000	0.000005
Ca	20000	-0.000020	20000	0.000003	20000	0.000000
Fe	26000	-0.000020	26000	0.000002	26000	0.000000
Zn	30000	-0.000020	30000	0.000002	30000	0.000000

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=103. See also The International Commission on Radiological Protection, ICRP PUBLICATION 89, Basic Anatomical and Physiological Data for Use in Radiological Protection: Refence Values, J. Valentin, Editor, 2003 ICRP Published by Elsevier Science Ltd.

355. Tissue, Breast

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.02 Total Atom Weight (atoms/b-cm) = 1.032E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions	Atom Fractions	Atom Densities
Isotopic			

H1	1001	-0.105972	1001	0.625700	1001	0.064589
H2	1002	-0.000024	1002	0.000072	1002	0.000007
C	6000	-0.332000	6000	0.164488	6000	0.016979
N14	7014	-0.029883	7014	0.012699	7014	0.001311
N15	7015	-0.000117	7015	0.000046	7015	0.000005
O16	8016	-0.525572	8016	0.195529	8016	0.020184
O17	8017	-0.000213	8017	0.000074	8017	0.000008
O18	8018	-0.001215	8018	0.000402	8018	0.000041
Na23	11023	-0.001000	11023	0.000259	11023	0.000027
P31	15031	-0.001000	15031	0.000192	15031	0.000020
S	16000	-0.002000	16000	0.000371	16000	0.000038
Cl35	17035	-0.000747	17035	0.000127	17035	0.000013
Cl37	17037	-0.000253	17037	0.000041	17037	0.000004
Elemental						
H	1000	-0.106000	1000	0.625772	1000	0.064596
C	6000	-0.332000	6000	0.164488	6000	0.016979
N	7000	-0.030000	7000	0.012745	7000	0.001316
O	8000	-0.527000	8000	0.196005	8000	0.020233
Na	11000	-0.001000	11000	0.000259	11000	0.000027
P	15000	-0.001000	15000	0.000192	15000	0.000020
S	16000	-0.002000	16000	0.000371	16000	0.000038
Cl	17000	-0.001000	17000	0.000168	17000	0.000017
Comments and References						
http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.htmlBased on the International Commission on Radiation Units and Measurements (ICRU-44).						

356. Tissue, Lung (ICRP)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.05 Total Atom Weight (atoms/b-cm) = 1.003E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101251	1001	0.633054	1001	0.063527
H2	1002	-0.000023	1002	0.000073	1002	0.000007
C	6000	-0.102310	6000	0.053676	6000	0.005386
N14	7014	-0.028538	7014	0.012842	7014	0.001289
N15	7015	-0.000112	7015	0.000047	7015	0.000005
O16	8016	-0.755021	8016	0.297442	8016	0.029848
O17	8017	-0.000306	8017	0.000113	8017	0.000011
O18	8018	-0.001746	8018	0.000611	8018	0.000061
Na23	11023	-0.001840	11023	0.000504	11023	0.000051
Mg	12000	-0.000730	12000	0.000189	12000	0.000019

P31	15031	-0.000800	15031	0.000163	15031	0.000016
S	16000	-0.002250	16000	0.000442	16000	0.000044
Cl35	17035	-0.001988	17035	0.000358	17035	0.000036
Cl37	17037	-0.000672	17037	0.000115	17037	0.000012
K	19000	-0.001940	19000	0.000313	19000	0.000031
Ca	20000	-0.000090	20000	0.000014	20000	0.000001
Fe	26000	-0.000370	26000	0.000042	26000	0.000004
Zn	30000	-0.000010	30000	0.000001	30000	0.000000
Elemental						
H	1000	-0.101278	1000	0.633127	1000	0.063534
C	6000	-0.102310	6000	0.053676	6000	0.005386
N	7000	-0.028650	7000	0.012889	7000	0.001293
O	8000	-0.757072	8000	0.298167	8000	0.029921
Na	11000	-0.001840	11000	0.000504	11000	0.000051
Mg	12000	-0.000730	12000	0.000189	12000	0.000019
P	15000	-0.000800	15000	0.000163	15000	0.000016
S	16000	-0.002250	16000	0.000442	16000	0.000044
Cl	17000	-0.002660	17000	0.000473	17000	0.000047
K	19000	-0.001940	19000	0.000313	19000	0.000031
Ca	20000	-0.000090	20000	0.000014	20000	0.000001
Fe	26000	-0.000370	26000	0.000042	26000	0.000004
Zn	30000	-0.000010	30000	0.000001	30000	0.000000
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=190.						

357. Tissue, Ovary

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.05 Total Atom Weight (atoms/b-cm) = 1.024E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.104972	1001	0.643149	1001	0.065861
H2	1002	-0.000024	1002	0.000074	1002	0.000008
C	6000	-0.093000	6000	0.047812	6000	0.004896
N14	7014	-0.023906	7014	0.010542	7014	0.001080
N15	7015	-0.000094	7015	0.000039	7015	0.000004
O16	8016	-0.765919	8016	0.295680	8016	0.030279
O17	8017	-0.000310	8017	0.000113	8017	0.000012
O18	8018	-0.001771	8018	0.000608	8018	0.000062
Na23	11023	-0.002000	11023	0.000537	11023	0.000055
P31	15031	-0.002000	15031	0.000399	15031	0.000041

S	16000	-0.002000	16000	0.000385	16000	0.000039
Cl35	17035	-0.001495	17035	0.000264	17035	0.000027
Cl37	17037	-0.000506	17037	0.000084	17037	0.000009
K	19000	-0.002000	19000	0.000316	19000	0.000032
Elemental						
H	1000	-0.105000	1000	0.643223	1000	0.065869
C	6000	-0.093000	6000	0.047812	6000	0.004896
N	7000	-0.024000	7000	0.010580	7000	0.001083
O	8000	-0.768000	8000	0.296400	8000	0.030353
Na	11000	-0.002000	11000	0.000537	11000	0.000055
P	15000	-0.002000	15000	0.000399	15000	0.000041
S	16000	-0.002000	16000	0.000385	16000	0.000039
Cl	17000	-0.002000	17000	0.000348	17000	0.000036
K	19000	-0.002000	19000	0.000316	19000	0.000032
Comments and References						
http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html Based on the International Commission on Radiation Units and Measurements (ICRU-44).						

358. Tissue, Soft (ICRP)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1 Total Atom Weight (atoms/b-cm) = 9.900E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.104444	1001	0.630372	1001	0.062410
H2	1002	-0.000024	1002	0.000073	1002	0.000007
C	6000	-0.232190	6000	0.117591	6000	0.011642
N14	7014	-0.024783	7014	0.010765	7014	0.001066
N15	7015	-0.000097	7015	0.000039	7015	0.000004
O16	8016	-0.628530	8016	0.239024	8016	0.023664
O17	8017	-0.000254	8017	0.000091	8017	0.000009
O18	8018	-0.001453	8018	0.000491	8018	0.000049
Na23	11023	-0.001130	11023	0.000299	11023	0.000030
Mg	12000	-0.000130	12000	0.000033	12000	0.000003
P31	15031	-0.001330	15031	0.000261	15031	0.000026
S	16000	-0.001990	16000	0.000377	16000	0.000037
Cl35	17035	-0.001001	17035	0.000174	17035	0.000017
Cl37	17037	-0.000339	17037	0.000056	17037	0.000006
K	19000	-0.001990	19000	0.000310	19000	0.000031
Ca	20000	-0.000230	20000	0.000035	20000	0.000003
Fe	26000	-0.000050	26000	0.000005	26000	0.000001
Zn	30000	-0.000030	30000	0.000003	30000	0.000000

Elemental						
H	1000	-0.104472	1000	0.630445	1000	0.062417
C	6000	-0.232190	6000	0.117591	6000	0.011642
N	7000	-0.024880	7000	0.010805	7000	0.001070
O	8000	-0.630238	8000	0.239606	8000	0.023722
Na	11000	-0.001130	11000	0.000299	11000	0.000030
Mg	12000	-0.000130	12000	0.000033	12000	0.000003
P	15000	-0.001330	15000	0.000261	15000	0.000026
S	16000	-0.001990	16000	0.000377	16000	0.000037
Cl	17000	-0.001340	17000	0.000230	17000	0.000023
K	19000	-0.001990	19000	0.000310	19000	0.000031
Ca	20000	-0.000230	20000	0.000035	20000	0.000003
Fe	26000	-0.000050	26000	0.000005	26000	0.000001
Zn	30000	-0.000030	30000	0.000003	30000	0.000000

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=261.

359. Tissue, Soft (ICRU four component)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1 Total Atom Weight (atoms/b-cm) = 9.580E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.101145	1001	0.630855	1001	0.060438
H2	1002	-0.000023	1002	0.000073	1002	0.000007
C	6000	-0.111000	6000	0.058093	6000	0.005566
N14	7014	-0.025898	7014	0.011626	7014	0.001114
N15	7015	-0.000101	7015	0.000042	7015	0.000004
O16	8016	-0.759764	8016	0.298583	8016	0.028605
O17	8017	-0.000308	8017	0.000114	8017	0.000011
O18	8018	-0.001757	8018	0.000614	8018	0.000059
Elemental						
H	1000	-0.101172	1000	0.630928	1000	0.060445
C	6000	-0.111000	6000	0.058093	6000	0.005566
N	7000	-0.026000	7000	0.011668	7000	0.001118
O	8000	-0.761828	8000	0.299311	8000	0.028675

Comments and References

Four-component soft tissue based on International Commission on Radiation Units and Measurements (ICRU). Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=262.

360. Tissue, Testes (ICRP)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.04 Total Atom Weight (atoms/b-cm) = 1.009E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.Based on the International Commission on Radiological Protection (ICRP).

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.104139	1001	0.641279	1001	0.064716
H2	1002	-0.000024	1002	0.000074	1002	0.000007
C	6000	-0.092270	6000	0.047678	6000	0.004811
N14	7014	-0.019862	7014	0.008803	7014	0.000888
N15	7015	-0.000078	7015	0.000032	7015	0.000003
O16	8016	-0.771787	8016	0.299458	8016	0.030220
O17	8017	-0.000312	8017	0.000114	8017	0.000012
O18	8018	-0.001785	8018	0.000615	8018	0.000062
Na23	11023	-0.002260	11023	0.000610	11023	0.000062
Mg	12000	-0.000110	12000	0.000028	12000	0.000003
P31	15031	-0.001250	15031	0.000250	15031	0.000025
S	16000	-0.001460	16000	0.000283	16000	0.000029
Cl35	17035	-0.001823	17035	0.000324	17035	0.000033
Cl37	17037	-0.000617	17037	0.000104	17037	0.000010
K	19000	-0.002080	19000	0.000330	19000	0.000033
Ca	20000	-0.000100	20000	0.000015	20000	0.000002
Fe	26000	-0.000020	26000	0.000002	26000	0.000000
Zn	30000	-0.000020	30000	0.000002	30000	0.000000
Elemental						
H	1000	-0.104166	1000	0.641353	1000	0.064723
C	6000	-0.092270	6000	0.047678	6000	0.004811
N	7000	-0.019940	7000	0.008835	7000	0.000892
O	8000	-0.773884	8000	0.300187	8000	0.030294
Na	11000	-0.002260	11000	0.000610	11000	0.000062
Mg	12000	-0.000110	12000	0.000028	12000	0.000003
P	15000	-0.001250	15000	0.000250	15000	0.000025
S	16000	-0.001460	16000	0.000283	16000	0.000029
Cl	17000	-0.002440	17000	0.000427	17000	0.000043
K	19000	-0.002080	19000	0.000330	19000	0.000033
Ca	20000	-0.000100	20000	0.000015	20000	0.000002
Fe	26000	-0.000020	26000	0.000002	26000	0.000000
Zn	30000	-0.000020	30000	0.000002	30000	0.000000

Comments and References

Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=258.

361. Tissue, Testis (ICRU)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.04 Total Atom Weight (atoms/b-cm) = 1.021E-01

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.105972	1001	0.645096	1001	0.065855
H2	1002	-0.000024	1002	0.000074	1002	0.000008
C	6000	-0.099000	6000	0.050569	6000	0.005162
N14	7014	-0.019922	7014	0.008728	7014	0.000891
N15	7015	-0.000078	7015	0.000032	7015	0.000003
O16	8016	-0.763924	8016	0.293013	8016	0.029912
O17	8017	-0.000309	8017	0.000112	8017	0.000011
O18	8018	-0.001767	8018	0.000602	8018	0.000061
Na23	11023	-0.002000	11023	0.000534	11023	0.000054
P31	15031	-0.001000	15031	0.000198	15031	0.000020
S	16000	-0.002000	16000	0.000383	16000	0.000039
Cl35	17035	-0.001495	17035	0.000262	17035	0.000027
Cl37	17037	-0.000506	17037	0.000084	17037	0.000009
K	19000	-0.002000	19000	0.000314	19000	0.000032
Elemental						
H	1000	-0.106000	1000	0.645170	1000	0.065863
C	6000	-0.099000	6000	0.050569	6000	0.005162
N	7000	-0.020000	7000	0.008760	7000	0.000894
O	8000	-0.766000	8000	0.293726	8000	0.029985
Na	11000	-0.002000	11000	0.000534	11000	0.000054
P	15000	-0.001000	15000	0.000198	15000	0.000020
S	16000	-0.002000	16000	0.000383	16000	0.000039
Cl	17000	-0.002000	17000	0.000346	17000	0.000035
K	19000	-0.002000	19000	0.000314	19000	0.000032

Comments and References

http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html Based on the International Commission on Radiation Units and Measurements (ICRU-44).

362. Titanium

Formula = Ti Molecular Weight (g/mole) = 47.867000
Density (g/cm3) = 4.54 Total Atom Weight (atoms/b-cm) = 5.712E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not

addressed. The following data was calculated from the input formula.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Ti	22000	-1.000000	22000	1.000000	22000	0.057118
Elemental						
Ti	22000	-1.000000	22000	1.000000	22000	0.057118
Comments and References						
Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=022.						

363. Titanium Dioxide

Formula = TiO2 Molecular Weight (g/mole) = 79.865800 Density (g/cm3) = 4.26 Total Atom Weight (atoms/b-cm) = 9.637E-02 The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.399571	8016	0.665047	8016	0.064087
O17	8017	-0.000162	8017	0.000253	8017	0.000024
O18	8018	-0.000924	8018	0.001367	8018	0.000132
Ti	22000	-0.599343	22000	0.333333	22000	0.032122
Elemental						
O	8000	-0.400657	8000	0.666667	8000	0.064244
Ti	22000	-0.599343	22000	0.333333	22000	0.032122
Comments and References						
Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=265.						

364. Titanium Hydride

Formula = TiH2 Molecular Weight (g/mole) = 49.882950 Density (g/cm3) = 3.75 Total Atom Weight (atoms/b-cm) = 1.358E-01 The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.040403	1001	0.666590	1001	0.090534
H2	1002	-0.000009	1002	0.000077	1002	0.000010
Ti	22000	-0.959586	22000	0.333333	22000	0.045272
Elemental						

H	1000	-0.040414	1000	0.666667	1000	0.090544
Ti	22000	-0.959586	22000	0.333333	22000	0.045272
Comments and References						
Density from http://www.matweb.com/search/DataSheet.aspx?MatGUID=2f54b82a7d6d4a6db688180ac43b70d8						

365. Titanium alloy, grade 5

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.43 Total Atom Weight (atoms/b-cm) = 5.902E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions for Al and V are set at the average of the given range.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.000800	6000	0.003011	6000	0.000178
O16	8016	-0.001995	8016	0.005637	8016	0.000333
O17	8017	-0.000001	8017	0.000002	8017	0.000000
O18	8018	-0.000005	8018	0.000012	8018	0.000001
N14	7014	-0.000498	7014	0.001608	7014	0.000095
N15	7015	-0.000002	7015	0.000006	7015	0.000000
H1	1001	-0.000150	1001	0.006726	1001	0.000397
H2	1002	-0.000000	1002	0.000001	1002	0.000000
Fe	26000	-0.004000	26000	0.003238	26000	0.000191
Al27	13027	-0.061250	13027	0.102610	13027	0.006056
V	23000	-0.040000	23000	0.035493	23000	0.002095
Ti	22000	-0.891300	22000	0.841657	22000	0.049676
Elemental						
C	6000	-0.000800	6000	0.003011	6000	0.000178
O	8000	-0.002000	8000	0.005650	8000	0.000333
N	7000	-0.000500	7000	0.001614	7000	0.000095
H	1000	-0.000150	1000	0.006727	1000	0.000397
Fe	26000	-0.004000	26000	0.003238	26000	0.000191
Al	13000	-0.061250	13000	0.102610	13000	0.006056
V	23000	-0.040000	23000	0.035493	23000	0.002095
Ti	22000	-0.891300	22000	0.841657	22000	0.049676
Comments and References						
Active Standard ASTM B348/B348M - 19: Standard Specification for Titanium and Titanium Alloy Bars and BilletsTABLE 1 Chemical Requirements. Grade 5, UNS Number R56400 Density obtained from http://www.matweb.com/search/DataSheet.aspx?MatGUID=b350a789eda946c6b86a3e4d3c577b39						

366. Toluene

Formula = C7H8 Molecular Weight (g/mole) = 92.138000
Density (g/cm3) = 0.8669 Total Atom Weight (atoms/b-cm) = 8.499E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.087496	1001	0.533272	1001	0.045323
H2	1002	-0.000020	1002	0.000061	1002	0.000005
C	6000	-0.912481	6000	0.466667	6000	0.039662
Elemental						
H	1000	-0.087519	1000	0.533333	1000	0.045328
C	6000	-0.912481	6000	0.466667	6000	0.039662

Comments and References

Density from https://physics.nist.gov/cgi-bin/Star/compos.pl?matno=266 Formula from https://pubchem.ncbi.nlm.nih.gov/compound/Toluene

367. Tributyl Borate

Formula = BO3C12H27 Molecular Weight (g/mole) = 230.154225
Density (g/cm3) = 0.8567 Total Atom Weight (atoms/b-cm) = 9.639E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.118217	1001	0.627835	1001	0.060517
H2	1002	-0.000027	1002	0.000072	1002	0.000007
B10	5010	-0.008658	5010	0.004628	5010	0.000446
B11	5011	-0.038315	5011	0.018628	5011	0.001796
C	6000	-0.626220	6000	0.279070	6000	0.026899
O16	8016	-0.207983	8016	0.069598	8016	0.006708
O17	8017	-0.000084	8017	0.000027	8017	0.000003
O18	8018	-0.000481	8018	0.000143	8018	0.000014
Elemental						
H	1000	-0.118248	1000	0.627907	1000	0.060524
B	5000	-0.046984	5000	0.023256	5000	0.002242
C	6000	-0.626220	6000	0.279070	6000	0.026899
O	8000	-0.208548	8000	0.069767	8000	0.006725

Comments and References

Formula and density from https://pubchem.ncbi.nlm.nih.gov/compound/Tributyl-borate

368. Tributyl Phosphate (TBP)

Formula = C12H27PO4 Molecular Weight (g/mole) = 266.313887
Density (g/cm3) = 0.978 Total Atom Weight (atoms/b-cm) = 9.731E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.102166	1001	0.613567	1001	0.059705
H2	1002	-0.000023	1002	0.000071	1002	0.000007
C	6000	-0.541193	6000	0.272727	6000	0.026539
O16	8016	-0.239658	8016	0.090688	8016	0.008825
O17	8017	-0.000097	8017	0.000035	8017	0.000003
O18	8018	-0.000554	8018	0.000186	8018	0.000018
P31	15031	-0.116305	15031	0.022727	15031	0.002212
Elemental						
H	1000	-0.102193	1000	0.613637	1000	0.059712
C	6000	-0.541193	6000	0.272727	6000	0.026539
O	8000	-0.240309	8000	0.090909	8000	0.008846
P	15000	-0.116305	15000	0.022727	15000	0.002212

Comments and References

Density and formula from https://pubchem.ncbi.nlm.nih.gov/source/hsdb/1678

369. Tungsten

Formula = W Molecular Weight (g/mole) = 183.840000
Density (g/cm3) = 19.3 Total Atom Weight (atoms/b-cm) = 6.322E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. The following data was calculated from the input formula.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
W	74000	-1.000000	74000	1.000000	74000	0.063222
Elemental						
W	74000	-1.000000	74000	1.000000	74000	0.063222

Comments and References

Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=074.

370. Uranium Carbide

Formula = UC Molecular Weight (g/mole) = 249.968460
Density (g/cm3) = 13.63 Total Atom Weight (atoms/b-cm) = 6.567E-02

CAS number 12070-09-6Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.048048	6000	0.500000	6000	0.032837
U234	92234	-0.000254	92234	0.000136	92234	0.000009
U235	92235	-0.028559	92235	0.015186	92235	0.000997
U236	92236	-0.000131	92236	0.000070	92236	0.000005
U238	92238	-0.923007	92238	0.484609	92238	0.031826
Elemental						
C	6000	-0.048048	6000	0.500000	6000	0.032837
U	92234	-0.000254	92234	0.000136	92234	0.000009
U	92235	-0.028559	92235	0.015186	92235	0.000997
U	92236	-0.000131	92236	0.000070	92236	0.000005
U	92238	-0.923007	92238	0.484609	92238	0.031826

Comments and References

Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=271 Formula from NIH PubChem pubchem.ncbi.nlm.nih.gov B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.' Density same as physics.nist.gov/cgibin/Star/compos.pl?matno=271.

371. Uranium Dicarbide

Formula = UC2 Molecular Weight (g/mole) = 261.979060
Density (g/cm3) = 11.28 Total Atom Weight (atoms/b-cm) = 7.779E-02

CAS number 12071-33-9Uranium isotopes Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
C	6000	-0.091691	6000	0.666667	6000	0.051859
U234	92234	-0.000243	92234	0.000090	92234	0.000007
U235	92235	-0.027249	92235	0.010124	92235	0.000788
U236	92236	-0.000125	92236	0.000046	92236	0.000004
U238	92238	-0.880692	92238	0.323072	92238	0.025131
Elemental						
C	6000	-0.091691	6000	0.666667	6000	0.051859
U	92234	-0.000243	92234	0.000090	92234	0.000007
U	92235	-0.027249	92235	0.010124	92235	0.000788
U	92236	-0.000125	92236	0.000046	92236	0.000004
U	92238	-0.880692	92238	0.323072	92238	0.025131

Comments and References
Density from https://physics.nist.gov/cgi-bin/Star/compos.pl?matno=270 Formula from https://ibilabs.com/uranium-uranyl-thorium-compounds/uranium-compounds/uranium-dicarbide/

372. Uranium Dioxide

Formula = UO2 Molecular Weight (g/mole) = 269.956660
Density (g/cm3) = 10.96 Total Atom Weight (atoms/b-cm) = 7.335E-02

CAS # 1344-57-6Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.118212	8016	0.665047	8016	0.048780
O17	8017	-0.000048	8017	0.000253	8017	0.000019
O18	8018	-0.000273	8018	0.001367	8018	0.000100
U234	92234	-0.000235	92234	0.000090	92234	0.000007
U235	92235	-0.026444	92235	0.010124	92235	0.000743
U236	92236	-0.000122	92236	0.000046	92236	0.000003
U238	92238	-0.854666	92238	0.323072	92238	0.023697
Elemental						
O	8000	-0.118533	8000	0.666667	8000	0.048899
U	92234	-0.000235	92234	0.000090	92234	0.000007
U	92235	-0.026444	92235	0.010124	92235	0.000743
U	92236	-0.000122	92236	0.000046	92236	0.000003
U	92238	-0.854666	92238	0.323072	92238	0.023697

Comments and References

Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=272 Formula from NIH PubChem pubchem.ncbi.nlm.nih.gov, also B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018)". Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.'

373. Uranium Hexafluoride

Formula = UF6 Molecular Weight (g/mole) = 351.948278
Density (g/cm3) = 5.09 Total Atom Weight (atoms/b-cm) = 6.097E-02

CAS Number 7783-81-55.09 at 20.7 °C/4 °C; (liq): 3.595 at 70 °C Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions	Atom Fractions	Atom Densities

Isotopic						
F19	9019	-0.323884	9019	0.857143	9019	0.052257
U234	92234	-0.000181	92234	0.000039	92234	0.000002
U235	92235	-0.020283	92235	0.004339	92235	0.000265
U236	92236	-0.000093	92236	0.000020	92236	0.000001
U238	92238	-0.655559	92238	0.138460	92238	0.008441
Elemental						
F	9000	-0.323884	9000	0.857143	9000	0.052257
U	92234	-0.000181	92234	0.000039	92234	0.000002
U	92235	-0.020283	92235	0.004339	92235	0.000265
U	92236	-0.000093	92236	0.000020	92236	0.000001
U	92238	-0.655559	92238	0.138460	92238	0.008441

Comments and References

Formula and density from NIH PubChem pubchem.ncbi.nlm.nih.gov The phase diagram for UF6 is at http://en.wikipedia.org/wiki/Uranium_hexafluoride. Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595. B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.' Density of 4.68 g/cm3 is listed for liquid HF6 at an elevated temp. on p.201 of LA-10860-MS, Criticality Dimensions of Systems Containing 235U, 239Pu, and 233U by Paxton and Pruvost, 1986 revision issued July 1987.Density = 5.09 g/cm3 for solid UF6 based on p.4-97 of CRC Handbook of Chemistry and Physics, 89th Ed. (www.hbcpnetbase.com/) and en.wikipedia.org/wiki/Uranium_hexafluoride.

374. Uranium Hydride

Formula = UH3 Molecular Weight (g/mole) = 240.981785
Density (g/cm3) = 11.1 Total Atom Weight (atoms/b-cm) = 1.110E-01

CAS Number 13598-56-6Density from Wikipedia is 10.95Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.012545	1001	0.749914	1001	0.083207
H2	1002	-0.000003	1002	0.000086	1002	0.000010
U234	92234	-0.000264	92234	0.000068	92234	0.000008
U235	92235	-0.029624	92235	0.007593	92235	0.000842
U236	92236	-0.000136	92236	0.000035	92236	0.000004
U238	92238	-0.957428	92238	0.242304	92238	0.026885
Elemental						
H	1000	-0.012548	1000	0.750000	1000	0.083217
U	92234	-0.000264	92234	0.000068	92234	0.000008
U	92235	-0.029624	92235	0.007593	92235	0.000842

U	92236	-0.000136	92236	0.000035	92236	0.000004
U	92238	-0.957428	92238	0.242304	92238	0.026885
Comments and References						
Formula and density from NIH PubChem pubchem.ncbi.nlm.nih.gov Density from American Elements: www.americanelements.com						

375. Uranium Nitride

Formula = UN Molecular Weight (g/mole) = 251.964715
Density (g/cm3) = 14.31 Total Atom Weight (atoms/b-cm) = 6.840E-02

CAS number 25658-43-9 Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
N14	7014	-0.055373	7014	0.498180	7014	0.034077
N15	7015	-0.000217	7015	0.001820	7015	0.000124
U234	92234	-0.000252	92234	0.000136	92234	0.000009
U235	92235	-0.028332	92235	0.015186	92235	0.001039
U236	92236	-0.000130	92236	0.000070	92236	0.000005
U238	92238	-0.915695	92238	0.484609	92238	0.033149
Elemental						
N	7000	-0.055590	7000	0.500000	7000	0.034202
U	92234	-0.000252	92234	0.000136	92234	0.000009
U	92235	-0.028332	92235	0.015186	92235	0.001039
U	92236	-0.000130	92236	0.000070	92236	0.000005
U	92238	-0.915695	92238	0.484609	92238	0.033149

Comments and References

Formula from NIH PubChem pubchem.ncbi.nlm.nih.gov, B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.' Density from https://www.webelements.com

376. Uranium Oxide

Formula = U3O8 Molecular Weight (g/mole) = 841.868781
Density (g/cm3) = 8.38 Total Atom Weight (atoms/b-cm) = 6.594E-02

CAS number 1344-59-8 Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.151625	8016	0.725505	8016	0.047839
O17	8017	-0.000061	8017	0.000276	8017	0.000018
O18	8018	-0.000351	8018	0.001491	8018	0.000098
U234	92234	-0.000226	92234	0.000074	92234	0.000005
U235	92235	-0.025439	92235	0.008283	92235	0.000546
U236	92236	-0.000117	92236	0.000038	92236	0.000003
U238	92238	-0.822181	92238	0.264332	92238	0.017430
Elemental						
O	8000	-0.152037	8000	0.727273	8000	0.047956
U	92234	-0.000226	92234	0.000074	92234	0.000005
U	92235	-0.025439	92235	0.008283	92235	0.000546
U	92236	-0.000117	92236	0.000038	92236	0.000003
U	92238	-0.822181	92238	0.264332	92238	0.017430
Comments and References						
Density and formula from https://ibilabs.com and https://www.webelements.com Note: density is listed as 8.3 in the following reference: B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.						

377. Uranium Tetrafluoride

Formula = UF4 Molecular Weight (g/mole) = 313.951472
Density (g/cm3) = 6.7 Total Atom Weight (atoms/b-cm) = 6.426E-02

CAS number 10049-14-6Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
F19	9019	-0.242055	9019	0.800000	9019	0.051407
U234	92234	-0.000202	92234	0.000054	92234	0.000003
U235	92235	-0.022738	92235	0.006074	92235	0.000390
U236	92236	-0.000105	92236	0.000028	92236	0.000002
U238	92238	-0.734900	92238	0.193843	92238	0.012456
Elemental						
F	9000	-0.242055	9000	0.800000	9000	0.051407
U	92234	-0.000202	92234	0.000054	92234	0.000003
U	92235	-0.022738	92235	0.006074	92235	0.000390
U	92236	-0.000105	92236	0.000028	92236	0.000002
U	92238	-0.734900	92238	0.193843	92238	0.012456
Comments and References						

Density and formula from https://ibilabs.com, alsoB. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.' Density = 6.7 g/cm3 also on page 4-97 of CRC Handbook of Chemistry and Physics 89th Ed. (www.hbcpnetbase.com) en.wikipedia.org/wiki/Uranium_hexafluorideLA-10860-MS, Criticality Dimensions of Systems Containing 235U, 239Pu, and 233U by H. C. Paxton and N. L. Pruvost, 1986 revision issued July 1987, page 201.

378. Uranium Trioxide

Formula = UO3 Molecular Weight (g/mole) = 285.956060
Density (g/cm3) = 7.29 Total Atom Weight (atoms/b-cm) = 6.141E-02

CAS number 1344-58-7Wikipedia reported density 5.5–8.7 Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.167397	8016	0.748177	8016	0.045946
O17	8017	-0.000068	8017	0.000285	8017	0.000018
O18	8018	-0.000387	8018	0.001538	8018	0.000094
U234	92234	-0.000222	92234	0.000068	92234	0.000004
U235	92235	-0.024964	92235	0.007593	92235	0.000466
U236	92236	-0.000115	92236	0.000035	92236	0.000002
U238	92238	-0.806847	92238	0.242304	92238	0.014880
Elemental						
O	8000	-0.167852	8000	0.750000	8000	0.046057
U	92234	-0.000222	92234	0.000068	92234	0.000004
U	92235	-0.024964	92235	0.007593	92235	0.000466
U	92236	-0.000115	92236	0.000035	92236	0.000002
U	92238	-0.806847	92238	0.242304	92238	0.014880

Comments and References

Formula from NIH PubChem pubchem.ncbi.nlm.nih.gov Density from https://ibilabs.com and https://www.webelements.com Additional reference B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.'

379. Uranium, Depleted, Typical

Formula = U Molecular Weight (g/mole) = 238.043155
Density (g/cm3) = 18.95 Total Atom Weight (atoms/b-cm) = 4.794E-02

The above density is estimated to be accurate to 4 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
U-234	92234	-0.000005	92234	0.000005	92234	0.000000
U-235	92235	-0.002500	92235	0.002532	92235	0.000121
U-238	92238	-0.997495	92238	0.997463	92238	0.047822
Elemental						
U	92234	-0.000005	92234	0.000005	92234	0.000000
U	92235	-0.002500	92235	0.002532	92235	0.000121
U	92238	-0.997495	92238	0.997463	92238	0.047822

Comments and References

The Health Physics and Radiological Health Handbook, p. 286, B. Shleien, editor, Scinta, Inc., 1992. Density adjusted from 18.95 g/cm3 to maintain same total atoms as for natural uranium based on http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=092.

380. Uranium, Enriched, Typical Commercial

Formula = U Molecular Weight (g/mole) = 237.959438
Density (g/cm3) = 18.944 Total Atom Weight (atoms/b-cm) = 4.794E-02

The above density is estimated to be accurate to 5 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
U-234	92234	-0.000305	92234	0.000310	92234	0.000015
U-235	92235	-0.029600	92235	0.029967	92235	0.001437
U-238	92238	-0.970095	92238	0.969723	92238	0.046492
Elemental						
U	92234	-0.000305	92234	0.000310	92234	0.000015
U	92235	-0.029600	92235	0.029967	92235	0.001437
U	92238	-0.970095	92238	0.969723	92238	0.046492

Comments and References

The Health Physics and Radiological Health Handbook, p. 286, B. Shleien, editor, Scinta, Inc., 1992. Density adjusted from 18.95 g/cm3 to maintain same total atoms as for natural uranium based on http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=092.

381. Uranium, HEU, Health Physics Society

Formula = U Molecular Weight (g/mole) = 235.200759
Density (g/cm3) = 18.724 Total Atom Weight (atoms/b-cm) = 4.794E-02

The above density is estimated to be accurate to 5 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
U-234	92234	-0.010530	92234	0.010582	92234	0.000507
U-235	92235	-0.931740	92235	0.932362	92235	0.044701
U-236	92236	-0.002060	92236	0.002053	92236	0.000098
U-238	92238	-0.055670	92238	0.055003	92238	0.002637
Elemental						
U	92234	-0.010530	92234	0.010582	92234	0.000507
U	92235	-0.931740	92235	0.932362	92235	0.044701
U	92236	-0.002060	92236	0.002053	92236	0.000098
U	92238	-0.055670	92238	0.055003	92238	0.002637

Comments and References

Bioassay Programs for Uranium, HPS 13.22-1995, American National Standards Institute, Inc., Oct. 1995. Density adjusted from 18.95 g/cm3 to maintain same total atoms as for natural uranium based on http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=092.

382. Uranium, HEU, Russian Average

Formula = U Molecular Weight (g/mole) = 235.301077
Density (g/cm3) = 18.732 Total Atom Weight (atoms/b-cm) = 4.794E-02

The above density is estimated to be accurate to 5 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
U-234	92234	-0.009670	92234	0.009722	92234	0.000466
U-235	92235	-0.898000	92235	0.898982	92235	0.043100
U-236	92236	-0.003810	92236	0.003798	92236	0.000182
U-238	92238	-0.088520	92238	0.087498	92238	0.004195
Elemental						
U	92234	-0.009670	92234	0.009722	92234	0.000466
U	92235	-0.898000	92235	0.898982	92235	0.043100
U	92236	-0.003810	92236	0.003798	92236	0.000182
U	92238	-0.088520	92238	0.087498	92238	0.004195

Comments and References

Personal communication with Andy Luksic based on Y-12 information. Density adjusted from 18.95 g/cm3 to maintain same total atoms as for natural uranium based on http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=092.

383. Uranium, HEU, US Average

Formula = U Molecular Weight (g/mole) = 235.199413
Density (g/cm3) = 18.724 Total Atom Weight (atoms/b-cm) = 4.794E-02

The above density is estimated to be accurate to 5 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
U-234	92234	-0.009800	92234	0.009849	92234	0.000472
U-235	92235	-0.931550	92235	0.932166	92235	0.044691
U-236	92236	-0.004500	92236	0.004484	92236	0.000215
U-238	92238	-0.054150	92238	0.053501	92238	0.002565
Elemental						
U	92234	-0.009800	92234	0.009849	92234	0.000472
U	92235	-0.931550	92235	0.932166	92235	0.044691
U	92236	-0.004500	92236	0.004484	92236	0.000215
U	92238	-0.054150	92238	0.053501	92238	0.002565

Comments and References

Personal communication with Andy Luksic based on Y-12 information. Density adjusted from 18.95 g/cm3 to maintain same total atoms as for natural uranium based on http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=092.

384. Uranium, Low Enriched (LEU)

Formula = U Molecular Weight (g/mole) = 237.957860
Density (g/cm3) = 18.944 Total Atom Weight (atoms/b-cm) = 4.794E-02

The above density is estimated to be accurate to 5 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
U-234	92234	-0.000267	92234	0.000271	92234	0.000013
U-235	92235	-0.030000	92235	0.030372	92235	0.001456
U-236	92236	-0.000138	92236	0.000139	92236	0.000007
U-238	92238	-0.969595	92238	0.969217	92238	0.046468
Elemental						
U	92234	-0.000267	92234	0.000271	92234	0.000013
U	92235	-0.030000	92235	0.030372	92235	0.001456
U	92236	-0.000138	92236	0.000139	92236	0.000007
U	92238	-0.969595	92238	0.969217	92238	0.046468

Comments and References

Density adjusted from 18.95 g/cm3 to maintain same total atoms as for natural uranium based on http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=092. Weight fractions

from 'A Nondestructive Method for Discriminating MOX Fuel from LEU Fuel for Safeguards Purposes' by C. Willman, et al, April 10, 2006, at http://www.sciencedirect.com/, at the direct link https://www.sciencedirect.com/science/article/pii/S0306454906000727, ANNALS OF NUCLEAR ENERGY Volume: 33 Issue: 9 Pages: 766-773 DOI: 10.1016/j.anucene.2006.04.006 Published: JUN 2006

385. Uranium, Natural (NU)

Formula = U Molecular Weight (g/mole) = 238.028620
Density (g/cm3) = 18.95 Total Atom Weight (atoms/b-cm) = 4.794E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
U-234	92234	-0.000057	92234	0.000058	92234	0.000003
U-235	92235	-0.007204	92235	0.007295	92235	0.000350
U-238	92238	-0.992739	92238	0.992647	92238	0.047591
Elemental						
U	92234	-0.000057	92234	0.000058	92234	0.000003
U	92235	-0.007204	92235	0.007295	92235	0.000350
U	92238	-0.992739	92238	0.992647	92238	0.047591

Comments and References

The Health Physics and Radiological Health Handbook, p. 286, B. Shleien, editor, Scinta, Inc., 1992. Density for natural uranium = 18.95 g/cm3, http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=092.

386. Uranium-Plutonium, Mixed Oxide (MOX)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 11 Total Atom Weight (atoms/b-cm) = 7.357E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.118141	8016	0.665047	8016	0.048929
O17	8017	-0.000048	8017	0.000253	8017	0.000019
O18	8018	-0.000273	8018	0.001367	8018	0.000101
Pu-238	94238	-0.001030	94238	0.000390	94238	0.000029
Pu-239	94239	-0.022532	94239	0.008487	94239	0.000624
Pu-240	94240	-0.010751	94240	0.004032	94240	0.000297
Pu-241	94241	-0.003913	94241	0.001462	94241	0.000108
Pu-242	94242	-0.002966	94242	0.001103	94242	0.000081

U-234	92234	-0.000010	92234	0.000004	92234	0.000000
U-235	92235	-0.002101	92235	0.000805	92235	0.000059
U-236	92236	-0.000000	92236	0.000000	92236	0.000000
U-238	92238	-0.838236	92238	0.317052	92238	0.023326
Elemental						
O	8000	-0.118462	8000	0.666667	8000	0.049048
Pu	94238	-0.001030	94238	0.000390	94238	0.000029
Pu	94239	-0.022532	94239	0.008487	94239	0.000624
Pu	94240	-0.010751	94240	0.004032	94240	0.000297
Pu	94241	-0.003913	94241	0.001462	94241	0.000108
Pu	94242	-0.002966	94242	0.001103	94242	0.000081
U	92234	-0.000010	92234	0.000004	92234	0.000000
U	92235	-0.002101	92235	0.000805	92235	0.000059
U	92236	-0.000000	92236	0.000000	92236	0.000000
U	92238	-0.838236	92238	0.317052	92238	0.023326

Comments and References

Density from (4 wt% PuO2, 96 wt% UO2) MOX from American Nuclear Society Light Water Reactor Mixed Oxide Benchmark I by J. C. Gemin and R. T. Primm, III, July 22, 1997, at https://www.researchgate.net/publication/242734898_American_Nuclear_Society_Light_Water_Reactor_Mixed_Oxide_Benchmark_I Weight fractions based on MOX with 3.0 wt% fissile Pu in heavy metal from 'A Nondestructive Method for Discriminating MOX Fuel from LEU Fuel for Safeguards Purposes' by C. Willman, et al, April 10, 2006, at http://www.sciencedirect.com/, at the direct link https://www.sciencedirect.com/science/article/pii/S0306454906000727, ANNALS OF NUCLEAR ENERGY Volume: 33 Issue: 9 Pages: 766-773 DOI: 10.1016/j.anucene.2006.04.006 Published: JUN 2006

387. Uranyl Fluoride

Formula = UO2F2 Molecular Weight (g/mole) = 307.953466
Density (g/cm3) = 6.37 Total Atom Weight (atoms/b-cm) = 6.228E-02

CAS number 13536-84-0 Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.103626	8016	0.399028	8016	0.024853
O17	8017	-0.000042	8017	0.000152	8017	0.000009
O18	8018	-0.000240	8018	0.000820	8018	0.000051
F19	9019	-0.123385	9019	0.400000	9019	0.024914
U234	92234	-0.000206	92234	0.000054	92234	0.000003
U235	92235	-0.023181	92235	0.006074	92235	0.000378
U236	92236	-0.000107	92236	0.000028	92236	0.000002
U238	92238	-0.749213	92238	0.193843	92238	0.012073
Elemental						
O	8000	-0.103908	8000	0.400000	8000	0.024914

F	9000	-0.123385	9000	0.400000	9000	0.024914
U	92234	-0.000206	92234	0.000054	92234	0.000003
U	92235	-0.023181	92235	0.006074	92235	0.000378
U	92236	-0.000107	92236	0.000028	92236	0.000002
U	92238	-0.749213	92238	0.193843	92238	0.012073
Comments and References						
Formula from NIH PubChem pubchem.ncbi.nlm.nih.gov Density from Dean, J.A. (ed.). Lange's Handbook of Chemistry. 13 ed.New York, NY: McGraw-Hill Book Co., 1985., p. 4-126, B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.'Also LA-10860-MS, Criticality Dimensions of Systems Containing 235U, 239Pu, and 233U by H. C. Paxton and N. L. Pruvost, 1986 revision issued July 1987, page 201.						

388. Uranyl Nitrate

Formula = UN2O8 Molecular Weight (g/mole) = 393.966770
Density (g/cm3) = 2.81 Total Atom Weight (atoms/b-cm) = 4.725E-02

CAS number 13520-83-7 Uranium isotopics assumed for LEU: Wt% U234/235/236/238 = 0.0267/3.0/0.0138/96.9595.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
N14	7014	-0.070829	7014	0.181156	7014	0.008559
N15	7015	-0.000277	7015	0.000662	7015	0.000031
O16	8016	-0.324008	8016	0.725505	8016	0.034279
O17	8017	-0.000131	8017	0.000276	8017	0.000013
O18	8018	-0.000749	8018	0.001491	8018	0.000070
U234	92234	-0.000161	92234	0.000025	92234	0.000001
U235	92235	-0.018120	92235	0.002761	92235	0.000130
U236	92236	-0.000083	92236	0.000013	92236	0.000001
U238	92238	-0.585640	92238	0.088111	92238	0.004163
Elemental						
N	7000	-0.071107	7000	0.181818	7000	0.008591
O	8000	-0.324888	8000	0.727273	8000	0.034363
U	92234	-0.000161	92234	0.000025	92234	0.000001
U	92235	-0.018120	92235	0.002761	92235	0.000130
U	92236	-0.000083	92236	0.000013	92236	0.000001
U	92238	-0.585640	92238	0.088111	92238	0.004163
Comments and References						
Formula and density from NIH PubChem pubchem.ncbi.nlm.nih.gov						

389. Vermiculite, Exfoliated

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.085 Total Atom Weight (atoms/b-cm) = 3.049E-03

CAS # 1318-00-9The density and composition can vary significantly depending on the source of the material. It is obtained primarily from mines in South Africa, USA, China, Brazil, Australia, Kenya, and Zimbabwe. After the high density mineral form is mined, it is heated to cause it to exfoliate (expand) to its low density form.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.011832	1001	0.197151	1001	0.000601
H2	1002	-0.000003	1002	0.000023	1002	0.000000
O16	8016	-0.495011	8016	0.519712	8016	0.001584
O17	8017	-0.000200	8017	0.000198	8017	0.000001
O18	8018	-0.001145	8018	0.001068	8018	0.000003
Mg	12000	-0.133383	12000	0.092157	12000	0.000281
Al27	13027	-0.063151	13027	0.039305	13027	0.000120
Si	14000	-0.189668	14000	0.113410	14000	0.000346
K	19000	-0.021668	19000	0.009307	19000	0.000028
Ca	20000	-0.016353	20000	0.006852	20000	0.000021
Ti	22000	-0.009854	22000	0.003457	22000	0.000011
Fe	26000	-0.057732	26000	0.017361	26000	0.000053
Elemental						
H	1000	-0.011835	1000	0.197174	1000	0.000601
O	8000	-0.496356	8000	0.520978	8000	0.001588
Mg	12000	-0.133383	12000	0.092157	12000	0.000281
Al	13000	-0.063151	13000	0.039305	13000	0.000120
Si	14000	-0.189668	14000	0.113410	14000	0.000346
K	19000	-0.021668	19000	0.009307	19000	0.000028
Ca	20000	-0.016353	20000	0.006852	20000	0.000021
Ti	22000	-0.009854	22000	0.003457	22000	0.000011
Fe	26000	-0.057732	26000	0.017361	26000	0.000053

Comments and References

Bulk density of medium size (2 to 8 mm) vermiculite is about 0.085 g/cm3 from http://www.schundler.com/techverm.htm The density is lower for larger pieces and higher for smaller pieces. The composition is calculated based on http://www.schundler.com/techverm.htm Density from 0.064 to 0.160 from http://www.vermiculite.org/properties.htm and http://www.vermiculite.net/.

390. Viton Fluoroelastomer

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.8 Total Atom Weight (atoms/b-cm) = 7.596E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.009415	1001	0.133307	1001	0.010126
H2	1002	-0.000002	1002	0.000015	1002	0.000001
C	6000	-0.280555	6000	0.333345	6000	0.025321
F19	9019	-0.710028	9019	0.533333	9019	0.040512
Elemental						
H	1000	-0.009417	1000	0.133322	1000	0.010127
C	6000	-0.280555	6000	0.333345	6000	0.025321
F	9000	-0.710028	9000	0.533333	9000	0.040512
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=275.						

391. Water, Heavy

Formula = H2O Molecular Weight (g/mole) = 20.027604
Density (g/cm3) = 1.1044 Total Atom Weight (atoms/b-cm) = 9.963E-02

CAS number 7789-20-0dens. 1.1044 at 25 °C. Temp of max density 11.23 °C; 1.1059 at 11.23 °C

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H2	1002	-0.201133	1002	0.666667	1002	0.066417
O16	8016	-0.796703	8016	0.332523	8016	0.033128
O17	8017	-0.000323	8017	0.000127	8017	0.000013
O18	8018	-0.001842	8018	0.000683	8018	0.000068
Elemental						
H	1002	-0.201133	1002	0.666667	1002	0.066417
O	8000	-0.798867	8000	0.333333	8000	0.033208
Comments and References						
Formula and density from NIH PubChem pubchem.ncbi.nlm.nih.gov Density also from O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 532						

392. Water, Liquid

Formula = H2O Molecular Weight (g/mole) = 18.015350
Density (g/cm3) = 0.997 Total Atom Weight (atoms/b-cm) = 9.998E-02

CAS number 7732-18-5

	Weight Fractions		Atom Fractions		Atom Densities	

Isotopic						
H1	1001	-0.111872	1001	0.666590	1001	0.066647
H2	1002	-0.000026	1002	0.000077	1002	0.000008
O16	8016	-0.885692	8016	0.332523	8016	0.033247
O17	8017	-0.000359	8017	0.000127	8017	0.000013
O18	8018	-0.002048	8018	0.000683	8018	0.000068
Elemental						
H	1000	-0.111902	1000	0.666667	1000	0.066655
O	8000	-0.888098	8000	0.333333	8000	0.033328
Comments and References						
Formula and density from NIH PubChem pubchem.ncbi.nlm.nih.gov Density = 1.00000 g/cm3 at http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=276.						

393. Water, Vapor

Formula = H2O Molecular Weight (g/mole) = 18.015350
Density (g/cm3) = 0.000756182 Total Atom Weight (atoms/b-cm) = 7.600E-05

CAS number 7732-18-5

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.111872	1001	0.666590	1001	0.000051
H2	1002	-0.000026	1002	0.000077	1002	0.000000
O16	8016	-0.885692	8016	0.332523	8016	0.000025
O17	8017	-0.000359	8017	0.000127	8017	0.000000
O18	8018	-0.002048	8018	0.000683	8018	0.000000
Elemental						
H	1000	-0.111902	1000	0.666667	1000	0.000051
O	8000	-0.888098	8000	0.333333	8000	0.000025
Comments and References						
Density = 7.56182E-04 g/cm3 from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=277.						

394. Wax, M3

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 1.05 Total Atom Weight (atoms/b-cm) = 1.134E-01

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.114288	1001	0.632122	1001	0.071706
H2	1002	-0.000026	1002	0.000073	1002	0.000008

C	6000	-0.655824	6000	0.304374	6000	0.034527
O16	8016	-0.091933	8016	0.032039	8016	0.003634
O17	8017	-0.000037	8017	0.000012	8017	0.000001
O18	8018	-0.000213	8018	0.000066	8018	0.000007
Mg	12000	-0.134792	12000	0.030913	12000	0.003507
Ca	20000	-0.002883	20000	0.000401	20000	0.000045
Elemental						
H	1000	-0.114318	1000	0.632195	1000	0.071714
C	6000	-0.655824	6000	0.304374	6000	0.034527
O	8000	-0.092183	8000	0.032117	8000	0.003643
Mg	12000	-0.134792	12000	0.030913	12000	0.003507
Ca	20000	-0.002883	20000	0.000401	20000	0.000045
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=191.						

395. Wax, Mix D

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.99 Total Atom Weight (atoms/b-cm) = 1.203E-01

The above density is estimated to be accurate to 2 significant digits. Uncertainties are not addressed.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.134005	1001	0.658796	1001	0.079272
H2	1002	-0.000031	1002	0.000076	1002	0.000009
C	6000	-0.777960	6000	0.320928	6000	0.038617
O16	8016	-0.034925	8016	0.010819	8016	0.001302
O17	8017	-0.000014	8017	0.000004	8017	0.000000
O18	8018	-0.000081	8018	0.000022	8018	0.000003
Mg	12000	-0.038594	12000	0.007867	12000	0.000947
Ti	22000	-0.014386	22000	0.001489	22000	0.000179
Elemental						
H	1000	-0.134040	1000	0.658871	1000	0.079281
C	6000	-0.777960	6000	0.320928	6000	0.038617
O	8000	-0.035020	8000	0.010845	8000	0.001305
Mg	12000	-0.038594	12000	0.007867	12000	0.000947
Ti	22000	-0.014386	22000	0.001489	22000	0.000179
Comments and References						
Density and weight fractions from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=199.						

396. Wax, Paraffin

Formula = C25H52 Molecular Weight (g/mole) = 352.679700
Density (g/cm3) = 0.812 Total Atom Weight (atoms/b-cm) = 1.068E-01

CAS number 629-99-2Pentacosane

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.148579	1001	0.675247	1001	0.072091
H2	1002	-0.000034	1002	0.000078	1002	0.000008
C	6000	-0.851382	6000	0.324675	6000	0.034663
Elemental						
H	1000	-0.148618	1000	0.675325	1000	0.072099
C	6000	-0.851382	6000	0.324675	6000	0.034663

Comments and References

Paraffin wax is a solid mixture of hydrocarbons with an approximation of C25H52 (pentacosane). Formula and density from NIH PubChem pubchem.ncbi.nlm.nih.gov density 0.812 g/cu cm at 20 °C Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 95th Edition. CRC Press LLC, Boca Raton: FL 2014-2015, p. 3-436

397. Wood (Southern Pine)

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 0.64 Total Atom Weight (atoms/b-cm) = 4.932E-02

It is assumed that the ash is composed of equal weight fractions of Mg, K, and Ca.Weight fractions are normalized so that they sum to unity.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.059626	1001	0.462360	1001	0.022803
H2	1002	-0.000014	1002	0.000053	1002	0.000003
C	6000	-0.497018	6000	0.323396	6000	0.015949
N14	7014	-0.004951	7014	0.002763	7014	0.000136
N15	7015	-0.000019	7015	0.000010	7015	0.000000
O16	8016	-0.426277	8016	0.208275	8016	0.010272
O17	8017	-0.000173	8017	0.000079	8017	0.000004
O18	8018	-0.000986	8018	0.000428	8018	0.000021
Mg	12000	-0.001988	12000	0.000639	12000	0.000032
S	16000	-0.004970	16000	0.001211	16000	0.000060
K	19000	-0.001988	19000	0.000397	19000	0.000020
Ca	20000	-0.001988	20000	0.000388	20000	0.000019
Elemental						
H	1000	-0.059642	1000	0.462413	1000	0.022805
C	6000	-0.497018	6000	0.323396	6000	0.015949
N	7000	-0.004970	7000	0.002773	7000	0.000137

O	8000	-0.427435	8000	0.208782	8000	0.010297
Mg	12000	-0.001988	12000	0.000639	12000	0.000032
S	16000	-0.004970	16000	0.001211	16000	0.000060
K	19000	-0.001988	19000	0.000397	19000	0.000020
Ca	20000	-0.001988	20000	0.000388	20000	0.000019
Comments and References						
Density = 0.64 g/cm3 is average for southern pine, density for ash (black) = 0.55, ash (white) = 0.67,balsa = 0.125, birch = 0.71, ceder = 0.35, cherry = 0.43, fir (douglas) = 0.51, elm = 0.56, hickory = 0.77, mahogany = 0.70, maple (sugar) = 0.68, maple (white) = 0.53, oak (black or red) = 0.67, oak (white) = 0.77, pine (white) = 0.43, pine (yellow) = 0.71, poplar = 0.43, redwood = 0.42, spruce = 0.45, walnut = 0.59 based on Table 6.1.5 of Mark's Standard Handbook for Mechanical Engineers, E. A. Avallone and T. Baumeister III, 10th edition. Density of course sawdust = 0.29 g/cm3, of fine sawdust = 0.40 g/cm3 based on https://www.engineeringtoolbox.com/wood-density-d_40.html. Weight fractions are from Mechanical Engineer's Reference Book, 12th Ed., edited by Edward H. Smith, 1998, Elsevier. Compositions for 6 different types of wood are given in Table 51.116 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.Plywood density = 0.58 g/cm3 based on 3.0 lb/ft2 for 1 thick plywood (Table 6.7.13 of Mark's Standard Handbook for Mechanical Engineers, 10th edition). Plywood density = 0.42 to 0.68 g/cm3 for 9 types of plywood in Table 51.115 of Reactor Handbook, 2nd edition, Vol. 1, Materials, edited by C. R. Tipton, 1960.See Table 11-15, Materials Data Book, by E.R. Parker, McGraw-Hill, 1967, for green and dry densities.						

398. Xenon

Formula = Xe Molecular Weight (g/mole) = 131.293000
Density (g/cm3) = 0.00548536 Total Atom Weight (atoms/b-cm) = 2.500E-05

CAS number 7440-63-3

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Xe	54000	-1.000000	54000	1.000000	54000	0.000025
Elemental						
Xe	54000	-1.000000	54000	1.000000	54000	0.000025
Comments and References						
Density from http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=054. From Wikipedia Density (at STP)5.894 g/L when liquid (at b.p.) 2.942 g/cm3[4]						

399. Yttrium Aluminum Oxide - 1 atom% Cerium

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 4.56 Total Atom Weight (atoms/b-cm) = 9.541E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.221757	8016	0.399028	8016	0.038073
O17	8017	-0.000090	8017	0.000152	8017	0.000015
O18	8018	-0.000513	8018	0.000820	8018	0.000078
Al27	13027	-0.468737	13027	0.500000	13027	0.047707
Y89	39089	-0.308903	39089	0.100000	39089	0.009541
Elemental						
O	8000	-0.222360	8000	0.400000	8000	0.038165
Al	13000	-0.468737	13000	0.500000	13000	0.047707
Y	39000	-0.308903	39000	0.100000	39000	0.009541
Comments and References						
Formula is Y3Al5O12(Ce) but the formula isn't used in the calculation due to the Ce dopant Material properties taken from https://www.epic-crystal.com/oxide-scintillators/yag-ce-scintillator.html Dopant (aka Activator) added at 1 atom percent						

400. Yttrium Aluminum Perovslite - 0.5 atom% Cerium

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 5.4 Total Atom Weight (atoms/b-cm) = 8.629E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Y89	39089	-0.469481	39089	0.199000	39089	0.017172
Al27	13027	-0.427441	13027	0.597000	13027	0.051517
O16	8016	-0.084258	8016	0.198516	8016	0.017131
O17	8017	-0.000034	8017	0.000076	8017	0.000007
O18	8018	-0.000195	8018	0.000408	8018	0.000035
Ce136	58136	-0.000033	58136	0.000009	58136	0.000001
Ce138	58138	-0.000046	58138	0.000013	58138	0.000001
Ce140	58140	-0.016419	58140	0.004423	58140	0.000382
Ce142	58142	-0.002093	58142	0.000556	58142	0.000048
Elemental						
Y	39000	-0.469481	39000	0.199000	39000	0.017172
Al	13000	-0.427441	13000	0.597000	13000	0.051517
O	8000	-0.084487	8000	0.199000	8000	0.017172
Ce	58000	-0.018591	58000	0.005000	58000	0.000431
Comments and References						
Formula is YOAl3(Ce) but the formula isn't used in the calculation due to the Ce dopant Material properties taken from https://www.epic-crystal.com/oxide-scintillators/yap-ce-scintillator.html Dopant (aka Activator) added at 0.5 atom percent						

401. Zeolite (Natrolite)

Formula = Na2Al2Si3O12H4 Molecular Weight (g/mole) = 380.222314
Density (g/cm3) = 2.25 Total Atom Weight (atoms/b-cm) = 8.196E-02

CAS No. 1318-95-2

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.010601	1001	0.173893	1001	0.014253
H2	1002	-0.000002	1002	0.000020	1002	0.000002
O16	8016	-0.503581	8016	0.520470	8016	0.042660
O17	8017	-0.000204	8017	0.000198	8017	0.000016
O18	8018	-0.001165	8018	0.001070	8018	0.000088
Na23	11023	-0.120928	11023	0.086957	11023	0.007127
Al27	13027	-0.141925	13027	0.086957	13027	0.007127
Si	14000	-0.221594	14000	0.130435	14000	0.010691
Elemental						
H	1000	-0.010604	1000	0.173913	1000	0.014255
O	8000	-0.504949	8000	0.521738	8000	0.042764
Na	11000	-0.120928	11000	0.086957	11000	0.007127
Al	13000	-0.141925	13000	0.086957	13000	0.007127
Si	14000	-0.221594	14000	0.130435	14000	0.010691

Comments and References

Formula and density from http://www.webmineral.com Non-clumping cat litter is often made of zeolite, diatomaceous earth, and/or sepiolite. The formula is for natrolite (http://www.galleries.com/Minerals/By_Name.htm) which is one form of the mineral group called zeolite (http://en.wikipedia.org/wiki/Zeolite).

402. Zinc

Formula = Zn Molecular Weight (g/mole) = 65.380000
Density (g/cm3) = 7.133 Total Atom Weight (atoms/b-cm) = 6.570E-02

CAS Number 7440-66-6

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Zn	30000	-1.000000	30000	1.000000	30000	0.065702
Elemental						
Zn	30000	-1.000000	30000	1.000000	30000	0.065702

Comments and References

Density from NIH PubChem pubchem.ncbi.nlm.nih.gov

403. Zinc Selenide

Formula = ZnSe			Molecular Weight (g/mole) = 144.351000			
Density (g/cm3) = 5.27			Total Atom Weight (atoms/b-cm) = 4.397E-02			
CAS Number 1315-09-9						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Zn	30000	-0.452924	30000	0.500000	30000	0.021986
Se74	34074	-0.004558	34074	0.004450	34074	0.000196
Se76	34076	-0.049280	34076	0.046850	34076	0.002060
Se77	34077	-0.040658	34077	0.038150	34077	0.001678
Se78	34078	-0.128305	34078	0.118850	34078	0.005226
Se80	34080	-0.274654	34080	0.248050	34080	0.010907
Se82	34082	-0.049541	34082	0.043650	34082	0.001919
Elemental						
Zn	30000	-0.452924	30000	0.500000	30000	0.021986
Se	34000	-0.547076	34000	0.500000	34000	0.021986
Comments and References						
Formula and density from American Elements: www.americanelements.com						

404. Zinc Sulfide

Formula = ZnS			Molecular Weight (g/mole) = 97.447500			
Density (g/cm3) = 4.09			Total Atom Weight (atoms/b-cm) = 5.055E-02			
CAS Number: 1314-98-3 Densities: 4.04 g/cu cm (sphalerite); 4.09 g/cu cm (wurtzite)						
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
S	16000	-0.329075	16000	0.500000	16000	0.025276
Zn	30000	-0.670925	30000	0.500000	30000	0.025276
Elemental						
S	16000	-0.329075	16000	0.500000	16000	0.025276
Zn	30000	-0.670925	30000	0.500000	30000	0.025276
Comments and References						
Formula and densities from NIH PubChem pubchem.ncbi.nlm.nih.gov						

405. Zircaloy-2

Formula =		Molecular Weight (g/mole) =
Density (g/cm3) = 6.56		Total Atom Weight (atoms/b-cm) = 4.348E-02

Weight fractions normalized to 1.0.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.001194	8016	0.006781	8016	0.000295
O17	8017	-0.000000	8017	0.000003	8017	0.000000
O18	8018	-0.000003	8018	0.000014	8018	0.000001
Cr	24000	-0.000997	24000	0.001742	24000	0.000076
Fe	26000	-0.000997	26000	0.001622	26000	0.000071
Ni	28000	-0.000499	28000	0.000772	28000	0.000034
Zr90	40090	-0.498109	40090	0.503377	40090	0.021888
Zr91	40091	-0.109835	40091	0.109774	40091	0.004773
Zr92	40092	-0.169730	40092	0.167792	40092	0.007296
Zr94	40094	-0.175752	40094	0.170042	40094	0.007394
Zr96	40096	-0.028918	40096	0.027395	40096	0.001191
Sn	50000	-0.013962	50000	0.010686	50000	0.000465
Elemental						
O	8000	-0.001197	8000	0.006797	8000	0.000296
Cr	24000	-0.000997	24000	0.001742	24000	0.000076
Fe	26000	-0.000997	26000	0.001622	26000	0.000071
Ni	28000	-0.000499	28000	0.000772	28000	0.000034
Zr	40000	-0.982348	40000	0.978381	40000	0.042541
Sn	50000	-0.013962	50000	0.010686	50000	0.000465

Comments and References

http://www.matweb.com/search/DataSheet.aspx?MatGUID=eb1dad5ce1ad4a1f9e92f86d5b44740d&ckck=1LA-10860-MS, Criticality Dimensions of Systems Containing 235U, 239Pu, and 233U by H. C. Paxton and N. L. Pruvost, 1986 revision issued July 1987, page 201.

406. Zircaloy-4

Formula = Molecular Weight (g/mole) =
Density (g/cm3) = 6.56 Total Atom Weight (atoms/b-cm) = 4.350E-02

The above density is estimated to be accurate to 3 significant digits. Uncertainties are not addressed. Weight fractions normalized to 1.0.

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
O16	8016	-0.001193	8016	0.006774	8016	0.000295
O17	8017	-0.000000	8017	0.000003	8017	0.000000
O18	8018	-0.000003	8018	0.000014	8018	0.000001
Cr	24000	-0.000997	24000	0.001741	24000	0.000076
Fe	26000	-0.001993	26000	0.003242	26000	0.000141
Zr90	40090	-0.497860	40090	0.502949	40090	0.021877
Zr91	40091	-0.109780	40091	0.109681	40091	0.004771
Zr92	40092	-0.169646	40092	0.167650	40092	0.007292

Zr94	40094	-0.175665	40094	0.169898	40094	0.007390
Zr96	40096	-0.028904	40096	0.027371	40096	0.001191
Sn	50000	-0.013955	50000	0.010677	50000	0.000464
Elemental						
O	8000	-0.001196	8000	0.006790	8000	0.000295
Cr	24000	-0.000997	24000	0.001741	24000	0.000076
Fe	26000	-0.001993	26000	0.003242	26000	0.000141
Zr	40000	-0.981859	40000	0.977550	40000	0.042520
Sn	50000	-0.013955	50000	0.010677	50000	0.000464
Comments and References						
http://www.matweb.com/search/DataSheet.aspx?MatGUID=e36a9590eb5945de94d89a35097b7faa						

407. Zirconium

Formula = Zr Molecular Weight (g/mole) = 91.224000
Density (g/cm3) = 6.52 Total Atom Weight (atoms/b-cm) = 4.304E-02

CAS Number 1314-23-4

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Zr90	40090	-0.507059	40090	0.514500	40090	0.022145
Zr91	40091	-0.111808	40091	0.112200	40091	0.004829
Zr92	40092	-0.172780	40092	0.171500	40092	0.007382
Zr94	40094	-0.178910	40094	0.173800	40094	0.007481
Zr96	40096	-0.029438	40096	0.028000	40096	0.001205
Elemental						
Zr	40000	-1.000000	40000	1.000000	40000	0.043042
Comments and References						
Density from NIH PubChem pubchem.ncbi.nlm.nih.gov						

408. Zirconium Hydride (Zr5H8)

Formula = Zr5H8 Molecular Weight (g/mole) = 464.183800
Density (g/cm3) = 5.61 Total Atom Weight (atoms/b-cm) = 9.462E-02

Zirconium hydride as a mixture of ZrH and ZrH2, with an effective composition of Zr5H8

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.017367	1001	0.615314	1001	0.058219
H2	1002	-0.000004	1002	0.000071	1002	0.000007
Zr90	40090	-0.498251	40090	0.197885	40090	0.018723

Zr91	40091	-0.109866	40091	0.043154	40091	0.004083
Zr92	40092	-0.169779	40092	0.065962	40092	0.006241
Zr94	40094	-0.175802	40094	0.066846	40094	0.006325
Zr96	40096	-0.028926	40096	0.010769	40096	0.001019
Elemental						
H	1000	-0.017372	1000	0.615385	1000	0.058226
Zr	40000	-0.982628	40000	0.384615	40000	0.036391
Comments and References						
B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.'						

409. Zirconium Hydride (ZrH2)

Formula = ZrH2			Molecular Weight (g/mole) = 93.239950			
Density (g/cm3) = 5.6			Total Atom Weight (atoms/b-cm) = 1.085E-01			
	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
H1	1001	-0.021615	1001	0.666590	1001	0.072330
H2	1002	-0.000005	1002	0.000077	1002	0.000008
Zr90	40090	-0.496096	40090	0.171500	40090	0.018609
Zr91	40091	-0.109391	40091	0.037400	40091	0.004058
Zr92	40092	-0.169045	40092	0.057167	40092	0.006203
Zr94	40094	-0.175042	40094	0.057933	40094	0.006286
Zr96	40096	-0.028801	40096	0.009333	40096	0.001013
Elemental						
H	1000	-0.021621	1000	0.666667	1000	0.072338
Zr	40000	-0.978379	40000	0.333333	40000	0.036169
Comments and References						
B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834. Data taken from Section 7.2, 'Standard Composition Library,' Table 7.2.4. 'Compounds.'						

410. ZnS(Ag):LiF 95wt% 6Li PHOSPHOR POWDER Neutron Detectors

Formula =			Molecular Weight (g/mole) =			
Density (g/cm3) = 4.09			Total Atom Weight (atoms/b-cm) = 5.554E-02			
	Weight Fractions		Atom Fractions		Atom Densities	

Isotopic						
Zn	30000	-0.648007	30000	0.439541	30000	0.024412
S	16000	-0.317833	16000	0.439541	16000	0.024412
F19	9019	-0.025901	9019	0.060459	9019	0.003358
Li6	3006	-0.007847	3006	0.057849	3006	0.003213
Li7	3007	-0.000413	3007	0.002610	3007	0.000145
Elemental						
Zn	30000	-0.648007	30000	0.439541	30000	0.024412
S	16000	-0.317833	16000	0.439541	16000	0.024412
F	9000	-0.025901	9000	0.060459	9000	0.003358
Li	3006	-0.007847	3006	0.057849	3006	0.003213
Li	3007	-0.000413	3007	0.002610	3007	0.000145
Comments and References						
Density and formula from https://www.crystals.saint-gobain.com/products/zns-and-lif-based-neutron-detectors, which uses a mixture ZnS(Ag)+Li with 0.95% Li. Also see PNNL-24895 Improving Neutron Measurements Venture: PNNL FY15 Year-End Report, S.C. Stave et al, PNNL 2015. States 7.27 grains of ZnS to 1 grain of LiF.						

411. ZnS:Ag PHOSPHOR POWDER EJ-600 for Neutron Detectors

Formula = ZnS Molecular Weight (g/mole) = 97.447500
Density (g/cm3) = 4.09 Total Atom Weight (atoms/b-cm) = 5.055E-02

	Weight Fractions		Atom Fractions		Atom Densities	
Isotopic						
Zn	30000	-0.670925	30000	0.500000	30000	0.025276
S	16000	-0.329075	16000	0.500000	16000	0.025276
Elemental						
Zn	30000	-0.670925	30000	0.500000	30000	0.025276
S	16000	-0.329075	16000	0.500000	16000	0.025276
Comments and References						
Density and formula from https://eljentechnology.com/23-products/zinc-sulfide-coated also from https://www.crystals.saint-gobain.com/products/zns-and-lif-based-neutron-detectors, which also lists a mixture ZnS(Ag)+Li with variable Li content						

Major References

American Elements, 10884 Weyburn Ave., Los Angeles, CA 90024. Reference for scintillator detector materials. https://www.americanelements.com.

ANSI/ANS-6.4-1985. *Guidelines on the Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants*. American National Standards Institute, New York; American Nuclear Society, La Grange Park, Illinois.

Avallone EA and T Baumeister III, eds. 1996. *Mark's Standard Handbook for Mechanical Engineers*. 10th ed., McGraw-Hill Education.

Blatt H, RJ Tracy, and BE Owens. 2006. *Petrology: Igneous, Sedimentary, and Metamorphic*. 3rd ed., WH Freeman and Company, New York.

Brandrup J, EH Immergut, EA Grulke, A Abe, DR Bloch, and R Daniel. 2005. *Polymer Handbook*. 4th ed., John Wiley & Sons.

Brewer R. 2009. *Criticality Calculations with MCNP5: A Primer*. LA-UR-09-00380, Los Alamos National Laboratory, Los Alamos, New Mexico.

Carter RD, GR Kiel, and KR Ridgway. 1968. *Criticality Handbook*. ARH-600, Vol. 1, Atlantic Richfield Company, Hanford, Washington.

Carter RD. 1978. *Concrete and Criticality*. RHO-SA-30, Rockwell Hanford Operations, Richland, Washington.

Chilton AB, JK Shultis, and RE Faw. 1984. *Principles of Radiation Shielding*. Prentice Hall, Englewood Cliffs, New Jersey.

DOE-STD-3013-2000. *DOE Standard: Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*. U.S. Department of Energy, Washington, D.C. https://www.standards.doe.gov/news/new-doe-std-3013-2018-stabilization-packaging-and-storage-of-plutonium-bearing-materials

Engineering Toolbox. 2020. "Liquids – Densities." Accessed in 2020 at http://www.engineeringtoolbox.com/liquids-densities-d_743.html.

Green DW and RH Perry. 2008. *Perry's Chemical Engineers' Handbook*. 8th ed., McGraw-Hill.

Greskovich C and S Duclos. 1997. "Ceramic Scintillators." *Annual Review of Material Science*, 27:69-88.

Guthrie VB, ed. 1960. *Petroleum Products Handbook*. McGraw-Hill.

Hungerford, HE. 1960. "Materials." In *Reactor Handbook*, 2nd ed., Vol. 1, ed. CR Tipton, Jr., Interscience Publishers, New York.

Jaeger RG, EP Blizard, and AB Chilton, eds. 1975. "Shielding Materials." In *Engineering Compendium on Radiation Shielding*, Vol. 2, Springer-Verlag, New York.

Knoll GF. 2000. Radiation Detection and Measurement. 3rd ed., John Wiley & Sons.

Knovel. 2008. *Knovel Critical Tables*. 2nd ed. Compiled by Knovel Corporation. http://knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=761&VerticalID=0.

Lide DR, ed. 2008. *CRC Handbook of Chemistry and Physics*. 89th ed., CRC Press, Taylor & Francis Group, Boca Raton, Florida.

Lide DR, ed. 2009. *CRC Handbook of Chemistry and Physics*. 90th ed., CRC Press, Taylor & Francis Group, , Boca Raton, Florida.

Maerker RE and FJ Muckenthaler. 1966. "Measurements and Single Velocity Calculations of Differential Angular Thermal-Neutron Albedos for Concrete." *Nuclear Science and Engineering*, 26(3):340.

Mantell CL, ed. 1958. *Engineering Materials Handbook*. McGraw-Hill.

MatWeb Material Property Data. 2020. Accessed 2019-2020 at http://www.matweb.com/search/search.aspx.

McConn Jr RJ, CJ Gesh, RT Pagh, RA Rucker, and RG Williams III. 2011. *Compendium of Material Composition Data for Radiation Transport Modeling*. PNNL-15870, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. PIET-43741-TM-963, Page 357 of 357.

Mine-Engineer.Com. 2019. "Minerals," at http://www.mine-engineer.com (last updated January 2019).

NCRP - National Council on Radiation Protection and Measurements. 2003. *Radiation Protection for Particle Accelerator Facilities*. NCRP Report No. 144, National Council on Radiation Protection and Measurements, Washington, D.C.

NIST - National Institute of Standards and Technology. 2004. NIST Standard Reference Database 126, *Tables of X-Ray Mass Attenuation Coefficients and Mass Energy-Absorption Coefficients*. Table 2, X-Ray Mass Attenuation Coefficients, at http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html.

NIST - National Institute of Standards and Technology. 2017. NIST Standard Reference Database 124, *Stopping-Power and Range Tables for Electrons, Protons, and Helium Ions*. "PSTAR and ASTAR: for Protons and Helium Ions (alpha particles)," Table 2, List of Materials for PSTAR and ASTAR at http://physics.nist.gov/PhysRefData/Star/Text/Table2.html, and Compositions of Materials data at http://physics.nist.gov/cgi-bin/Star/compos.pl?matno.

Parker ER. 1967. *Materials Data Book*. McGraw-Hill.

Paxton HC and NL Pruvost. 1986. *Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu, and ^{233}U: 1986 Revision*. LA-10860-MS, Los Alamos National Laboratory, Los Alamos, New Mexico.

Pohanish RP. 2002. *Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens*. 4th ed., William Andrew Publishing/Noyes.

Rearden BT and MA Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.3, Section 7.2, Standard Composition Library. Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 2018). Available from Radiation Safety Information Computational Center as CCC-834.

Saint-Gobain. *Lithium Glass Scintillators Product Data Sheet*. Saint-Gobain Ceramics & Plastics, Northboro, Massachusetts, at https://www.crystals.saint-gobain.com/products/lithium-glass-scintillators. Additional scintillators references from https://www.crystals.saint-gobain.com/.

Schaeffer NM, ed. 1973. *Reactor Shielding for Nuclear Engineers*. TID-25951, prepared by Radiation Research Associates for the U.S. Atomic Energy Commission Office of Information Services, Oak Ridge, Tennessee.

Shleien B, ed. 1992. *Health Physics and Radiological Health Handbook*. Scinta, Inc., Silver Spring, Maryland.

Shultis JK and RE Faw. 1996. *Radiation Shielding*. Prentice Hall, Englewood Cliffs, New Jersey.

Söderlind P. 2001. "Ambient pressure phase diagram of plutonium: A unified theory for α-Pu and δ-Pu." *Europhysics Letters*, 55 (4):525 at http://iopscience.iop.org/0295-5075/55/4/525/fulltext.

Speight JG. 2015. *Handbook of Coal Analysis*. John Wiley & Sons.

Speight JG. 2001. *Handbook of Petroleum Analysis*. John Wiley & Sons.

Spokas JJ and DR White. 1982. "A Conducting Plastic Simulating Cortical Bone." *Physics in Medicine and Biology* 27(1):115.

"Standard Composition Library" for the SCALE code system in *SCALE Ver 6.2.4: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design.* ORNL/TM-2005/39, Version 6.2.4 (April 2020)

Tanaka M, K Hara, S Kim, K Kondo, H Takano, M Kobayashi, H Ishibashi, K Kurashige, K Susa, and M Ishii. 1998. "Applications of Cerium-Doped Gadolinium Silicate Gd_2SiO_5:Ce Scintillator to Calorimeters in High Radiation Environment." *Nuclear Instruments and Methods in Physics Research*, *Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, 404(2):283-294 at http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.30.4620.

Walker R. 2009. "Si Metric Density of Bulk Materials" chart. Accessed September 28, 2010, at http://www.simetric.co.uk/si_materials.htm (last updated April 4, 2009).

Washburn EW, ed. 2003; originally published 1926 – 1930. *International Critical Tables of Numerical Data, Physics, Chemistry and Technology (1st Electronic Edition)*. Knovel Corporation. Online version at http://www.knovel.com/web/portal/basic_search/display?_EXT_KNOVEL_DISPLAY_bookid=735.

Wess JA, LD Olsen, and MH Sweeney. 2004. *Concise International Chemical Assessment Document 59, Asphalt (Bitumen)*. International Programme on Chemical Safety (IPCS), Geneva, Switzerland.

X-5 Monte Carlo Team. 2003. *MCNP — A General Monte Carlo N-Particle Transport Code, Version 5 - Volume II: Users Guide*. LA-CP-03-0245, Los Alamos National Laboratory, Los Alamos, New Mexico.

X-5 Monte Carlo Team. 2005. *MCNP — A General Monte Carlo N-Particle Transport Code, Version 5, Volume I: Overview and Theory*. LA-UR-03-1987 (issued April 24, 2003; revised October 3, 2005), Los Alamos National Laboratory, Los Alamos, New Mexico.

Yaws CL. 2008. *Yaws' Handbook of Physical Properties for Hydrocarbons and Chemicals*. Knovel Corporation. http://knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=2147&VerticalID=0.

Yinon J and S Zitrin. 1993. *Modern Methods and Applications in Analysis of Explosives*. John Wiley & Sons.

Zudas JA and WP Walters, eds. 2002. *Explosive Effects and Applications*. Springer-Verlag, New York.

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