Selected X-ray Crystallographic Data Molar Volumes, and Densities of Minerals and Related Substances

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SELECTED X-RAY CRYSTALLOGRAPHIC DATA, MOLAR VOLUMES, AND DENSITIES OF MINERALS AND RELATED SUBSTANCES

By RICHARD A. ROBIE, PHILIP M. BETHKE, and KEITH M. BEARDSLEY

ABSTRACT

X-ray cell parameters and calculated cell volumes, molar volumes, and densities are presented for approximately 400 minerals and related compounds. The data are presented by mineralogical groups and were selected from the best modern available measurements. For many of the compounds, references are included for recent three-dimensional structural refinements.

INTRODUCTION

X-ray crystallographic data are perhaps the most useful type of information available to the mineralogist. Besides the considerations of structural chemistry, they provide one of the most accurate methods for phase and (or) compositional determination of minerals and are the principal source of accurate molar-volume and density data.

These tables contain data for approximately 400 minerals. The data have been taken from the recent literature or from unpublished sources. With minor exceptions, we have restricted ourselves to the inclusion of data for chemically and physically well-defined phases for which the unit-cell parameters are known with an accuracy of the order of 0.2 percent or better. For nonsilicates the data are presented by mineral groups following Dana's system (Palache and others, 1944, 1951). Within a group, however, the order may be alphabetical (elements and oxides), structural (carbonates and silicates), or, for the sulfides for example, approximately by increasing metal-to-sulfur ratio. For the silicates the data are grouped approximately following Deer, Howie, and Zussman (1962, 1963).

Because most minerals are intermediate members of multicomponent solid solutions, data have been included for several phases not known as minerals but which form the end member of a solid solution. For similar reasons we have also included a few values of hypothetical phases (for example, FeS in the wurtzite and sphalerite structures and CdS in rock salt structure) based on the extrapolation of measured cell dimensions from incomplete solid solutions. These theoretical phases are so indicated in the tables. The majority of the data included are for pure synthetic phases for which unit-cell parameters have been determined with an accuracy of 0.1 percent or better. In some instances, where the mineral deviates from the stoichiometric composition, either by substitution or omission solid solution, one or more values are given for materials of known composition as noted in the formula column.

ARRANGEMENT OF DATA

The tables are divided into two sections. In the first section are listed the crystal symmetry and the cell parameters and their uncertainties; in the second section the formula weight and the unit-cell volume, molar volume, density, and their standard errors.

All cell dimensions are given in angstrom units, 10^{-8} centimeters. Where necessary, older data have been converted from kX units to angstroms by using the conversion factor 1.00202, although this is undoubtedly too low (Bearden, 1965). The formula weights are based on the International Atomic Weights for 1963. Avogadro's number used in calculating the molar volumes was $(6.02252 \pm 0.00028) \times 10^{23}$ $mole^{-1}$, as recommended by the National Academy of Science-National Research Council (U.S. Natl. Bur. Standards Tech. News Bull., v. 47, p. 175–177, 1963).

The uncertainties listed are not necessarily those of the original investigator, but represent our attempt to evaluate the interval within which the true value should lie. The results of a recent cooperative investigation by the International Union of Crystallography (Parrish, 1960), involving more than twenty laboratories, have shown that although the reproducibility (that is, precision) of an individual may be a few thousandths of a percent, different investigators working on the same sample showed agreement with one another of only 0.005 to 0.015 percent. Unit-cell data claiming an accuracy of better than 0.01 percent should be considered with these limitations in mind.

Temperatures at which the measurements were made are given in the second column from the right. The letter "r" indicates the data were obtained at an unspecified room temperature and may be taken as $25° \pm 5°C$. The number of gram formula weights per unit cell is given in the column labeled "Z."

Compounds denoted by an asterisk indicate the measurements were made on natural specimens which may have deviated slightly from the listed formula. Densities given for these minerals were calculated using the formula weight for the stoiciometric phase. Substances of rhombohedral symmetry are denoted by the symbol "hex-R" to distinguish them from materials of true hexagonal symmetry. The cell volume and number of formula weights, Z, listed for these compounds are, however, given for the larger hexagonal cell. The space group is given along with its number in "Symmetry Groups," v. 1 of "International Tables for X-ray Crystallography," (N.F.M. Henry and Kathleen Lonsdale, eds., 1952, Kynoch Press, Birmingham). The source of the cell-edge data is listed in the extreme righthand column. Whenever possible, we have also tried to give reference to a modern least squares refinement of the crystal structure.

Molar volumes were calculated from the unit-cell dimensions from the relation:

$$V=\frac{(\text{unit-cell volume in cm}^3)(\text{Avogadro's number})}{(\text{number of formula weights per unit cell})}=\frac{vN}{Z} \quad (1)$$

The density, ρ, was calculated from:

$$\rho=\frac{M}{V} \quad (2)$$

where M is the formula weight in grams.

The molar volumes of the gases of importance in mineralogical equilibria have not been tabulated because the reference state of a gas for thermodynamic calculations is the ideal gas at 1 atmosphere pressure. Accordingly all ideal gases have the same molar volume at 25°C (298.15°K) equal to RT or 24465.0 ± 3.4 cm^3 mole^{-1}. For mineral equilibrium calculations at higher pressures, one needs to know the VdP term in the expression for the free energy. Accordingly, the molar volumes have been given in both the conventional units of cm^3 mole^{-1} and also in terms of calories bar^{-1} to facilitate thermodynamic calculations.

For several substances (for example, silicon, diamond, KCl, $CaCO_3$, α-quartz), densities have been measured with an accuracy comparable to the X-ray cell measurements. References have been given for some of these data.

The uncertainties listed for the densities include only the contribution due to the accuracy of the cell-edge data and do not include the uncertainty in the formula weight or Avogadro's number. The uncertainties given for the unit-cell volumes were calculated by using the standard methods for the propagation of error assuming that the estimated uncertainties in the cell edge represented standard errors. For example in the monoclinic case the expression for the standard error becomes:

$$\sigma=abc\ \sin\beta\left[\left(\frac{\Delta a}{a}\right)^2+\left(\frac{\Delta b}{b}\right)^2+\left(\frac{\Delta c}{c}\right)^2+(\cot\beta\Delta\beta)^2\right]^{1/2}$$

In order that the tables may be rapidly revised, the input data, cell parameters, their uncertainties, and the formula weights are listed on punched cards. The cell volume, molar volume, density, and their uncertainties were calculated using a Burroughs 220 computer, and the completed tables then processed by a Burroughs 280 computer and printed by a photo-composing machine.

More extensive summaries of X-ray data are given by Berry and Thompson (1962), Donnay and others (1963), and Pearson (1958).

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
		Elements		
Silver Ag	cubic	Fm3m(225)	face-centered cubic	4
Arsenic As	hex-R	$R\bar{3}m$(166)	arsenic	6
Gold Au	cubic	Fm3m(225)	face-centered cubic	4
Bismuth Bi	hex-R	$R\bar{3}m$(166)	arsenic	6
Diamond C*	cubic	Fd3m(227)	diamond	8
Graphite C*	hex.	C6/mmc(194)	graphite	4
Copper Cu	cubic	Fm3m(225)	face-centered cubic	4
α-Iron Fe	cubic	Im3m(229)	body-centered cubic	2
Nickel Ni	cubic	Fm3m(225)	face-centered cubic	4
Lead Pb	cubic	Fm3m(225)	face-centered cubic	4
Platinum Pt	cubic	Fm3m(225)	face-centered cubic	4
orthorhombic Sulfur S	orth.	Fddd(70)	S_8 ring molecules	128
monoclinic Sulfur S	mon.	$P2_1/c$(14)	S_8 ring molecules	48
rhombohedral Sulfur S	hex-R	$R\bar{3}$(148)	S_6 ring molecules	18
Antimony Sb	hex-R	$R\bar{3}m$(166)	arsenic	6
Selenium Se	hex.	$P3_121$(152) $P3_221$(154)		3
Silicon Si	cubic	Fd3m(227)	diamond	8
β-Tin (white) Sn	tet.	$I4_1/amd$(141)		4
Tellurium Te	hex.	$P3_121$(152) $P3_221$(154)		3
Zinc Zn	hex.	$P6_3/mmc$(194)	hexagonal close packed	2
		Sulfides, arsenides, tellurides, selenides, and sulfosalts		
Shandite β-$Ni_3Pb_2S_2$*	hex-R	$R\bar{3}m$(166)		3
High-Argentite Ag_2S I	cubic			4
Argentite Ag_2S II	cubic			2

Elements

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
4.0862 ± .0002						25	254, 198
3.760 ± .001		10.555 ± .003				26	231, 256
4.0786 ± .0002						25	254, 10
4.5459 ± .0010		11.8622 ± .0030				26	129, 221 256
3.5670 ± .0001						25	189, 227 172
2.4612 ± .0001		6.7079 ± .0010				15	173
3.6150 ± .0005						25	254
2.8664 .0005						25	257
3.5238 ± .0005						25	254
4.9505 ± .0005						25	254
3.9231 ± .0005						25	254
10.4646 ± .0020	12.8660 ± .0020	24.4860 ± .0040				25	54, 41
11.04 ± .03	10.98 ± .03	10.92 ± .03		96.73 ± .50		103	67
10.818 ± .002		4.280 ± .001				r	69
4.310 ± .001		11.279 ± .003				26	231, 221 256
4.3642 ± .0008		4.9588 ± .0008				26	250
5.4305 ± .0003						25	189, 10 121
5.8315 ±.0008		3.1813 ± .0006				26	129
4.4570 ± .0008		5.9290 ± .0010				25	254
2.665 ± .001		4.947 ± .001				25	254

Sulfides, arsenides, tellurides, selenides, and sulfosalts

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
5.576 ± .010		13.658 ± .010				r	124, 194
6.269 ± .020						600	64
4.870 ± .008						189	64

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X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued				
Acanthite Ag_2S III	mon.	$P2_1/c(14)$		4
High-Naumanite Ag_2Se	cubic			2
Ag_2Te I	cubic			2
Ag_2Te II	cubic			4
Hessite Ag_2Te III	mon.	$P2_1/c(14)$		4
$Ag_{1.55}Cu_{.45}S$ I	cubic			4
$Ag_{1.55}Cu_{.45}S$ II	cubic			2
Jalpaite $Ag_{1.55}Cu_{.45}S$ III	tet.			16
$Ag_{.93}Cu_{1.07}S$ I	cubic			4
$Ag_{.93}Cu_{1.07}S$ II	hex.			2
Stromeyerite $Ag_{.93}Cu_{1.07}S$ III	orth.	Cmcm(63)		4
Eucairite AgCuSe	orth.	pseudo P4/nmm(129)		10
Petzite Ag_3AuTe_2*	cubic	$I4_132(214)$		8
Maldonite Au_2Bi	cubic	Fd3m(227)	Cu_2Mg	8
High-Digenite Cu_2S I	cubic			4
High-Chalcocite Cu_2S II	hex.			2
Chalcocite Cu_2S III	orth.	Ab2m(39)		96
Digenite $Cu_{1.79}S$ (Cu rich side)	cubic		deformed fluorite	4
Digenite $Cu_{1.77}S$ (S rich side)	cubic		deformed fluorite	4
Berzelianite Cu_2Se	cubic			4
High-Bornite Cu_5FeS_4*	cubic			1
Metastable Bornite Cu_5FeS_4	cubic			8
Low-Bornite Cu_5FeS_4*	tet.	$P\bar{4}2_1c(144)$		16
Umangite Cu_3Se_2	tet.	P4/mmm(123)		2

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued							
4.228 ± .002	6.928 ± .005	7.862 ± .003		99.58 ± .30		25	263, 64
4.993 ± .016						170	207
5.29 ± .01						825	207
6.585 ± .010						250	207
8.09 ± .02	4.48 ± .01	8.96 ± .02		123.33 ± .30		r	94
6.110 ± .010						300	64
4.825 ± .005						116	64
8.673 ± .004		11.756 ± .006				r	64
5.961 ± .009						196	64
4.138 ± .004		7.105 ± .007				100	64
4.066 ± .002	6.628 ± .003	7.972 ± .004				r	64
4.105 ± .010	20.35 ± .02	6.31 ± .01				r	92
10.38 ± .02						r	93
7.958 ± .002						r	135
5.725 ± .010						465	63, 212
3.961 ± .004		6.722 ± .007				152	63, 212
11.881 ± .004	27.323 ± .010	13.491 ± .004				r	63, 212
5.5695 ± .0010						25	63, 212
5.5542 ± .0010						25	63, 212
5.85 ± .01						170	212
5.50 ± .01						240	166
10.94 ± .02						r	166
10.94 ± .02		21.88 ± .04				r	166
6.402 ± .010		4.276 ± .010				r	17, 72

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued				
Heazelwoodite Ni_3S_2	hex-R	R32(155)		3
Maucherite $Ni_{11}As_8$	tet.	$P4_12_12(92)$		4
Pentlandite $Fe_{5.25}Ni_{3.75}S_8$	cubic	Fm3m(225)		4
Pentlandite $Fe_{3.75}Ni_{5.25}S_8$	cubic	Fm3m(225)		4
Sternbergite $AgFe_2S_3$*	orth.	Ccmm(63)		8
Argentopyrite $AgFe_2S_3$*	orth.	Pmmm(47)		4
Realgar AsS*	mon.	$P2_1/m(11)$		16
Oldhamite CaS	cubic	Fm3m(225)	rock salt	4
Greenockite CdS	hex.	$P6_3mc(186)$	zincite	2
Hawleyite CdS	cubic	$F\bar{4}3m(216)$	sphalerite	4
(hypothetical) CdS	cubic	Fm3m(225)	rock salt	4
Cadmoselite CdSe	hex.	$P6_3mc(186)$	zincite	2
CdTe	cubic	$F\bar{4}3m(216)$	sphalerite	4
(hypothetical) CoS	cubic	$F\bar{4}3m(216)$	sphalerite	4
Chalcopyrite ($CuFeS_2$) $CuFeS_{1.90}$	tet.	I42d(122)		4
Cubanite $CuFe_2S_3$*	orth.	Pcmn(62)		4
Covellite CuS	hex.	$P6_3/mmc(194)$		6
Klockmannite CuSe	hex.		deformed covellite	78
Troilite FeS	hex.	$P6_3/mmc(194)$	niccolite	2
Pyrrhotite $Fe_{.980}S$	hex.	$P6_3/mmc(194)$	defect niccolite	2
Pyrrhotite $Fe_{.885}S$	hex.	$P6_3/mmc(194)$	defect niccolite	2
(hypothetical) FeS	cubic	$F\bar{4}3m(216)$	sphalerite	4
(hypothetical) FeS	hex.	$P6_3mc(186)$	zincite	2
Cinnabar HgS	hex.	$P3_121(152)$ $P3_221(154)$	cinnabar	3

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.

Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
5.746 ± .001		7.134 ± .002				r	144, 153
6.870 ± .001		21.81 ± .01				r	296
10.196 ± .010						r	154
10.095 ± .010						r	154
11.60 ± .02	12.675 ± .020	6.63 ± .01				r	193
6.64 ± .01	11.47 ± .02	6.45 ± .02				r	171
9.29 ± .05	13.53 ± .05	6.57 ± .03		106.55 ± .30		r	26, 128
5.689 ± .006						r	260, 115 206
4.1354 ± .0010		6.7120 ± .0010				r	235
5.833 ± .002						r	228, 18 276
5.516 ± .002						r	19
4.2977 ± .0010		7.0021 ± .0010				r	18, 260
6.4805 ± .0006						25	18, 266
5.339 ± .001						r	117
5.2988 ± .0010		10.434 ± .005				r	18
6.46 ± .01	11.12 ± .01	6.23 ± .01				r	30
3.792 ± .001		16.34 ± .01				r	257
14.206 ± .010		17.25 ± .05				r	71, 268
3.446 ± .003		5.877 ± .001				28	274
3.446 ± .001		5.848 ± .002				28	274
3.440 ± .001		5.709 ± .003				28	274
5.455 ± .001						r	228, 234
3.872 ± .001		6.345 ± .002				r	235
4.149 ± .001		9.495 ± .002				r	18, 257

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued				
Metacinnabar HgS	cubic	F$\bar{4}$3m(216)	sphalerite	4
Tiemannite $HgSe$	cubic	F$\bar{4}$3m(216)	sphalerite	4
Coloradoite $HgTe$	cubic	F$\bar{4}$3m(216)	sphalerite	4
Alabandite MnS	cubic	Fm3m(225)	rock salt	4
(hypothetical) MnS	cubic	F$\bar{4}$3m(216)	sphalerite	4
(hypothetical) MnS	hex.	$P6_3mc$(186)	zincite	2
Niccolite $NiAs$	hex.	$P6_3/mmc$(194)	niccolite	2
Millerite NiS	hex-R	R3m(160)		9
Breithauptite $NiSb$	hex.	$P6_3/mmc$(194)	niccolite	2
Galena PbS	cubic	Fm3m(225)	rock salt	4
Clausthalite $PbSe$	cubic	Fm3m(225)	rock salt	4
Teallite $PbSnS_2$	orth.	Pbnm(62)	GeS	2
Altaite $PbTe$	cubic	Fm3m(225)	rock salt	4
Cooperite PtS	tet.	$P4_2/mmc$(131)		2
Herzenbergite SnS	orth.	Pbnm(62)	GeS	4
Sphalerite ZnS	cubic	F$\bar{4}$3m(216)	sphalerite	4
Wurtzite ZnS	hex.	$P6_3mc$(186)	zincite	2
Stilleite $ZnSe$	cubic	F$\bar{4}$3m(216)	sphalerite	4
$ZnTe$	cubic	F$\bar{4}$3m(216)	sphalerite	4
Orpiment As_2S_3*	mon.	$P2_1/n$(14)		4
Bismuthinite Bi_2S_3	orth.	Pbnm(62)	stibnite	4
Tellurobismuthite Bi_2Te_3	hex-R	R$\bar{3}$m(166)	Bi_2Te_2S	3
Stibnite Sb_2S_3	orth.	Pbnm(62)	stibnite	4
Linnaeite Co_3S_4	cubic	Fd3m(227)	spinel	8

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued							
5.8517 ± .0010						r	18, 257
6.0853 ± .0050						r	18, 260
6.4600 ± .0006						r	18
5.2234 ± .0005						r	229, 18
5.611 ± .002						r	228
3.986 ± .001		6.465 ± .002				r	235
3.618 ± .001		5.034 ± .001				r	296
9.616 ± .001		3.152 ± .001				r	18, 264 144, 153
3.942 ± .001		5.155 ± .001				r	123
5.9360 ± .0005						26	19, 255 282
6.1255 ± .0005						r	19
4.266 ± .003	11.419 ± .007	4.090 ± .002				r	167
6.4606 ± .0005						r	18
3.4699 ± .0006		6.1098 ± .0010				r	18, 109
4.328 ± .002	11.190 ± .004	3.978 ± .001				r	167
5.4093 ± .0005						r	19, 228 233, 234
3.8230 ± .0010		6.2565 ± .0010				r	233, 235 230
5.6685 ± .0005						r	19, 106
6.1020 ± .0006						r	18, 266
11.49 ± .02	9.59 ± .02	4.25 ± .01		90.45 ± .30		r	29
11.150 ± .004	11.300 ± .004	3.981 ± .001				26	257
4.3835 ± .0020		30.487 ± .003				25	88, 283 266
11.229 ± .004	11.310 ± .004	3.8389 ± .0010				25	258
9.401 ± .001						r	156

Name and formula	Crystal system	Space group	Structure type	Z
		Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued		
Greigite Fe_3S_4	cubic	Fd3m(227)	spinel	8
Daubreeite $FeCr_2S_4$	cubic	Fd3m(227)	spinel	8
Violarite $FeNi_2S_4$	cubic	Fd3m(227)	spinel	8
Polymidite Ni_3S_4	cubic	Fd3m(227)	spinel	8
Co-Safflorite $CoAs_2$	mon.		deformed marcasite	2
Safflorite $(Co_{.5}Fe_{.5})As_2$	orth.	Pnnm(58)	marcasite	2
Cobaltite CoAsS*	cubic	$P2_13(198)$	NiSbS	4
Glaucodot (Co,Fe)AsS*	orth.	Cmmm(65)		24
Cattierite CoS_2	cubic	Pa3(205)	pyrite	4
Trogtalite $CoSe_2$	cubic	Pa3(205)	pyrite	4
Loellingite $FeAs_2$	orth.	Pnnm(58)	marcasite	2
Arsenopyrite FeAsS*	tri.	$P\bar{1}(2)$		4
Gudmundite FeSbS*	mon.	$B2_1/d(14)$		8
Pyrite FeS_2	cubic	Pa3(205)	pyrite	4
Marcasite FeS_2*	orth.	Pnnm(58)	marcasite	2
Ferroselite $FeSe_2$	orth.	Pnnm(58)	marcasite	2
Frohbergite $FeTe_2$	orth.	Pnnm(58)	marcasite	2
Hauerite MnS_2	cubic	Pa3(205)	pyrite	4
Molybdenite MoS_2	hex.	$P6_3/mmc(194)$	molybdenite	2
Rammelsbergite $NiAs_2$	orth.	Pnnm(58)	marcasite	2
Pararammelsbergite $NiAs_2$	orth.	Pbca(61)		8
Gersdorfite NiAsS	cubic	$P2_13(198)$		4
Vaesite NiS_2	cubic	Pa3(205)	pyrite	4
$NiSe_2$	cubic	Pa3(205)	pyrite	4

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued							
9.876 ± .002						r	237
9.966 ± .005						r	152
9.464 ± .005						r	155
9.480 ± .001						r	144
5.049 ± .002	5.872 ± .002	3.127 ± .001		90.45 ± .20		26	211, 263
5.231 ± .002	5.953 ± .002	2.962 ± .002				26	211, 263
5.60 ± .05						r	17
6.64 ± .05	28.39 ± .10	5.64 ± .05				r	17
5.5345 ± .0005						r	251, 156
5.8588 ± .0010						r	21
5.300 ± .002	5.981 ± .002	2.882 ± .001				26	211, 263
5.760 ± .010	5.690 ± .005	5.785 ± .005	90.00 ± .20	112.23 ± .20	90.00 ± .20	r	165
10.00 ± .05	5.93 ± .03	6.73 ± .03		90.00 ± .50		r	28
5.4175 ± .0005						r	229, 149 251, 105
4.443 ± .002	5.423 ± .002	3.3876 ± .0015				25	229, 27
4.801 ± .005	5.778 ± .005	3.587 ± .004				r	113, 17
5.265 ± .005	6.265 ± .005	3.869 ± .002				r	110
6.1014 ± .0006						28	229
3.1604 ± .0010		12.295 ± .002				26	258
4.757 ± .002	5.797 ± .004	3.542 ± .002				26	211, 263 296
5.75 ± .01	5.82 ± .01	11.428 ± .02				r	191, 143
5.693 ± .001						26	264
5.6873 ± .0005						r	18, 144 153
5.9604 ± .0010						20	111

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X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued				
Melonite $NiTe_2$	hex.	P$\bar{3}$m1(164)	cadmium iodide	1
Sperrylite $PtAs_2$	cubic	Pa3(205)	pyrite	4
Laurite RuS_2	cubic	Pa3(205)	pyrite	4
Tungstenite WS_2	hex.	$P6_3$/mmc(194)	molybdenite	2
Co-Skutterudite $CoAs_{3-x}$ $CoAs_{2.95}$	cubic	Im3(204)		8
Fe-Skutterudite $FeAs_{3-x}$ $FeAs_{2.95}$	cubic	Im3(204)		8
Ni-Skutterudite $NiAs_{3-x}$ $NiAs_{2.95}$	cubic	Im3(204)		8
Tennantite $Cu_{12}As_4S_{13}$	cubic	I$\bar{4}$3m(217)	tetrahedrite	2
Tetrahedrite $Cu_{12}Sb_4S_{13}$	cubic	I$\bar{4}$3m(217)	tetrahedrite	2
Enargite Cu_3AsS_4	orth.	Pnn2(34)		2
Luzonite Cu_3AsS_4*	tet.	I$\bar{4}$2m(121)		2
Famatimite Cu_3SbS_4*	tet.	I$\bar{4}$m(121)		2
Proustite Ag_3AsS_3	hex-R	R3c(161)		6
Pyrargyrite Ag_3SbS_3	hex-R	R3c(161)		6
Miargyrite $AgSbS_2$*	mon.	Cc(9)		8
Oxides and hydroxides				
Corundum Al_2O_3	hex-R	R$\bar{3}$c(167)	corundum	6
Boehmite AlO(OH)*	orth.	Cmcm(63)	lepidocrocite	4
Diaspore AlO(OH)*	orth.	Pbnm(62)		4
Gibbsite $Al(OH)_3$	mon.	$P2_1$/n(14)		8
Arsenolite As_2O_3	cubic	Fd3m(227)	diamond	16
Claudetite As_2O_3	mon.	$P2_1$/n(14)		4
Bromellite BeO	hex.	$P6_3$mc(186)	zincite	2
Bismite α-Bi_2O_3	mon.	$P2_1$/c(14)	pseudo orthorhombic	8

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued							
3.869 ± .010		5.308 ± .010				84	269
5.968 ± .005						r	105, 270
5.60 ± .02						r	9, 17 62, 183
3.154 ± .001		12.362 ± .004				26	261
8.2060 ± .0010						r	210
8.1814 ± .0010						r	210
8.3300 ± .0010						r	210
10.190 ± .004						r	229
10.327 ± .004						r	229, 292
6.426 ± .005	7.422 ± .005	6.144 ± .005				26	229
5.289 ± .005		10.440 ± .008				26	229, 96
5.384 ± .005		10.770 ± .008				26	229, 96
10.816 ± .001		8.6948 ± .0013				26	273
11.052 ± .002		8.7177 ± .0020				26	273
12.862 ± .013	4.111 ± .004	13.220 ± .010		98.63 ± .15		r	139
Oxides and hydroxides							
4.7591 ± .0004		12.9894 ± .0030				25	130, 53 176
2.868 ± .003	12.227 ± .003	3.700 ± .003				26	256
4.401 ± .005	9.421 ± .005	2.845 ± .002				r	40, 256
9.719 ± .002	5.0705 ± .0010	8.6412 ± .0010		94.57 ± .25		r	67
11.074 ± .005						25	254, 11
5.339 ± .002	12.984 ± .005	4.5405 ± .0010		94.27 ± .10		25	266
2.6979 ± .0005		4.3772 ± .0005				26	16, 254
8.166 ± .005	13.827 ± .010	5.850 ± .004		90.00 ± .20		25	266

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
		Oxides and hydroxides—Continued		
Lime CaO	cubic	Fm3m(225)	rock salt	4
Portlandite $Ca(OH)_2$	hex.	P$\bar{3}$m1(164)	CdI_2	1
Monteponite CdO	cubic	Fm3m(225)	rock salt	4
Cerianite CeO_2	cubic	Fm3m(225)	fluorite	4
 CoO	cubic	Fm3m(225)	rock salt	4
Eskolaite Cr_2O_3	hex-R	R$\bar{3}$c(167)	corundum	6
Tenorite CuO	mon.	C2/c(15)		4
Cuprite Cu_2O	cubic	Pn3m(224)		2
Wustite $Fe_{.953}O$	cubic	Fm3m(225)	defect rock salt	4
Hematite Fe_2O_3	hex-R	R$\bar{3}$c(167)	corundum	6
Magnetite Fe_3O_4	cubic	Fd3m(227)	spinel	8
Goethite α-FeO(OH)*	orth.	Pbnm(62)		4
Lepidocrocite γ-FeO(OH)*	orth.	Amam(63)		4
 α-Ga_2O_3	hex-R	R$\bar{3}$c(167)	corundum	6
Low-germania GeO_2	tet.	P4/mnm(136)	rutile	2
High-germania GeO_2	hex.	$P3_121(152)$ $P3_221(154)$	α-quartz	3
Ice H_2O	hex.	$P6_3/mmc(194)$		4
Hafnia HfO_2	mon.	$P2_1/c(14)$	baddeleyite	4
Montroydite HgO	orth.	Pnma(62)		4
Periclase MgO	cubic	Fm3m(225)	rock salt	4
Brucite $Mg(OH)_2$	hex.	P$\bar{3}$m1(164)	CdI_2	1
Manganosite MnO	cubic	Fm3m(225)	rock salt	4
Pyrolusite MnO_2	tet.	P4/mnm(136)	rutile	2
Bixbyite Mn_2O_3	cubic	Ia3(206)	Tl_2O_3	16

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
			Oxides and hydroxides—Continued				
4.8108 ± .0005						26	25, 254
3.5933 ± .0005		4.9086 ± .0020				26	25, 254
4.6953 ± .0010						27	255
5.4110 ± .0020						26	254
4.260 ± .002						26	262
4.9607 ± .0020		13.599 ± .010				r	176, 258
4.684 ± .005	3.425 ± .005	5.129 ± .005		99.47 ± .17		26	254
4.2696 ± .0010						26	255
4.3088 ± .0003						17	285
5.0329 ± .0010		13.7492 ± .0010				25	112, 284
8.3940 ± .0005						22	1, 272
4.596 ± .005	9.957 ± .010	3.021 ± .003				r	192
3.868 ± .010	12.525 ± .010	3.066 ± .003				r	192
4.9793 ± .0010		13.429 ± .003				24	257
4.3963 ± .0010		2.8626 ± .0010				25	261, 12
4.987 ± .002		5.652 ± .002				26	254, 243
4.5212 ± .0010		7.3666 ± .0010				0	147
5.1156 ± .0010	5.1722 ± .0010	5.2948 ± .0010		99.18 ± .08		r	3
6.608 ± .003	5.518 ± .003	3.519 ± .003				25	262
4.2117 ± .0005						25	227, 254
3.147 ± .004		4.769 ± .004				26	259
4.4448 ± .0005						26	258, 101
4.388 ± .003		2.865 ± .002				r	286, 67
9.411 ± .005						25	262

Name and formula	Crystal system	Space group	Structure type	Z
Oxides and hydroxides—Continued				
Hausmanite Mn_3O_4	tet.	$I4_1/amd(141)$		8
Molybdite MoO_3	orth.	Pbnm(62)		4
Bunsenite NiO	cubic	Fm3m(225)	rock salt	4
Litharge PbO red	tet.	P4/nmm(129)		2
Massicot PbO yellow	orth.	Pb2a(32)		4
Minium Pb_3O_4	tet.	$P4_2/mbc(135)$		4
Senarmontite Sb_2O_3	cubic	Fm3m(225)	arsenic trioxide	16
Valentinite Sb_2O_3	orth.	Pccn(56)	antimony trioxide	4
Cervantite Sb_2O_4	cubic	Fd3m(227)		8
Selenolite SeO_2	tet.	$P4_2/mbc(135)$ $P4_2bc(106)$		8
α-Quartz SiO_2*	hex.	$P3_121(152)$ $P3_221(154)$		3
β-Quartz SiO_2*	hex.	$P6_422(181)$ $P6_222(180)$		3
α-Cristobalite SiO_2	tet.	$P4_12_12(92)$ $P4_32_12(96)$		4
β-Cristobalite SiO_2	cubic	Fd3m(227)		8
Keatite SiO_2	tet.	$P4_12_12(92)$ $P4_32_12(96)$		12
β-Tridymite SiO_2	hex.	$P\bar{6}2c(172)$ $P6_3/mmc(194)$		4
Coesite SiO_2*	mon.	B2/b(15)		16
Stishovite SiO_2*	tet.	P4/mnm(136)	rutile	2
Melanophlogite SiO_2*	cubic	Pm3n(223)	clathrate type	46
Cassiterite SnO_2	tet.	P4/mnm(136)	rutile	2
Tellurite TeO_2*	orth.	Pbca(61)	tellurite	8
Paratellurite TeO_2	tet.	$P4_12_12(92)$ $P4_32_12(96)$		4
Thorianite ThO_2	cubic	Fm3m(225)	fluorite	4
Rutile TiO_2	tet.	P4/mnm(136)		2

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
		Oxides and hydroxides—Continued					
8.136 ± .005		9.422 ± .005				20	277
3.962 ± .002	13.858 ± .005	3.697 ± .004				26	256
4.177 ± .002						26	254
3.9759 ± .0040		5.023 ± .004				27	255
5.489 ± .003	4.755 ± .004	5.891 ± .004				27	255
8.815 ± .005		6.565 ± .003				25	261
11.152 ± .003						26	256
4.914 ± .002	12.468 ± .005	5.421 ± .004				25	263
10.305 ± .005						26	263
8.35 ± .01		5.08 ± .01				26	254
4.9136 ± .0001		5.4051 ± .0001				25	90, 53 242
4.999 ± .001		5.4592 ± .0020				575	90, 131
4.971 ± .003		6.918 ± .003				25	263, 65
7.1382 ± .0010						405	245
7.456 ± .003		8.604 ± .005				r	225, 89
5.0463 ± .0020		8.2563 ± .0030				405	245
7.152 ± .001	12.379 ± .002	7.152 ± .001		120.00 ± .17		25	230, 300
4.1790 ± .0010		2.6649 ± .0010				r	44
13.402 ± .004						r	232, 136
4.738 ± .003		3.188 ± .003				26	254
5.607 ± .003	12.034 ± .005	5.463 ± .003				25	262, 20
4.810 ± .002		7.613 ± .002				25	263
5.5952 ± .0005						25	227, 254
4.5937 ± .0005		2.9618 ± .0010				25	252, 55 254

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Oxides and hydroxides—Continued				
Anatase TiO_2	tet.	$I4_1/amd(141)$		4
Brookite TiO_2*	orth.	Pcab(61)		8
Titanium sesquioxide Ti_2O_3	hex-R	$R\bar{3}c(167)$	corundum	6
Uraninite UO_2	cubic	Fm3m(225)	fluorite	4
Karelianite V_2O_3	hex-R	$R\bar{3}c(167)$	corundum	6
Zincite ZnO	hex.	$P6_3mc(186)$	zincite	2
Baddeleyite ZrO_2	mon.	$P2_1/c(14)$	baddeleyite	4
Multiple oxides				
Spinel $MgAl_2O_4$	cubic	Fd3m(227)	spinel	8
Hercynite $FeAl_2O_4$	cubic	Fd3m(227)	spinel	8
Galaxite $MnAl_2O_4$	cubic	Fd3m(227)	spinel	8
Gahnite $ZnAl_2O_4$	cubic	Fd3m(227)	spinel	8
Magnetite $FeFe_2O_4$	cubic	Fd3m(227)	spinel	8
Jacobsite $MnFe_2O_4$	cubic	Fd3m(227)	spinel	8
Trevorite $NiFe_2O_4$	cubic	Fd3m(227)	spinel	8
Picrochromite $MgCr_2O_4$	cubic	Fd3m(227)	spinel	8
Ilmenite $FeTiO_3$	hex-R	$R\bar{3}(148)$	ilmenite	6
Geikielite $MgTiO_3$	hex-R	$R\bar{3}(148)$	ilmenite	6
Pyrophanite $MnTiO_3$	hex-R	$R\bar{3}(148)$	ilmenite	6
Cobalt Titanate $CoTiO_3$	hex-R	$R\bar{3}(148)$	ilmenite	6
Perovskite $CaTiO_3$	orth.	Pcmn(62)	perovskite	4
Chrysoberyl $BeAl_2O_4$	orth.	Pmnb(62)	olivine	4
Halides				
Halite NaCl	cubic	Fm3m(225)	rock salt	4

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Oxides and hydroxides—Continued							
3.785 ± .002		9.514 ± .006				r	55, 254
5.456 ± .002	9.182 ± .005	5.143 ± .003				r	266
5.149 ± .002		13.642 ± .010				r	176
5.4682 ± .0010						26	255
4.952 ± .002		14.002 ± .010				r	176
3.2495 ± .0005		5.2069 ± .0005				25	120
5.1454 ± .0010	5.2075 ± .0010	5.3107 ± .0010		99.23 ± .08		r	3, 241
Multiple oxides							
8.080 ± .002						26	255
8.150 ± .004						25	275
8.258 ± .002						25	262
8.0848 ± .0020						26	255
8.3940 ± .0005						22	272
8.499 ± .002						25	262
8.339 ± .003						25	263
8.333 ± .003						26	262
5.093 ± .005		14.055 ± .020				r	186
5.054 ± .005		13.898 ± .010				26	258
5.155 ± .005		14.18 ± .01				r	214
5.066 ± .001		13.918 ± .005				r	177
5.3670 ± .0010	7.6438 ± .0010	5.4439 ± .0010				r	137
5.4756 ± .0020	9.4041 ± .0030	4.4267 ± .0020				25	262,80
Halides							
5.6402 ± .0002						26	255

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X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
	Halides—Continued			
Sylvite KCl	cubic	Fm3m(225)	rock salt	4
Villiaumite NaF	cubic	Fm3m(225)	rock salt	4
Chlorargyrite $AgCl$	cubic	Fm3m(225)	rock salt	4
Bromargyrite $AgBr$	cubic	Fm3m(225)	rock salt	4
Nantockite $CuCl$	cubic	$F\bar{4}3m$(216)	sphalerite	4
Marshite CuI	cubic	$F\bar{4}3m$(216)	sphalerite	4
Miersite AgI	cubic	$F\bar{4}3m$(216)	sphalerite	4
Iodargyrite AgI	hex.	$P6_3mc$(186)	zincite	2
Calomel $HgCl$	tet.	I4/mm(139)		4
Fluorite CaF_2	cubic	Fm3m(225)	fluorite	4
Sellaite MgF_2	tet.	$P4_2/mnm$(136)	rutile	2
Chloromagnesite $MgCl_2$	hex-R	$R\bar{3}m$(166)		3
Lawrencite $FeCl_2$	hex-R	$R\bar{3}m$(166)		3
Scacchite $MnCl_2$	hex-R	$R\bar{3}m$(166)		3
Cotunnite $PbCl_2$	orth.	Pnmb(62)		4
Matlockite $PbFCl$	tet.	P4/nmm(129)		2
Cryolite Na_3AlF_6*	mon.	$P2_1/n$(14)		2
Neighborite $NaMgF_3$	orth.	Pcmn(62)	perovskite	4
	Carbonates and nitrates			
Calcite $CaCO_3$	hex-R	$R\bar{3}c$(167)	calcite	6
Otavite $CdCO_3$	hex-R	$R\bar{3}c$(167)	calcite	6
Cobalticalcite $CoCO_3$	hex-R	$R\bar{3}c$(167)	calcite	6
Siderite $FeCO_3$	hex-R	$R\bar{3}c$(167)	calcite	6
Magnesite $MgCO_3$	hex-R	$R\bar{3}c$(167)	calcite	6

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Halides—Continued							
6.2931 ± .0002						25	254, 126
4.6342 ± .0005						25	254
5.5491 ± .0005						26	257
5.7745 ± .0005						26	257
5.416 ± .003						25	257
6.0507 ± .0010						26	257
6.4963 ± .0010						r	279
4.5955 ± .0010		7.5005 ± .0033				25	279,261
4.478 ± .005		10.910 ± .005				26	254
5.4638 ± .0004						25	10,254 5
4.621 ± .001		3.050 ± .001				18	70,257
3.632 ± .004		17.795 ± .016				r	83
3.593 ± .003		17.58 ± .09				r	83
3.711 ± .002		17.59 ± .07				r	83
4.535 ± .005	7.62 ± .01	9.05 ± .01				26	255
4.106 ± .005		7.23 ± .01				26	254
5.40 ± .01	5.60 ± .01	7.776 ± .010		90.18 ± .25		r	186
5.363 ± .001	7.676 ± .001	5.503 ± .001				18	43
Carbonates and nitrates							
4.9899 ± .0010		17.064 ± .002				26	107, 15 46
4.9204 ± .0010		16.298 ± .003				26	107
4.6581 ± .0010		14.958 ± .003				26	107
4.6887 ± .0010		15.373 ± .003				26	107
4.6330 ± .0010		15.016 ± .003				26	107, 260

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
		Carbonates and nitrates—Continued		
Rhodochrosite $MnCO_3$	hex-R	$R\bar{3}c(167)$	calcite	6
Nickelous Carbonate $NiCO_3$	hex-R	$R\bar{3}c(167)$	calcite	6
Smithsonite $ZnCO_3$	hex-R	$R\bar{3}c(167)$	calcite	6
Dolomite $CaMg(CO_3)_2$*	hex-R	$R\bar{3}(148)$	calcite	3
Huntite $Mg_3Ca(CO_3)_4$*	hex-R	R32(155)	calcite	3
Norsethite $BaMg(CO_3)_2$*	hex-R	R32(155)	calcite	3
Vaterite $CaCO_3$	hex.			6
Witherite $BaCO_3$	orth.	Pnam(62)	aragonite	4
Aragonite $CaCO_3$	orth.	Pnam(62)	aragonite	4
Cerussite $PbCO_3$	orth.	Pnam(62)	aragonite	4
Strontianite $SrCO_3$	orth.	Pnam(62)	aragonite	4
Shortite $Na_2Ca_2(CO_3)_3$	orth.	Amm2(38)		2
Malachite $Cu_2(OH)_2CO_3$	mon.	$P2_1/a(14)$		4
Azurite $Cu_3(OH)_2(CO_3)_2$	mon.	$P2_1/a(14)$		2
Niter KNO_3	orth.	Pnam(62)	aragonite	4
Soda Niter $NaNO_3$	hex-R	$R\bar{3}c(167)$	calcite	6
Gerhardite $Cu_2(NO_3)(OH)_3$	orth.	$P2_12_12_1(19)$		4
		Sulfates and borates		
Barite $BaSO_4$	orth.	Pnma(62)	barite	4
Anhydrite $CaSO_4$	orth.	Amma(63) Ccmm(63)	anhydrite	4
Anglesite $PbSO_4$	orth.	Pnma(62)	barite	4
Celestite $SrSO_4$	orth.	Pnma(62)	barite	4
Zinkosite $ZnSO_4$	orth.	Pnma(62)	barite	4
Arcanite K_2SO_4	orth.	Pnma(62)	arcanite	4

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Carbonates and nitrates—Continued							
4.7771 ± .0010		15.664 ± .003				26	107, 260
4.5975 ± .0010		14.723 ± .002				26	107
4.6528 ± .0010		15.025 ± .003				26	107, 261
4.8079 ± .0010		16.010 ± .003				26	107
9.498 ± .003		7.816 ± .004				26	107
5.020 ± .005		16.75 ± .02				r	168
7.135 ± .005		8.524 ± .007				r	157,150
6.430 ± .005	8.904 ± .005	5.314 ± .005				26	255
5.741 ± .005	7.968 ± .005	4.959 ± .005				26	256
6.152 ± .005	8.436 ± .005	5.195 ± .005				26	255
6.029 ± .005	8.414 ± .005	5.107 ± .005				26	256,230
4.961 ± .005	11.03 ± .02	7.12 ± .01				r	169
9.502 ± .007	11.974 ± .007	3.240 ± .003		98.75 ± .25		25	263
5.008 ± .005	5.844 ± .005	10.336 ± .005		92.45 ± .25		25	263
6.431 ± .005	9.164 ± .005	5.414 ± .005				26	256
5.0696 ± .0010		16.829 ± .005				25	259
6.075 ± .004	13.812 ± .008	5.592 ± .004				r	184
Sulfates and borates							
8.878 ± .005	5.450 ± .005	7.152 ± .003				26	256
6.991 ± .005	6.996 ± .005	6.238 ± .005				26	257, 45
8.480 ± .005	5.398 ± .005	6.958 ± .003				25	256
8.359 ± .005	5.352 ± .005	6.866 ± .005				26	97, 255
8.588 ± .008	6.740 ± .006	4.770 ± .005				25	260
5.772 ± .005	10.072 ± .005	7.483 ± .004				25	256

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
		Sulfates and borates—Continued		
Mascagnite $(NH_4)_2SO_4$	orth.	Pnma(62)	arcanite	4
Thenardite Na_2SO_4	orth.	Fddd(70)	thenardite	8
Gypsum $CaSO_4.2H_2O$*	mon.	C2/c(15)		4
Epsomite $MgSO_4.7H_2O$	orth.	$P2_12_12_1(19)$		4
Goslarite $ZnSO_4.7H_2O$	orth.	$P2_12_12_1(19)$	epsomite	4
Mirabilite $Na_2SO_4.10H_2O$	mon.	$P2_1/c(14)$		4
Chalcanthite $CuSO_4.5H_2O$	tri.	$P\bar{1}(2)$		2
Brochantite $Cu_4SO_4(OH)_6$*	mon.	$P2_1/c(14)$		4
Syngenite $K_2Ca(SO_4)_2.H_2O$	mon.	$P2_1/m(11)$		2
Alunite $KAl_3(SO_4)_2(OH)_6$	hex-R	R3m(160)		3
Natroalunite $NaAl_3(SO_4)_2(OH)_6$	hex-R	R3m(160)		3
Hexahydrite $MgSO_4.6H_2O$	mon.	C2/c(15)		8
Leonhardtite $MgSO_4.4H_2O$	mon.	$P2_1/n(14)$		4
Melanterite $FeSO_4.7H_2O$	mon.	$P2_1/c(14)$		4
Vanthoffite $MgSO_4.3Na_2SO_4$	mon.	$P2_1/c(14)$		2
Dolerophanite $Cu_2O(SO_4)$	mon.	C2/m(15)		4
Retgersite $NiSO_4.4H_2O$	tet.	$P4_12_12(92)$ $P4_32_1(96)$		4
Colemanite $CaB_3O_4(OH)_3.H_2O$*	mon.	$P2_1/a(14)$		4
Borax $Na_2B_4O_7.10H_2O$	mon.	C2/c(15)		4
Kernite $Na_2B_4O_7.4H_2O$	mon.	$P2_1/c(14)$		4
Hambergite $Be_2BO_3.(OH,F)$*	orth.	Pbca(61)		8
		Phosphates, molybdates, and tungstates		
Berlinite $AlPO_4$	hex.	$P3_121(152)$ $P3_221(154)$	α-quartz	3
Xenotime YPO_4	tet.	$I4_1/amd(141)$	zircon	4

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Sulfates and borates—Continued							
7.782 ± .005	5.993 ± .005	10.636 ± .005				25	262
5.863 ± .005	12.304 ± .005	9.821 ± .005				25	255
5.68 ± .01	15.18 ± .01	6.29 ± .01		113.83 ± .22		r	186
11.86 ± .01	11.99 ± .01	6.858 ± .007				25	260
11.779 ± .005	12.050 ± .005	6.822 ± .003				25	261
11.51 ± .01	10.38 ± .01	12.83 ± .01		107.75 ± .17		24	215
6.1045 ± .0050	10.72 ± .01	5.949 ± .007	97.57 ± .17	107.28 ± .17	77.43 ± .17	r	85
13.066 ± .010	9.85 ± .01	6.022 ± .010		103.27 ± .25		r	67
9.775 ± .005	7.156 ± .005	6.251 ± .005		104.00 ± .25		r	7
6.982 ± .005		17.32 ± .01				r	22,188 281
6.974 ± .005		16.69 ± .01				r	188
10.110 ± .005	7.212 ± .004	24.41 ± .01		98.30 ± .10		r	298
5.922 ± .006	13.604 ± .004	7.905 ± .005		90.85 ± .20		r	13
14.072 ± .010	6.503 ± .007	11.041 ± .010		105.57 ± .15		r	14
9.797 ± .003	9.217 ± .003	8.199 ± .003		113.50 ± .10		r	86
9.355 ± .010	6.312 ± .005	7.628 ± .005		122.29 ± .10		r	87
6.782 ± .004		18.28 ± .01				25	260
8.743 ± .004	11.264 ± .002	6.102 ± .003		110.12 ± .08		r	47
11.858 ± .005	10.674 ± .005	12.197 ± .005		106.68 ± .03		r	163
7.022 ± .003	9.151 ± .004	15.676 ± .008		108.83 ± .25		r	213
9.755 ± .001	12.201 ± .001	4.426 ± .001				r	297
Phosphates, molybdates, and tungstates							
4.942 ± .005		10.97 ± .007				25	263
6.885 ± .005		5.982 ± .005				26	261,142

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal systeM	Space group	Structure type	Z
Phosphates—Continued				
Hydroxylapatite $Ca_5(PO_4)_3OH$	hex.	$P6_3/m(176)$	apatite	2
Fluorapatite $Ca_5(PO_4)_3F$	hex.	$P6_3/m(176)$	apatite	2
Chlorapatite $Ca_5(PO_4)_3Cl$	hex.	$P6_3/m(176)$	apatite	2
Carbonate-apatite $Ca_{10}(PO_4)_6CO_3H_2O$	hex.	$P6_3/m(176)$	apatite	1
Turquois $CuAl_6(PO_4)_4(OH)_8.4H_2O$*	tri.	$P\bar{1}(2)$		1
Powellite $CaMoO_4$	tet.	$I4_1/a(100)$	scheelite	4
Wulfenite $PbMoO_4$	tet.	$I4_1/a(100)$	scheelite	4
Scheelite $CaWO_4$	tet.	$I4_1/a(100)$	scheelite	4
Stolzite $PbWO_4$	tet.	$I4_1/a(100)$	scheelite	4
Ferberite $FeWO_4$	mon.	$P2/c(13)$	wolframite	2
Huebnerite $MnWO_4$	mon.	$P2/c(13)$	wolframite	2
Wolframite $Fe_{.5}Mn_{.5}WO_4$	mon.	$P2/c(13)$	wolframite	2
Sanmartinite $ZnWO_4$	mon.	$P2/c(13)$	wolframite	2
Ortho and ring structure silicates				
Forsterite Mg_2SiO_4	orth.	Pbnm(62)	olivine	4
Fayalite Fe_2SiO_4	orth.	Pbnm(62)	olivine	4
Tephroite Mn_2SiO_4*	orth.	Pbnm(62)	olivine	4
Lime Olivine γCa_2SiO_4	orth.	Pbnm(62)	olivine	4
Nickel Olivine Ni_2SiO_4	orth.	Pbnm(62)	olivine	4
Cobalt Olivine Co_2SiO_4	orth.	Pbnm(62)	olivine	4
Monticellite $CaMgSiO_4$	orth.	Pbnm(62)	olivine	4
Kerschsteinite $CaFeSiO_4$	orth.	Pbnm(62)	olivine	4
Knebelite $MnFeSiO_4$*	orth.	Pbnm(62)	olivine	4
Glauchroite $CaMnSiO_4$	orth.	Pbnm(62)	olivine	4

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
			Phosphates—Continued				
9.418 ± .003		6.883 ± .003				r	158, 204
9.3684 ± .0030		6.8841 ± .0030				25	266
9.629 ± .005		6.777 ± .003				r	67
9.436 ± .010		6.883 ± .010				r	239
7.424 ± .008	7.629 ± .008	9.910 ± .010	68.61 ± .20	69.71 ± .20	65.08 ± .20	r	48
5.226 ± .005		11.43 ± .007				25	259
5.435 ± .005		12.110 ± .007				25	260
5.242 ± .005		11.372 ± .005				25	259
5.4616 ± .0030		12.046 ± .005				25	260
4.732 ± .004	5.708 ± .003	4.965 ± .004		90.00 ± .05		r	222
4.834 ± .004	5.758 ± .005	4.999 ± .004		91.18 ± .10		r	222, 265
4.782 ± .004	5.731 ± .004	4.982 ± .004		90.57 ± .10		r	222
4.691 ± .003	5.720 ± .003	4.925 ± .003		89.36 ± .20		25	265
			Ortho and ring structure silcates				
4.758 ± .002	10.214 ± .003	5.984 ± .002				25	230, 118
4.817 ± .005	10.477 ± .005	6.105 ± .010				r	295
4.871 ± .005	10.636 ± .005	6.232 ± .005				r	125
5.091 ± .010	11.371 ± .020	6.782 ± .010				r	240
4.727 ± .002	10.121 ± .005	5.915 ± .002				r	179, 203
4.782 ± .002	10.301 ± .005	6.003 ± .002				r	181, 203
4.827 ± .005	11.084 ± .005	6.376 ± .005				r	219
4.886 ± .005	11.146 ± .005	6.434 ± .010				r	219
4.854 ± .010	10.602 ± .010	6.162 ± .010				r	57
4.944 ± .004	11.19 ± .01	6.529 ± .005				r	42

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X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Ortho and ring structure silicates—Continued				
Fluor-Norbergite $Mg_2SiO_4.MgF_2$	orth.	Pnmb(62)		4
Chondrodite $2Mg_2SiO_4.MgF_2$*	mon.	$P2_1/c(14)$		2
Fluor-Humite $3Mg_2SiO_4.MgF_2$	orth.	Pnma(62)		4
Clinohumite $4Mg_2SiO_4.MgF_2$*	mon.	$P2_1/c(14)$		2
Grossularite $Ca_3Al_2Si_3O_{12}$	cubic	Ia3d(230)	garnet	8
Uvarovite $Ca_3Cr_2Si_3O_{12}$	cubic	Ia3d(230)	garnet	8
Andradite $Ca_3Fe_2Si_3O_{12}$	cubic	Ia3d(230)	garnet	8
Goldmanite $Ca_3V_2Si_3O_{12}$	cubic	Ia3d(230)	garnet	8
Almandite $Fe_3Al_2Si_3O_{12}$	cubic	Ia3d(230)	garnet	8
Pyrope $Mg_3Al_2Si_3O_{12}$	cubic	Ia3d(230)	garnet	8
Spessartite $Mn_3Al_2Si_3O_{12}$	cubic	Ia3d(230)	garnet	8
Zircon $ZrSiO_4$*	tet.	I4/amd(141)	zircon	4
Thorite $ThSiO_4$	tet.	I4/amd(141)	zircon	4
Coffinite $USiO_4$	tet.	I4/amd(141)	zircon	4
Kyanite Al_2SiO_5*	tri.	$P\bar{1}(2)$		4
Andalusite Al_2SiO_5*	orth.	Pnnm(58)		4
Sillimanite Al_2SiO_5*	orth.	Pbnm(62) Pnma(62)		4
3.2 Mullite $3Al_2O_3.2SiO_2$	orth.			3/4
2.1 Mullite $2Al_2O_3.SiO_2$	orth.	Pbam(55)		6/5
Staurolite $Fe_2Al_9Si_4O_{22}(OH)_2$*	mon.	C2/m(15)		2
Topaz $Al_2(SiO_4)(OH)$*	orth.	Pmnb(62)		4
Phenacite Be_2SiO_4*	hex-R	$R\bar{3}(148)$	phenacite	18
Willemite Zn_2SiO_4	hex-R	$R\bar{3}(148)$	phenacite	18
Dioptase CuH_2SiO_4*	hex-R	$R\bar{3}(148)$	phenacite	18

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
		Ortho and ring structure silicates—Continued					
8.727 ± .005	10.271 ± .010	4.709 ± .002				25	263
7.89 ± .03	4.743 ± .020	10.29 ± .03		109.03 ± .30		r	218, 57
10.243 ± .005	20.72 ± .02	4.735 ± .002				25	264, 218
13.68 ± .04	4.75 ± .02	10.27 ± .02		100.83 ± .50		r	218, 57
11.851 ± .001						25	226, 2
11.999 ± .002						26	263
12.048 ± .001						25	226
12.070 ± .005						r	253
11.526 ± .001						25	226
11.459 ± .001						25	226, 100
11.621 ± .001						25	226
6.604 ± .005		5.979 ± .005				25	257, 146
7.143 ± .004		6.327 ± .003				r	95
6.995 ± .004		6.263 ± .005				r	95
7.123 ± .001	7.848 ± .002	5.564 ± .008	89.92 ± .15	101.25 ± .08	105.97 ± .08	25	236, 34
7.7959 ± .0050	7.8983 ± .0020	5.5583 ± .0020				25	236, 38
7.4843 ± .0030	7.6730 ± .0030	5.7711 ± .0040				25	236, 35
7.557 ± .002	7.6876 ± .0020	2.8842 ± .0010				r	4
7.5788 ± .0020	7.6909 ± .0020	2.8883 ± .0010				r	4, 36 216
7.90 ± .10	16.65 ± .15	5.63 ± .10		90.00 ± .25		r	57
8.394 ± .005	8.792 ± .007	4.649 ± .003				26	264, 146
12.472 ± .005		8.252 ± .005				25	261
13.94 ± .01		9.309 ± .003				25	260
14.61 ± .02		7.80 ± .01				r	119

Name and formula	Crystal system	Space group	Structure type	Z
Ortho and ring structure silicates—Continued				
Larnite β-Ca_2SiO_4*	mon.	$P2_1/n(14)$		4
Akermanite $Ca_2MgSi_2O_7$	tet.	$P\bar{4}2_1m(113)$	melilite	2
Gehlenite $Ca_2Al_2SiO_7$	tet.	$P\bar{4}2_1m(113)$	melilite	2
Fe-Gehlenite $Ca_2Fe_2SiO_7$	tet.	$P\bar{4}2_1m(113)$	melilite	2
Hardystonite $Ca_2ZnSi_2O_7$*	tet.	$P\bar{4}2_1m(113)$	melilite	2
Sodium Melilite $NaCaAlSi_2O_7$	tet.	$P\bar{4}2_1m(113)$	melilite	2
Beryl $Be_3Al_2(Si_6O_{18})$*	hex.	P6/mmc(192)	beryl	2
Indialite high Cordierite $Mg_2Al_3(AlSi_5O_{18})$	hex.	P6/mmc(192)	beryl	2
Low Cordierite $Mg_2Al_3(AlSi_5O_{18})$	orth.	Cccm(66)		4
Fe-Indialite $Fe_2Al_3(AlSi_5O_{18})$	hex.	P6/mmc(192)	beryl	2
Fe-Cordierite $Fe_2Al_3(AlSi_5O_{18})$	orth.	Cccm(66)	cordierite	4
Mn-Indialite $Mn_2Al_3(AlSi_5O_{18})$	hex.	P6/mmc(192)	beryl	2
Sapphirine $Mg_2Al_4O_6SiO_4$*	mon.	$P2_1/c(14)$		8
Elbaite $NaLiAl_{7.67}B_3Si_6O_{27}(OH)_4$*	hex-R	R3m(160)	tourmaline	3
Schorl $NaFe_3Al_6B_3Si_6O_{27}(OH)_4$*	hex-R	R3m(160)	tourmaline	3
Dravite $NaMg_3Al_6B_3Si_6O_{27}(OH)_4$	hex-R	R3m(160)	tourmaline	3
Uvite $CaMg_4Al_5B_3Si_6O_{27}(OH)_4$	hex-R	R3m(160)	tourmaline	3
Sphene $CaTiSiO_5$*	mon.	A2/a(15)		4
Datolite $CaBSiO_4(OH)$*	mon.	$P2_1/c(14)$		4
Euclase $AlBeSiO_4(OH)$*	mon.	$P2_1/a(14)$		4
Chloritoid $H_2FeAl_2SiO_7$*	mon.	C2/c(15)		8
Hemimorphite $Zn_4(OH)_2Si_2O_7.H_2O$*	orth.	Imm2(35)		2
Zoisite $Ca_2Al_3(SiO_4)_3OH$	orth.	Pnma(62)		4
Clinozoisite $Ca_2Al_3(SiO_4)_3OH$	mon.	$P2_1/m(11)$		2

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
		Ortho and ring structure silicates—Continued					
5.48 ± .02	6.76 ± .02	9.28 ± .02		94.55 ± .33		r	161
7.8435 ± .0030		5.010 ± .003				r	6, 174 182, 77
7.690 ± .003		5.0675 ± .0030				r	6, 174 182, 77
7.54 ± .01		4.855 ± .005				r	182
7.87 ± .03		5.01 ± .02				r	67
8.511 ± .005		4.809 ± .003				r	182
9.215 ± .005		9.192 ± .005				25	262
9.7698 ± .0030		9.3517 ± .0030				25	223, 264
9.721 ± .003	17.062 ± .006	9.339 ± .003				25	264, 223 73, 99
9.860 ± .010		9.285 ± .010				r	162, 57
9.726 ± .010	17.065 ± .010	9.287 ± .010				r	73
9.925 ± .010		9.297 ± .010				r	73
11.26 ± .03	14.46 ± .03	9.95 ± .02		125.33 ± .50		r	57
15.842 ± .010		7.009 ± .010				r	74, 32
16.032 ± .010		7.149 ± .010				r	74
15.942 ± .010		7.224 ± .010				r	74, 209 32
15.86 ± .01		7.19 ± .01				r	209
7.07 ± .01	8.72 ± .01	6.56 ± .01		113.95 ± .25		r	67
9.62 ± .03	7.60 ± .03	4.84 ± .02		90.15 ± .25		r	127
4.763 ± .005	14.29 ± .02	4.618 ± .005		100.25 ± .10		r	170
9.48 ± .01	5.48 ± .01	18.18 ± .01		101.77 ± .25		r	116
8.370 ± .005	10.719 ± .005	5.120 ± .005				25	255
16.15 ± .01	5.581 ± .005	10.06 ± .01				r	202
8.887 ± .007	5.581 ± .005	10.14 ± .01		115.93 ± .33		r	202

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Ortho and ring structure silicates—Continued				
Epidote $Ca_2Al_{1.5}Fe_{1.5}(SiO_4)_3OH$*	mon.	$P2_1/m(11)$		2
Piemontite $Ca_2Al_{1.5}Mn_{1.5}(SiO_4)_3OH$*	mon.	$P2_1/m(11)$		2
Lawsonite $CaAl_2Si_2O_7(OH)_2.H_2O$	orth.	Cccm(63)		4
Chain and band structure silicates				
Enstatite $MgSiO_3$*	orth.	Pcab(61)		16
Clinoenstatite $MgSiO_3$	mon.	$P2_1/c(15)$		8
Protoenstatite $MgSiO_3$	orth.	Pbcn(60)		8
High Clinoenstatite $MgSiO_3$	tri.			8
Clinoferrosilite $FeSiO_3$	mon.	$P2_1/c(15)$		8
Orthoferrosilite $FeSiO_3$	orth.	Pcab(61)	enstatite	16
Diopside $CaMg(SiO_3)_2$	mon.	C2/c(15)	diopside	4
Hedenbergite $CaFe(SiO_3)_2$*	mon.	C2/c(15)	diopside	4
Johannsenite $CaMn(SiO_3)_2$*	mon.	C2/c(15)	diopside	4
Ureyite $NaCr(SiO_3)_2$	mon.	C2/c(15)	diopside	4
Jadeite $NaAl(SiO_3)_2$*	mon.	C2/c(15)	diopside	4
Acmite (Aegirine) $NaFe(SiO_3)_2$	mon.	C2/c(15)	diopside	4
Ca Tschermak Molecule $CaAl_2SiO_6$	mon.	C2/c(15)	diopside	4
Spodumene $LiAl(SiO_3)_2$	mon.	C2/c(15)	diopside	4
β-Spodumene $LiAl(SiO_3)_2$	tet.	$P4_32_12(96)$ $P4_12_12(92)$		4
Pectolite $Ca_2NaH(SiO_3)_3$*	tri.	$P\bar{1}(2)$		2
Wollastonite $CaSiO_3$*	tri.	$P\bar{1}(2)$		6
Parawollastonite $CaSiO_3$*	mon.	$P2_1(4)$		12
Pseudowollastonite $CaSiO_3$*	tri.			24
Rhodonite $MnSiO_3$*	tri.	$P\bar{1}(2)$		10

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Ortho and ring structure silicates—Continued							
8.89 ± .02	5.63 ± .01	10.19 ± .02		115.40 ± .30		r	224
8.95 ± .02	5.70 ± .01	9.41 ± .02		115.70 ± .50		r	57
8.787 ± .005	5.836 ± .005	13.123 ± .008				r	201, 185
Chain and band structure silicates							
8.829 ± .010	18.22 ± .01	5.192 ± .005				r	52, 259 122
9.620 ± .005	8.825 ± .005	5.188 ± .005		108.33 ± .17		r	164
9.25 ± .01	8.74 ± .01	5.32 ± .01				r	24
10.000 ± .005	8.934 ± .004	5.170 ± .003	88.27 ± .05	70.03 ± .04	91.01 ± .04		200
9.7085 ± .0010	9.0872 ± .0011	5.2284 ± .004		108.43 ± .05		r	37
9.080 ± .002	18.431 ± .004	5.238 ± .001				r	37, 287
9.743 ± .005	8.923 ± .005	5.251 ± .003		105.93 ± .25		r	220, 49
9.854 ± .010	9.024 ± .010	5.263 ± .010		104.23 ± .33		r	145
9.83 ± .03	9.04 ± .03	5.27 ± .02		105.00 ± .50		r	58
9.550 ± .016	8.712 ± .007	5.273 ± .008		107.44 ± .16		r	91
9.409 ± .005	8.564 ± .005	5.220 ± .005		107.50 ± .20		r	205
9.658 ± .005	8.795 ± .005	5.294 ± .005		107.42 ± .20		r	180
9.615 ± .005	8.661 ± .005	5.272 ± .003		106.12 ± .20		r	49
9.451 ± .002	8.387 ± .002	5.208 ± .001		110.07 ± .03		r	249, 58
7.5332 ± .0008		9.1540 ± .0008				r	238
7.99 ± .01	7.04 ± .01	7.02 ± .01	90.05 ± .25	95.27 ± .25	102.47 ± .25	r	33, 31
7.94 ± .01	7.32 ± .01	7.07 ± .01	90.03 ± .25	95.37 ± .25	103.43 ± .25	r	31, 190 33
15.417 ± .004	7.321 ± .002	7.066 ± .003		95.40 ± .10		r	271, 190
6.90 ± .02	11.78 ± .02	19.65 ± .02	90.00 ± .30	90.80 ± .30	90.00 ± .30	r	132
7.682 ± .002	11.818 ± .003	6.707 ± .002	92.36 ± .05	93.95 ± .05	105.66 ± .05	r	196

X-Ray Crystallographic Data of Minerals

Chain and band structure silicates—Continued

Name and formula	Crystal system	Space group	Structure type	Z
Bustamite $CaMn(SiO_3)_2$*	tri.	$A\bar{1}(2)$		6
Pyroxmangite $MnFe(SiO_3)_2$*	tri.	$P\bar{1}(2)$		7
Tremolite $Ca_2Mg_5[Si_8O_{22}](OH)_2$*	mon.	C2/m(12)	tremolite	2
Fluor-tremolite $Ca_2Mg_5[Si_8O_{22}]F_2$	mon.	C2/m(12)	tremolite	2
Ferrotremolite $Ca_2Fe_5[Si_8O_{22}](OH)_2$	mon.	C2/m(12)	tremolite	2
Grunerite $Fe_7[Si_8O_{22}](OH)_2$	mon.	C2/m(12)	tremolite	2
Cummingtonite (hypo.) $Mg_7[Si_8O_{22}](OH)_2$	mon.	C2/m(12)	tremolite	2
Riebeckite $Na_2Fe_3Fe_2[Si_8O_{22}](OH)_2$	mon.	C2/m(12)	tremolite	2
Magnesioriebeckite $Na_2Mg_3Fe_2[Si_8O_{22}](OH)_2$	mon.	C2/m(12)	tremolite	2
Gaucophane I $Na_2Mg_3Al_2[Si_8O_{22}](OH)_2$	mon.	C2/m(12)	tremolite	2
Glaucophane II $Na_2Mg_3Al_2[Si_8O_{22}](OH)_2$	mon.	C2/m(12)	tremolite	2
Fluor-edenite $NaCa_2Mg_5[AlSi_7O_{22}]F_2$	mon.	C2/m(12)	tremolite	2
Fluor-richterite $Na_2CaMg_5[Si_8O_{22}]F_2$	mon.	C2/m(12)	tremolite	2
Anthophyllite $Mg_7[Si_8O_{22}](OH)_2$	orth.	Pnma(62)		4

Framework structure silicates

Name and formula	Crystal system	Space group	Structure type	Z
Microcline $KAlSi_3O_8$	tri.	$C\bar{1}(2)$		4
High Sanidine $KAlSi_3O_8$	mon.	C2/m(12)		4
Orthoclase $KAlSi_3O_8$*	mon.	C2/m(12)		4
Fe-Sanidine $KFeSi_3O_8$	mon.	C2/m(12)		4
Fe-Microcline $KFeSi_3O_8$	tri.	$C\bar{1}(2)$		4
Low Albite $NaAlSi_3O_8$	tri.	$C\bar{1}(2)$		4
High Albite (Analbite) $NaAlSi_3O_8$	tri.	$C\bar{1}(2)$		4
Anorthite $CaAl_2Si_2O_8$	tri.	$P\bar{1}(2)$	primitive cell	8
Synthetic $CaAl_2Si_2O_8$	hex.	$P6_3/mcm(193)$		2

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Chain and band structure silicates—Continued							
7.736 ± .003	7.157 ± .003	13.824 ± .010	90.52 ± .25	94.58 ± .25	103.87 ± .25	r	197, 195
7.56 ± .02	17.45 ± .05	6.67 ± .02	84.00 ± .30	94.30 ± .30	113.70 ± .30	r	151
9.840 ± .010	18.052 ± .020	5.275 ± .010		104.70 ± .25		r	248, 301, 58
9.781 ± .007	18.01 ± .01	5.267 ± .005		104.52 ± .25		20	52, 58
9.97 ± .01	18.34 ± .02	5.30 ± .01		104.50 ± .10		r	76
9.572 ± .005	18.44 ± .01	5.342 ± .007		101.77 ± .25		r	138, 278
9.476 ± .010	17.935 ± .010	5.292 ± .005		102.23 ± .25		r	278, 98
9.729 ± .020	18.065 ± .020	5.334 ± .010		103.31 ± .25		r	75
9.733 ± .010	17.946 ± .020	5.299 ± .010		103.30 ± .25		r	75
9.748 ± .010	17.915 ± .020	5.273 ± .010		102.78 ± .25		r	75
9.663 ± .010	17.696 ± .020	5.277 ± .010		103.67 ± .10		r	75, 58
9.847 ± .005	18.00 ± .01	5.282 ± .005		104.83 ± .25		r	140, 58
9.823 ± .005	17.96 ± .01	5.268 ± .005		104.33 ± .25		r	140, 58
18.61 ± .02	18.01 ± .06	5.24 ± .01				r	108
Framework structure silicates							
8.582 ± .002	12.964 ± .005	7.222 ± .002	90.62 ± .10	115.92 ± .10	87.68 ± .10	r	249, 84, 280, 23
8.615 ± .002	13.031 ± .003	7.177 ± .002		115.98 ± .10		r	249, 66
8.562 ± .003	12.996 ± .004	7.193 ± .003		116.02 ± .15		r	134
8.689 ± .008	13.12 ± .01	7.319 ± .007		116.10 ± .30		r	291
8.68 ± .01	13.10 ± .01	7.340 ± .007	90.75 ± .25	116.05 ± .25	86.23 ± .25	r	291
8.139 ± .002	12.788 ± .003	7.160 ± .002	94.27 ± .10	116.57 ± .10	87.68 ± .10	26	249, 82, 51, 280
8.160 ± .002	12.870 ± .003	7.106 ± .002	93.54 ± .10	116.36 ± .10	90.19 ± .10	r	249, 82, 148, 246
8.177 ± .002	12.877 ± .003	14.169 ± .003	93.17 ± .02	115.85 ± .02	91.22 ± .02	r	249, 51, 159
5.10 ± .02		14.72 ± .02				r	267

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Framework structure silicates—Continued				
Synthetic $CaAl_2Si_2O_8$	orth.	$P2_12_12(18)$		2
Celsian $BaAl_2Si_2O_8$*	mon.	$I2_1/c(15)$		8
Paracelsian $BaAl_2Si_2O_8$*	mon.	$P2_1/a(14)$		4
Banalsite $BaNa_2Al_4Si_4O_{16}$*	orth.			4
Danburite $CaB_2Si_2O_8$*	orth.	Pnam(62)		4
Low Nepheline $NaAlSiO_4$	hex.	$C6_3(178)$		8
High Carnegeite $NaAlSiO_4$	cubic			4
Kaliophilite natural $KAlSiO_4$*	hex.	$P6_322(182)$		54
Kaliophilite synthetic $KAlSiO_4$	hex.	$P6_3(173)$ $P6_322(182)$		2
Kalsilite $KAlSiO_4$	hex.	$P6_3(173)$		2
Leucite $KAlSi_2O_6$	tet.	$I4_1/a(100)$		16
High Leucite $KAlSi_2O_6$*	cubic	Ia3d(230)		16
Fe-Leucite $KFeSi_2O_6$	tet.	$I4_1/a(100)$		16
Petalite $LiAlSi_4O_{10}$*	mon.	$P2_1/n(14)$		2
Marialite $Na_4Al_3Si_9O_{24}Cl$	tet.	I4/m(87) P4/m(83)		2
Meionite $Ca_4Al_6Si_6O_{24}CO_3$	tet.	I4/m(87) P4/m(83)		2
Sheet structure silicates				
Muscovite $KAl_2[AlSi_3O_{10}](OH)_2$*	mon.	C2/c(15)	$2M_2$ mica	4
Paragonite $NaAl_2[AlSi_3O_{10}](OH)_2$*	mon.	C2/c(15)	$2M_1$ mica	4
Lepidolite $K_2Al_3Li_2[AlSi_7O_{20}](OH)_4$*	mon.	C2/c(15)	$2M_2$ mica	2
Phlogopite $KMg_3[AlSi_3O_{10}](OH)_2$	mon.	Cm(8)	1M mica	2
Fluor-phlogopite $KMg_3[AlSi_3O_{10}]F_2$	mon.	Cm(8)	1M mica	2
Annite $KFe_3[AlSi_3O_{10}](OH)_2$	mon.	Cm(8)	1M mica	2
Ferriannite $KFe_3[FeSi_3O_{10}](OH)_2$	mon.	C2/m(12)		2

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Framework structure silicates—Continued							
8.22 ± .02	8.60 ± .02	4.83 ± .01				r	56
8.627 ± .010	13.045 ± .010	14.408 ± .020		115.20 ± .25		r	178
8.58 ± .02	9.583 ± .020	9.08 ± .02		90.00 ± .50		r	244, 60
8.50 ± .02	9.97 ± .02	16.72 ± .03				r	60
8.04 ± .02	8.77 ± .02	7.74 ± .02				r	133, 60
9.986 ± .005		8.330 ± .004				r	68, 247
7.325 ± .004						750	247
26.930 ± .010		8.522 ± .004				r	247
5.180 ± .002		8.559 ± .004				r	247
5.1597 ± .0020		8.7032 ± .0030				r	247, 199
13.074 ± .003		13.738 ± .003				25	81
13.43 ± .05						625	67
13.205 ± .002		13.970 ± .003				25	81
11.32 ± .03	5.14 ± .01	7.62 ± .01		105.90 ± .20		r	67
12.064 ± .008		7.514 ± .004				r	78, 187
12.174 ± .008		7.652 ± .015				r	78
Sheet structure silicates							
5.203 ± .005	8.995 ± .005	20.030 ± .010		94.47 ± .33		r	294, 108
5.13 ± .03	8.89 ± .05	19.32 ± .10		95.17 ± .50		r	79, 108
9.2 ± .1	5.3 ± .1	20.0 ± .2		98.00 ± .50		r	59
5.326 ± .010	9.210 ± .010	10.311 ± .010		100.17 ± .10		r	290, 293
5.299 ± .005	9.188 ± .005	10.135 ± .005		99.92 ± .10		r	141
5.391 ± .010	9.350 ± .005	10.313 ± .020		99.70 ± .25		r	79
5.430 ± .002	9.404 ± .003	10.341 ± .006		100.07 ± .20		r	289

X-Ray Crystallographic Data of Minerals

Name and formula	Crystal system	Space group	Structure type	Z
Sheet structure silicates—Continued				
Margarite $CaAl_2[Al_2Si_2O_{10}](OH)_2$*	mon.	C2/c(15)	2M mica	4
Talc $Mg_3Si_4O_{10}(OH)_2$*	mon.	C2/c(15)	$2M_1$	4
Pyrophyllite $Al_2Si_4O_{10}(OH)_2$*	mon.	C2/c(15)	$2M_1$	4
Minnesotaite $Fe_3Si_4O_{10}(OH)_2$*	mon.	C2/c(15)		4
Dickite $Al_2Si_2O_5(OH)_4$*	mon.	Cc(9)		4
Kaolinite $Al_2Si_2O_5(OH)_4$*	tri.	P1(1)		2
Nacrite $Al_2Si_2O_5(OH)_4$*	mon.	Cc(9)		4
Zeolites				
Analcite $NaAlSi_2O_6.H_2O$	cubic	Ia3d(230)		16
Natrolite $Na_2Al_2Si_3O_{10}.2H_2O$*	orth.	Fdd2(43)		8

a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
Sheet structure silicates—Continued							
5.13 ± .02	8.92 ± .03	19.50 ± .05		95.00 ± .50		r	59
5.287 ± .007	9.158 ± .010	18.95 ± .01		99.50 ± .20		r	248
5.14 ± .02	8.90 ± .02	18.55 ± .03		99.92 ± .20		r	114
5.4 ± .1	9.42 ± .04	19.4 ± .1		100.00 ± .50		r	59
5.150 ± .002	8.940 ± .003	14.736 ± .005		103.58 ± .10		r	175, 8
5.155 ± .007	8.959 ± .010	7.407 ± .008	91.68 ± .35	104.87 ± .35	89.93 ± .35	r	104
8.909 ± .010	5.146 ± .010	15.697 ± .020		113.70 ± .25		r	8
Zeolites							
13.733 ± .005						r	217
18.30 ± .02	18.63 ± .02	6.60 ± .01				r	160

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell. volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Elements									
Silver	107.870	4	cubic	68.227	10.272	.24556	10.501	25	254, 198
Ag				± .010	± .002	± .00008	± .002		
Arsenic	74.922	6	hex-R	129.23	12.972	.31007	5.776	26	231, 256
As				± .08	± .002	± .00023	± .004		
Gold	196.967	4	cubic	67.847	10.215	.24420	19.282	25	254, 10
Au				± .010	± .002	± .00008	± .003		
Bismuth	208.980	6	hex-R	212.29	21.309	.50934	9.8071	26	129, 221
Bi				± .11	± .011	± .00030	± .0050		256
Diamond	12.011	8	cubic	45.385	3.4166	.08170	3.5155	25	189, 227
C*				± .004	± .0003	± .00005	± .0003		172
Graphite	12.011	4	hex.	35.189	5.2982	.12668	2.2670	15	173
C*				± .006	± .0009	± .00007	± .0004		
Copper	63.54	4	cubic	47.242	7.1128	.17005	8.9331	25	254
Cu				± .020	± .0030	± .00012	± .0037		
α-Iron	55.847	2	cubic	23.551	7.0918	.16954	7.8748	25	257
Fe				± .012	± .0037	± .00013	± .0041		
Nickel	58.71	4	cubic	43.756	6.5880	.15750	8.9117	25	254
Ni				± .019	± .0028	± .00011	± .0038		
Lead	207.19	4	cubic	121.32	18.267	.43663	11.342	25	254
Pb				± .04	± .006	± .00018	± .003		
Platinum	195.09	4	cubic	60.379	9.0909	.21732	21.460	25	254
Pt				± .023	± .0035	± .00013	± .008		
orthorhombic Sulfur	32.064	128	orth.	3296.73	15.511	.37078	2.0671	25	54, 41
S				± .97	± .005	± .00015	± .0006		
monoclinic Sulfur	32.064	48	mon.	1314.6	16.49	.3943	1.944	103	67
S				± 6.4	± .08	± .0020	± .009		

rhombohedral Sulfur	32.064	18	hex-R	433.78	14.514	.34693	2.2092	r	69
S				± .19	± .006	± .00020	± .0010		
Antimony	121.75	6	hex-R	181.45	18.213	.43535	6.685	26	231, 221
Sb				± .09	± .010	± .00028	± .004		256
Selenium	78.96	3	hex.	81.793	16.420	.39249	4.8088	26	250
Se				± .033	± .007	± .00020	± .0019		
Silicon	28.086	8	cubic	160.15	12.056	.28819	2.3296	25	189, 10
Si				± .03	± .002	± .00009	± .0004		121
β-Tin (white)	118.69	4	tet.	108.18	16.289	.38935	7.2867	26	129
Sn				± .04	± .005	± .00017	± .0024		
Tellurium	127.60	3	hex.	102.00	20.476	.48944	6.2316	25	254
Te				± .04	± .008	± .00024	± .0025		
Zinc	65.37	2	hex.	30.428	9.162	.2190	7.134	25	254
Zn				± .024	± .007	± .0002	± .006		
Sulfides, arsenides, tellurides, selenides, and sulfosalts									
Shandite	654.638	3	hex-R	367.76	73.83	1.765	8.867	r	124, 194
β-$Ni_3Pb_2S_2$*				± 1.35	± .27	± .007	± .033		
High-Argentite	247.804	4	cubic	246.4	37.09	.8866	6.680	600	64
Ag_2S I									
Argentite				± 2.4	± .36	± .0085	± .064		
Ag_2S II	247.804	2	cubic	115.5	34.78	.8313	7.125	189	64
Acanthite				± .6	± .17	± .0041	± .035		
Ag_2S III	247.804	4	mon.	227.08	34.19	.8172	7.248	25	263, 64
High-Naumanite				± .29	± .04	± .0011	± .009		
Ag_2Se	294.700	2	cubic	124.48	37.48	.8959	7.862	170	207
				± 1.20	± .36	± .0087	± .076		
	343.340	2	cubic	148.0	44.58	1.065	7.702	825	207
Ag_2Te I				± .8	± .26	± .006	± .044		
	343.340	4	cubic	285.54	42.99	1.028	7.986	250	207
Ag_2Te II				± 1.30	± .20	± .005	± .036		
Hessite	343.340	4	mon.	271.33	40.85	.9764	8.405	r	94
Ag_2Te III				± 1.43	± .22	± .0052	± .044		

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued									
$Ag_{1.55}Cu_{.45}S$ I	227.856	4	cubic	228.10 ± 1.12	34.34 ± .17	.8209 ±.0041	6.635 ± .033	300	64
$Ag_{1.55}Cu_{.45}S$ II	227.856	2	cubic	112.33 ± .35	33.83 ± .11	.8085 ± .0026	6.736 ± .021	116	64
Jalpaite $Ag_{1.55}Cu_{.45}S$ III	227.856	16	tet.	884.30 ± .93	33.286 ± .035	.79559 ± .00088	6.8455 ± .0072	r	64
$Ag_{.93}Cu_{1.07}S$ I	200.371	4	cubic	211.82 ± .96	31.89 ± .14	.7623 ± .0035	6.283 ± .029	196	64
$Ag_{.93}Cu_{1.07}S$ II	200.371	2	hex.	105.36 ± .23	31.73 ± .07	.7583 ± .0017	6.316 ± .014	100	64
Stromeyerite $Ag_{.93}Cu_{1.07}S$ III	200.371	4	orth.	214.84 ± .18	32.35 ± .03	.7732 ± .0007	6.194 ± .005	r	64
Eucairite AgCuSe	250.370	10	orth.	527.12 ± 1.62	31.75 ± .10	.7588 ± .0024	7.887 ± .024	r	92
Petzite Ag_3AuTe_2*	775.777	8	cubic	1118.4 ± 6.5	84.19 ± .49	2.012 ± .012	9.214 ± .053	r	93
Maldonite Au_2Bi	602.914	8	cubic	503.98 ± .38	37.94 ± .03	.9068 ± .0007	15.891 ± .012	r	135
High-Digenite Cu_2S I	159.144	4	cubic	187.64 ± .98	28.25 ± .15	.6753 ± .0036	5.633 ± .030	465	63, 212
High-Chalcocite Cu_2S II	159.144	2	hex.	91.34 ± .21	27.50 ± .06	.6574 ± .0015	5.786 ± .013	152	63, 212
Chalcocite Cu_2S III	159.144	96	orth.	4379.5 ± 2.5	27.475 ± .016	.65671 ± .00043	5.7924 ± .0034	r	63, 212
Digenite $Cu_{1.79}S$ (Cu rich side)	145.801	4	cubic	172.76 ± .09	26.012 ± .014	.6217 ± .0004	5.605 ± .003	25	63, 212

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Digenite $Cu_{1.77}S$ (S rich side)	144.530	4	cubic	171.34 ± .09	25.798 ± .014	.6166 ± .0004	5.602 ± .003	25	63, 212
Berzelianite Cu_2Se	206.040	4	cubic	200.2 ± 1.0	30.14 ± .15	.7205 ± .0037	6.835 ± .035	170	212
High-Bornite Cu_5FeS_4*	501.803	1	cubic	166.4 ± .9	100.2 ± .5	2.395 ± .013	5.008 ± .027	240	166
Metastable Bornite Cu_5FeS_4	501.803	8	cubic	1309.34 ± 7.18	98.57 ± .54	2.356 ± .013	5.091 ± .028	r	166
Low-Bornite Cu_5FeS_4*	501.803	16	tet.	2618.7 ± 10.7	98.57 ± .40	2.356 ± .010	5.091 ± .021	r	166
Umangite Cu_3Se_2	348.54	2	tet.	175.25 ± .68	52.77 ± .21	1.261 ± .005	6.604 ± .026	r	17, 72
Heazelwoodite Ni_3S_2	240.258	3	hex-R	203.98 ± .09	40.95 ± .02	.9788 ± .0005	5.867 ± .003	r	144, 153
Maucherite $Ni_{11}As_8$	1245.183	4	tet.	1029.36 ± .56	154.98 ± .08	3.7043 ± .0021	8.0343 ± .0044	r	296
Pentlandite $Fe_{5.25}Ni_{3.75}S_8$	769.725	4	cubic	1059.96 ± 3.12	159.59 ± .47	3.8144 ± .0113	4.823 ± .014	r	154
Pentlandite $Fe_{3.75}Ni_{5.25}S_8$	774.166	4	cubic	1028.77 ± 3.06	154.89 ± .46	3.702 ± .011	4.998 ± .015	r	154
Sternbergite $AgFe_2S_3$*	315.756	8	orth.	974.81 ± 2.71	73.39 ± .20	1.754 ± .005	4.303 ± .012	r	193
Argentopyrite $AgFe_2S_3$*	315.756	4	orth.	491.2 ± 1.9	73.96 ± .29	1.768 ± .007	4.269 ± .017	r	171
Realgar AsS*	106.986	16	mon.	791.6 ± 6.4	29.80 ± .24	.7122 ± .0058	3.591 ± .029	r	26, 128
Oldhamite CaS	72.144	4	cubic	184.12 ± .58	27.722 ± .088	.6626 ± .0021	2.602 ± .008	r	260, 115 206
Greenockite CdS	144.464	2	hex.	99.407 ± .050	29.934 ± .015	.71549 ± .00041	4.8261 ± .0024	r	235
Hawleyite CdS	144.464	4	cubic	198.46 ± .20	29.88 ± .03	.7142 ± .0008	4.835 ± .005	r	228, 18 276

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued									
(hypothetical)	144.464	4	cubic	167.83	25.27	.6040	5.717	r	19
CdS				± .18	± .03	± .0007	± .006		
Cadmoselite	191.36	2	hex.	112.00	33.727	.80614	5.6738	r	18, 260
CdSe				± .05	± .016	± .00044	± .0028		
	240.00	4	cubic	272.16	40.977	.97943	5.8569	25	18, 266
CdTe				± .08	± .012	± .00032	± .0016		
(hypothetical)	90.997	4	cubic	152.19	22.91	.5477	3.971	r	117
CoS				± .09	± .02	± .0004	± .002		
Chalcopyrite	180.309	4	tet.	292.96	44.109	1.0543	4.0878	r	18
($CuFeS_2$) $CuFeS_{1.90}$				± .18	± .027	± .0007	± .0025		
Cubanite	271.246	4	orth.	447.53	67.38	1.611	4.026	r	30
$CuFe_2S_3$*				± 1.08	± .16	± .004	± .010		
Covellite	95.604	6	hex.	203.48	20.42	.4882	4.682	r	257
CuS				± .16	± .02	± .0005	± .001		
Klockmannite	142.50	78	hex.	3014.8	23.28	.5564	6.122	r	71, 268
CuSe				± 9.7	± .08	± .0018	± .020		
Troilite	87.911	2	hex.	60.439	18.20	.4350	4.830	28	274
FeS				± .106	± .03	± .0008	± .009		
Pyrrhotite	86.794	2	hex.	60.14	18.11	.4329	4.793	28	274
$Fe_{.980}S$				± .04	± .01	± .0003	± .003		
Pyrrhotite	81.489	2	hex.	58.507	17.62	.4211	4.625	28	274
$Fe_{.885}S$				± .046	± .02	± .0004	± .004		
(hypothetical)	87.911	4	cubic	162.32	24.44	.5842	3.597	r	228, 234
FeS				± .09	± .01	± .0004	± .002		
(hypothetical)	87.911	2	hex.	82.38	24.81	.5930	3.544	r	235
FeS				± .05	± .02	± .0004	± .002		

Cinnabar HgS	232.654	3	hex.	141.55 ± .07	28.416 ± .015	.6792 ± .0004	8.187 ± .004	r	18, 257
Metacinnabar HgS	232.654	4	cubic	200.38 ± .10	30.169 ± .016	.7211 ± .0004	7.712 ± .004	r	18, 257
Tiemannite HgSe	279.55	4	cubic	225.34 ± .56	33.928 ± .084	.8110 ± .0020	8.239 ± .020	r	18, 260
Coloradoite HgTe	328.19	4	cubic	269.59 ± .08	40.590 ± .011	.97016 ± .00032	8.0855 ± .0023	r	18
Alabandite MnS	87.002	4	cubic	142.51 ± .04	21.457 ± .006	.51289 ± .00019	4.0546 ± .0012	r	229, 18
(hypothetical) MnS	87.002	4	cubic	176.65 ± .19	26.60 ± .03	.6357 ± .0007	3.271 ± .004	r	228
(hypothetical) MnS	87.002	2	hex.	88.96 ± .05	26.79 ± .02	.6403 ± .0004	3.248 ± .002	r	235
Niccolite NiAs	133.632	2	hex.	57.07 ± .03	17.18 ± .01	.4108 ± .0003	7.776 ± .005	r	296
Millerite NiS	90.774	9	hex-R	252.41 ± .10	16.891 ± .006	.40374 ± .00020	5.3743 ± .0020	r	18, 264 144, 153
Breithauptite NiSb	180.46	2	hex.	69.37 ± .04	20.89 ± .01	.4994 ± .0004	8.639 ± .005	r	123
Galena PbS	239.254	4	cubic	209.16 ± .05	31.492 ± .008	.75272 ± .00024	7.5973 ± .0019	26	19, 255 282
Clausthalite PbSe	286.15	4	cubic	229.84 ± .06	34.605 ± .009	.82713 ± .00025	8.2690 ± .0020	r	19
Teallite $PbSnS_2$	390.008	2	orth.	199.24 ± .21	59.996 ± .063	1.4340 ± .0016	6.501 ± .007	r	167
Altaite PbTe	334.79	4	cubic	269.66 ± .06	40.601 ± .009	.97043 ± .00027	8.2459 ± .0019	r	18
Cooperite PtS	227.154	2	tet.	73.563 ± .028	22.152 ± .008	.5295 ± .0003	10.254 ± .004	r	18, 109
Herzenbergite SnS	150.754	4	orth.	192.66 ± .12	29.01 ± .02	.6933 ± .0005	5.197 ± .003	r	167

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued									
Sphalerite ZnS	97.434	4	cubic	158.28 ± .04	23.831 ± .007	.56962 ± .00020	4.0885 ± .0011	r	19, 228 233, 234
Wurtzite ZnS	97.434	2	hex.	79.190 ± .043	23.846 ± .013	.56998 ± .00036	4.0859 ± .0022	r	233, 235 230
Stilleite $ZnSe$	144.33	4	cubic	182.14 ± .05	27.424 ± .007	.65548 ± .00022	5.2630 ± .0014	r	19, 106
 $ZnTe$	192.97	4	cubic	227.20 ± .07	34.209 ± .010	.81765 ± .00029	5.6410 ± .0017	r	18, 266
Orpiment As_2S_3*	246.035	4	mon.	468.3 ± 1.7	70.51 ± .25	1.685 ± .006	3.490 ± .013	r	29
Bismuthinite Bi_2S_3	514.152	4	orth.	501.59 ± .28	75.520 ± .043	1.8050 ± .0011	6.8081 ± .0038	26	257
Tellurobismuthite Bi_2Te_3	800.76	3	hex-R	507.33 ± .47	101.85 ± .09	2.4342 ± .0023	7.862 ± .007	25	88, 283 266
Stibnite Sb_2S_3	339.692	4	orth.	487.54 ± .28	73.406 ± .042	1.7545 ± .0010	4.6276 ± .0026	25	258
Linnaeite Co_3S_4	305.056	8	cubic	830.85 ± .27	62.548 ± .020	1.4950 ± .0005	4.8772 ± .0016	r	156
Greigite Fe_3S_4	295.797	8	cubic	963.26 ± .59	72.52 ± .04	1.733 ± .001	4.079 ± .003	r	237
Daubreeite $FeCr_2S_4$	288.095	8	cubic	989.83 ± 1.49	74.52 ± .11	1.781 ± .003	3.866 ± .006	r	152
Violarite $FeNi_2S_4$	301.523	8	cubic	847.66 ± 1.34	63.81 ± .10	1.525 ± .002	4.725 ± .008	r	155
Polymidite Ni_3S_4	304.386	8	cubic	851.97 ± .27	64.138 ± .020	1.5330 ± .0005	4.7458 ± .0015	r	144

Co-Safflorite	208.776	2	mon.	92.706	27.92	.6672	7.479	26	211, 263
$CoAs_2$				± .057	± .02	± .0005	± .005		
Safflorite	207.233	2	orth.	92.237	27.775	.6639	7.461	26	211, 263
$(Co_{.5}Fe_{.5})As_2$				± .078	± .024	± .0006	± .006		
Cobaltite	165.919	4	cubic	175.62	26.44	.6320	6.275	r	17
CoAsS*				± 4.70	± .71	± .0170	± .168		
Glaucodot	164.376	24	orth.	1063.2	26.68	.6377	6.161	r	17
(Co,Fe)AsS*				± 12.9	± .32	± .0078	± .075		
Cattierite	123.061	4	cubic	169.53	25.524	.61009	4.8213	r	251, 156
CoS_2				± .05	± .007	± .00021	± .0013		
Trogtalite	216.853	4	cubic	201.11	30.279	.72374	7.1618	r	21
$CoSe_2$				± .10	± .016	± .00042	± .0037		
Loellingite	205.69	2	orth.	91.357	27.51	.6576	7.477	26	211, 263
$FeAs_2$				± .056	± .02	± .0005	± .005		
Arsenopyrite	162.833	4	tri.	175.51	26.42	.6316	6.162	r	165
FeAsS*				± .44	± .07	± .0016	± .015		
Gudmundite	209.661	8	mon.	399.09	30.04	.7181	6.978	r	28
FeSbS*				± 3.35	± .25	± .0061	± .059		
Pyrite	119.975	4	cubic	159.00	23.940	.57221	5.0116	r	229, 149
FeS_2				± .04	± .007	± .00020	± .0014		251, 105
Marcasite	119.975	2	orth.	81.622	24.579	.58749	4.8813	25	229, 27
FeS_2*				± .060	± .018	± .00047	± .0036		
Ferroselite	213.767	2	orth.	99.50	29.96	.7162	7.134	r	113, 17
$FeSe_2$				± .17	± .05	± .0013	± .013		
Frohbergite	311.047	2	orth.	127.62	38.43	.9185	8.094	r	110
$FeTe_2$				± .17	± .05	± .0013	± .011		
Hauerite	119.066	4	cubic	227.14	34.198	.81741	3.4816	28	229
MnS_2				± .07	± .010	± .00029	± .0010		
Molybdenite	160.068	2	hex.	106.35	32.025	.76547	4.9982	26	258
MoS_2				± .07	± .021	± .00055	± .0033		
Rammelsbergite	208.553	2	orth.	97.645	29.41	.7030	7.091	26	211, 263
$NiAs_2$				± .096	± .03	± .0007	± .007		296

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Sulfides, arsenides, tellurides, selenides, and sulfosalts—Continued									
Pararammelsbergite	208.553	8	orth.	382.42	28.79	.6882	7.244	r	191, 143
$NiAs_2$				± 1.15	± .09	± .0021	± .022		
Gersdorfite	165.696	4	cubic	184.51	27.78	.6640	5.964	26	264
$NiAsS$				± .10	± .01	± .0004	± .003		
Vaesite	122.838	4	cubic	183.96	27.697	.66203	4.4350	r	18, 144
NiS_2				± .05	± .007	± .00022	± .0012		153
	216.63	4	cubic	211.75	31.882	.76204	6.7948	20	111
$NiSe_2$				± .11	± .016	± .00043	± .0034		
Melonite	313.910	1	hex.	68.81	41.44	.9905	7.575	84	269
$NiTe_2$				± .38	± .23	± .0055	± .042		
Sperrylite	344.933	4	cubic	212.56	32.00	.7650	10.778	r	105, 270
$PtAs_2$				± .53	± .08	± .0020	± .027		
Laurite	165.198	4	cubic	175.6	26.44	.6320	6.248	r	9, 17
RuS_2				± 1.9	± .28	± .0068	± .067		62, 183
Tungstenite	247.978	2	hex.	106.50	32.069	.76652	7.7325	26	261
WS_2				± .08	± .023	± .00059	± .0055		
Co-Skutterudite	279.952	8	cubic	552.58	41.599	.99428	6.7298	r	210
$CoAs_{3-x}$ $CoAs_{2.95}$				± .20	± .015	± .00041	± .0025		
Fe-Skutterudite	276.866	8	cubic	547.62	41.226	.98537	6.7158	r	210
$FeAs_{3-x}$ $FeAs_{2.95}$				± .20	± .015	± .00041	± .0025		
Ni-Skutterudite	279.729	8	cubic	578.01	43.513	1.0400	6.4286	r	210
$NiAs_{3-x}$ $NiAs_{2.95}$				± .21	± .016	± .0004	± .0023		
Tennantite	1478.998	2	cubic	1058.09	318.62	7.1652	4.642	r	229
$Cu_{12}As_4S_{13}$				± 1.25	± .38	± .0090	± .006		
Tetrahedrite	1666.312	2	cubic	1101.3	331.64	7.9266	5.024	r	229, 292
$Cu_{12}Sb_4S_{13}$				± 1.3	± .39	± .0094	± .006		

Enargite	393.798	2	orth.	293.03	88.24	2.109	4.463	26	229
Cu_3AsS_4				± .38	± .12	± .003	± .006		
Luzonite	393.798	2	tet.	292.04	87.94	2.1019	4.478	26	229, 96
Cu_3AsS_4*				± .60	± .18	± .0043	± .009		
Famatimite	440.626	2	tet.	312.19	94.01	2.2469	4.687	26	229, 96
Cu_3SbS_4*				± .62	± .19	± .0045	± .009		
Proustite	494.724	6	hex-R	880.89	88.420	2.1133	5.595	26	273
Ag_3AsS_3				± .21	± .021	± .0006	± .001		
Pyrargyrite	541.552	6	hex-R	922.18	92.564	2.2124	5.8506	26	273
Ag_3SbS_3				± .40	± .040	± .0010	± .0025		
Miargyrite	293.748	8	mon.	691.10	52.027	1.244	5.646	r	139
$AgSbS_2$*				± 1.14	± .086	± .002	± .009		

Oxides and hydroxides

Corundum	101.961	6	hex-R	254.78	25.575	.61128	3.9869	25	130, 53
Al_2O_3				± .07	± .007	± .00022	± .0011		176
Boehmite	59.988	4	orth.	129.75	19.535	.46695	3.071	26	256
AlO(OH)*				± .17	± .026	± .00067	± .004		
Diaspore	59.988	4	orth.	117.96	17.760	.4245	3.378	r	40, 256
AlO(OH)*				± .17	± .026	± .0007	± .005		
Gibbsite	78.004	8	mon.	424.49	31.956	.7638	2.441	r	67
$Al(OH)_3$				± .20	± .015	± .0004	± .001		
Arsenolite	197.841	16	cubic	1358.0	51.118	1.2218	3.870	25	254, 11
As_2O_3				± 1.8	± .069	± .0017	± .005		
Claudetite	197.841	4	mon.	313.88	47.259	1.1296	4.1863	25	266
As_2O_3				± .19	± .028	± .0007	± .0025		
Bromellite	25.012	2	hex.	27.592	8.3086	.19862	3.0104	26	16, 254
BeO				± .011	± .0032	± .00012	± .0012		
Bismite	465.958	8	mon.	660.53	49.73	1.1885	9.371	25	266
α-Bi_2O_3				± .77	± .06	± .0014	± .011		
Lime	56.079	4	cubic	111.34	16.764	.40071	3.3453	26	25, 254
CaO				± .03	± .005	± .00017	± .0010		

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Oxides and hydroxides—Continued									
Portlandite	74.095	1	hex.	54.888	33.056	.79011	2.2415	26	25, 254
$Ca(OH)_2$				± .027	± .016	± .00043	± .0011		
Monteponite	128.399	4	cubic	103.51	15.585	.37254	8.2386	27	255
CdO				± .07	± .010	± .00028	± .0053		
Cerianite	172.119	4	cubic	158.43	23.853	.57016	7.216	26	254
CeO_2				± .18	± .026	± .00068	± .008		
	74.933	4	cubic	77.31	11.64	.2782	6.438	26	262
CoO				± .11	± .02	± .0004	± .009		
Eskolaite	151.990	6	hex-R	289.82	29.090	.6953	5.225	r	176, 258
Cr_2O_3				± .32	± .032	± .0008	± .006		
Tenorite	79.539	4	mon.	81.16	12.22	.2921	6.509	26	254
CuO				± .17	± .03	± .0007	± .014		
Cuprite	143.079	2	cubic	77.833	23.437	.56021	6.1047	26	255
Cu_2O				± .055	± .016	± .00044	± .0043		
Wustite	69.221	4	cubic	79.996	12.044	.28791	5.7471	17	285
$Fe_{.953}O$				± .017	± .003	± .00011	± .0012		
Hematite	159.692	6	hex-R	301.61	30.274	.72361	5.2749	25	112, 284
Fe_2O_3				± .12	± .012	± .00034	± .0021		
Magnetite	231.539	8	cubic	591.43	44.524	1.0642	5.2003	22	1, 272
Fe_3O_4				± .11	± .008	± .0002	± .0009		
Goethite	88.854	4	orth.	138.2	20.82	.4975	4.269	r	192
α-FeO(OH)*				± .2	± .04	± .0009	± .008		
Lepidocrocite	88.854	4	orth.	148.54	22.364	.5346	3.973	r	192
γ-FeO(OH)*				± .43	± .064	± .0016	± .011		
	187.438	6	hex-R	288.34	28.943	.69179	6.4762	24	257
α-Ga_2O_3				± .13	± .013	± .00036	± .0030		

Low-germania GeO_2	104.589	2	tet.	55.327 ± .032	16.660 ± .010	.39824 ±.00027	6.2777 ±.0036	25	261, 12
High-germania GeO_2	104.589	3	hex.	121.73 ± .11	24.438 ± .021	.58413 ±.00056	4.2797 ±.0038	26	254, 243
Ice H_2O	18.015	4	hex.	130.41 ± .06	19.635 ± .009	.46932 ±.00026	.9175 ±.0004	0	147
Hafnia HfO_2	210.489	4	mon.	138.30 ± .06	20.823 ± .008	.49772 ±.00025	10.108 ±.004	r	3
Montroydite HgO	216.589	4	orth.	128.3 ± .1	19.32 ± .02	.4618 ±.0006	11.21 ±.01	25	262
Periclase MgO	40.311	4	cubic	74.709 ± .027	11.248 ± .004	.26889 ±.00014	3.5837 ±.0013	25	227, 254
Brucite $Mg(OH)_2$	58.327	1	hex.	40.90 ± .11	24.63 ± .07	.5888 ±.0016	2.368 ±.006	26	259
Manganosite MnO	70.937	4	cubic	87.813 ± .030	13.221 ± .004	.31604 ±.00015	5.3653 ±.0018	26	258, 101
Pyrolusite MnO_2	86.937	2	tet.	55.16 ± .08	16.61 ± .02	.3971 ±.0007	5.234 ±.008	r	286, 67
Bixbyite Mn_2O_3	157.874	16	cubic	833.5 ± 1.3	31.37 ± .05	.7499 ±.0012	5.032 ±.008	25	262
Hausmanite Mn_3O_4	228.812	8	tet.	623.68 ± .84	46.95 ± .06	1.1222 ±.0016	4.873 ±.007	20	277
Molybdite MoO_3	143.938	4	orth.	202.98 ± .25	30.56 ± .04	.7305 ±.0010	4.710 ±.006	26	256
Bunsenite NiO	74.709	4	cubic	72.88 ± .10	10.97 ± .02	.2623 ±.0004	6.809 ±.010	26	254
Litharge PbO red	223.189	2	tet.	79.40 ± .17	23.91 ± .05	.5715 ±.0013	9.334 ±.020	27	255
Massicot PbO yellow	223.189	4	orth.	153.8 ± .2	23.15 ± .03	.5533 ±.0007	9.641 ±.012	27	255
Minium Pb_3O_4	685.568	4	tet.	510.13 ± .62	76.81 ± .09	1.836 ±.002	8.926 ±.009	25	261

Molar Volumes and Densities of Minerals

Name and formula -	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Oxides and hydroxides—Continued									
Senarmontite	291.498	16	cubic	1386.9	52.206	1.2478	5.5837	26	256
Sb_2O_3				± 1.1	± .042	± .0011	± .0045		
Valentinite	291.498	4	orth.	332.13	50.007	1.1952	5.8292	25	263
Sb_2O_3				± .31	± .047	± .0012	± .0054		
Cervantite	307.498	8	cubic	1094.3	82.38	1.9690	3.733	26	263
Sb_2O_4				± 1.6	± .12	± .0029	± .005		
Selenolite	110.959	8	tet.	354.2	26.66	.6373	4.161	26	254
SeO_2				± 1.1	± .08	± .0020	± .013		
α-Quartz	60.085	3	hex.	113.01	22.688	.54229	2.6483	25	90, 53
SiO_2*				± .01	± .001	± .00007	± .0001		242
β-Quartz	60.085	3	hex.	118.15	23.718	.5669	2.533	575	90, 131
SiO_2*				± .06	± .013	± .0004	± .002		
α-Cristobalite	60.085	4	tet.	170.95	25.739	.61521	2.3344	25	263, 65
SiO_2				± .22	± .033	± .00083	± .0030		
β-Cristobalite	60.085	8	cubic	363.72	27.381	.65447	2.1944	405	245
SiO_2				± .15	± .012	± .00032	± .0009		
Keatite	60.085	12	tet.	478.3	24.01	.5738	2.503	r	225, 89
SiO_2				± .5	± .02	± .0006	± .003		
β-Tridymite	60.085	4	hex.	182.08	27.414	.65527	2.1917	405	245
SiO_2				± .16	± .024	± .00062	± .0019		
Coesite	60.085	16	mon.	548.37	20.641	.49338	2.9110	25	230, 300
SiO_2*				± .95	± .036	± .00090	± .0050		
Stishovite	60.085	2	tet.	46.540	14.014	.33500	4.2874	r	44
SiO_2*				± .028	± .009	± .00025	± .0026		
Melanophlogite	60.085	46	cubic	2407.2	31.516	.75325	1.9065	r	232, 136
SiO_2*				± 2.2	± .028	± .00072	± .0017		

Cassiterite	150.689	2	tet.	71.57	21.55	.5151	6.992	26	254
SnO_2				± .11	± .03	± .0009	± .011		
Tellurite	159.599	8	orth.	368.61	27.750	.66328	5.7514	25	262, 20
TeO_2*				± .32	± .024	± .00062	± .0050		
Paratellurite	159.599	4	tet.	176.14	26.52	.6339	6.018	25	263
TeO_2				± .15	± .02	± .0006	± .005		
Thorianite	264.037	4	cubic	175.16	26.373	.63038	10.012	25	227, 254
ThO_2				± .05	± .007	± .00021	± .003		
Rutile	79.899	2	tet.	62.500	18.820	.44986	4.2453	25	252, 55
TiO_2				± .025	± .008	± .00023	± .0017		254
Anatase	79.899	4	tet.	136.30	20.522	.4905	3.893	r	55, 254
TiO_2				± .17	± .025	± .0007	± .005		
Brookite	79.899	8	orth.	257.6	19.40	.4636	4.119	r	266
TiO_2*				± .2	± .02	± .0005	± .004		
Titanium sesquioxide	143.798	6	hex-R	313.2	31.44	.7515	4.574	r	176
Ti_2O_3				± .3	± .03	± .0009	± .005		
Uraninite	270.029	4	cubic	163.51	24.618	.58843	10.969	26	255
UO_2				± .09	± .014	± .00037	± .006		
Karelianite	149.882	6	hex-R	297.36	29.848	.71342	5.0216	r	176
V_2O_3				± .32	± .032	± .00081	± .0054		
Zincite	81.369	2	hex.	47.615	14.338	.34273	5.6750	25	120
ZnO				± .015	± .005	± .00016	± .0018		
Baddeleyite	123.219	4	mon.	140.46	21.148	.50548	5.8267	r	3, 241
ZrO_2				± .06	± .009	± .00025	± .0023		
				Multiple oxides					
Spinel	142.273	8	cubic	527.5	39.71	.9492	3.583	26	255
$MgAl_2O_4$				± .4	± .03	± .0008	± .003		
Hercynite	173.808	8	cubic	541.3	40.75	.9740	4.265	25	275
$FeAl_2O_4$				± .6	± .05	± .0011	± .005		
Galaxite	172.899	8	cubic	563.2	42.39	1.013	4.078	25	262
$MnAl_2O_4$				± .4	± .03	± .001	± .003		

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Multiple oxides—Continued									
Gahnite $ZnAl_2O_4$	183.331	8	cubic	528.45 ± .39	39.783 ± .030	.95088 ± .00075	4.6083 ± .0034	26	255
Magnetite $FeFe_2O_4$	231.539	8	cubic	591.43 ± .11	44.524 ± .008	1.0642 ± .0002	5.2003 ± .0009	22	272
Jacobsite $MnFe_2O_4$	230.630	8	cubic	613.9 ± .4	46.22 ± .03	1.105 ± .001	4.990 ± .004	25	262
Trevorite $NiFe_2O_4$	234.402	8	cubic	579.9 ± .6	43.65 ± .05	1.043 ± .001	5.370 ± .006	25	263
Picrochromite $MgCr_2O_4$	192.302	8	cubic	578.6 ± .6	43.56 ± .05	1.041 ± .001	4.415 ± .005	26	262
Ilmenite $FeTiO_3$	151.745	6	hex-R	315.73 ± .75	31.69 ± .08	.7574 ± .0019	4.788 ± .012	r	186
Geikielite $MgTiO_3$	120.210	6	hex-R	307.44 ± .65	30.86 ± .07	.7376 ± .0016	3.896 ± .008	26	258
Pyrophanite $MnTiO_3$	150.836	6	hex-R	326.3 ± .7	32.76 ± .07	.7829 ± .0017	4.605 ± .010	r	214
Cobalt Titanate $CoTiO_3$	154.831	6	hex-R	309.34 ± .17	31.05 ± .02	.7422 ± .0004	4.986 ± .003	r	177
Perovskite $CaTiO_3$	135.978	4	orth.	223.33 ± .07	33.626 ± .010	.80371 ± .00028	4.0439 ± .0012	r	137
Chrysoberyl $BeAl_2O_4$	126.973	4	orth.	227.94 ± .15	34.320 ± .023	.82031 ± .00059	3.6997 ± .0025	25	262, 80
Halides									
Halite NaCl	58.443	4	cubic	179.43 ± .02	27.015 ± .003	.64571 ± .00011	2.1634 ± .0002	26	255

Sylvite	74.555	4	cubic	249.23	37.524	.89690	1.9868	25	254, 126
KCl				± .02	± .004	± .00013	± .0002		
Villiaumite	41.988	4	cubic	99.523	14.984	.35818	2.8021	25	254
NaF				± .032	± .005	± .00016	± .0009		
Chlorargyrite	143.323	4	cubic	170.87	25.727	.61493	5.5710	26	257
AgCl				± .05	± .007	± .00021	± .0015		
Bromargyrite	187.779	4	cubic	192.55	28.991	.69294	6.4772	26	257
AgBr				± .05	± .008	± .00022	± .0017		
Nantockite	98.993	4	cubic	158.87	23.92	.5717	4.139	25	257
CuCl				± .26	± .04	± .0010	± .007		
Marshite	190.444	4	cubic	221.52	33.353	.7972	5.710	26	257
CuI				± .11	± .017	± .0004	± .003		
Miersite	234.774	4	cubic	274.16	41.278	.9866	5.688	r	279
AgI				± .10	± .020	± .0004	± .003		
Iodargyrite	234.774	2	hex.	137.18	41.308	.9873	5.683	25	279, 261
AgI				± .10	± .030	± .0009	± .004		
Calomel	236.043	4	tet.	218.77	32.939	.7873	7.166	26	254
HgCl				± .50	± .075	± .0018	± .016		
Fluorite	78.077	4	cubic	163.11	24.558	.58701	3.1792	25	10, 254
CaF_2				± .04	± .005	± .00017	± .0007		5
Sellaite	62.309	2	tet.	65.13	19.61	.4688	3.177	18	70, 257
MgF_2				± .04	± .01	± .0003	± .002		
Chloromagnesite	95.218	3	hex-R	203.29	40.81	.9754	2.333	r	83
$MgCl_2$				± .48	± .10	± .0024	± .006		
Lawrencite	126.753	3	hex-R	196.55	39.46	.9431	3.212	r	83
$FeCl_2$				± 1.06	± .21	± .0051	± .017		
Scacchite	125.844	3	hex-R	209.79	42.11	1.007	2.988	r	83
$MnCl_2$				± .86	± .17	± .004	± .012		
Cotunnite	278.096	4	orth.	312.74	47.09	1.1254	5.906	26	255
$PbCl_2$				± .64	± .10	± .0023	± .012		
Matlockite	361.641	2	tet.	121.89	36.70	.8773	9.853	26	254
PbFCl				± .34	± .10	± .0025	± .028		

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Halides—Continued									
Cryolite Na_3AlF_6*	209.941	2	mon.	235.1 ± .7	70.81 ± .20	1.692 ± .005	2.965 ± .009	r	186
Neighborite $NaMgF_3$	104.297	4	orth.	226.54 ± .07	34.11 ± .01	.8152 ± .0003	3.058 ± .001	18	43
Carbonates and nitrates									
Calcite $CaCO_3$	100.089	6	hex-R	367.96 ± .15	36.934 ± .015	.88278 ± .00041	2.7100 ± .0011	26	107, 15 46
Otavite $CdCO_3$	172.409	6	hex-R	341.72 ± .15	34.300 ± .015	.81983 ± .00041	5.0265 ± .0022	26	107
Cobalticalcite $CoCO_3$	118.943	6	hex-R	281.07 ± .13	28.213 ± .013	.67435 ± .00036	4.2159 ± .0020	26	107
Siderite $FeCO_3$	115.856	6	hex-R	292.68 ± .14	29.378 ± .014	.70219 ± .00037	3.9436 ± .0018	26	107
Magnesite $MgCO_3$	84.321	6	hex-R	279.13 ± .13	28.018 ± .013	.66969 ± .00036	3.0095 ± .0014	26	107, 260
Rhodochrosite $MnCO_3$	114.947	6	hex-R	309.57 ± .14	31.073 ± .014	.74272 ± .00039	3.6992 ± .0017	26	107, 260
Nickelous Carbonate $NiCO_3$	118.719	6	hex-R	269.51 ± .12	27.052 ± .012	.64660 ± .00034	4.3886 ± .0020	26	107
Smithsonite $ZnCO_3$	125.379	6	hex-R	281.69 ± .13	28.275 ± .013	.67583 ± .00037	4.4343 ± .0021	26	107, 261
Dolomite $CaMg(CO_3)_2$*	184.411	3	hex-R	320.50 ± .15	64.341 ± .029	1.5378 ± .0008	2.8661 ± .0013	26	107
Huntite $Mg_3Ca(CO_3)_4$*	353.053	3	hex-R	610.63 ± .50	122.58 ± .10	2.9299 ± .0024	2.880 ± .002	26	107

Norsethite	281.671	3	hex-R	365.6	73.39	1.754	3.838	r	168
$BaMg(CO_3)_2$*				± .8	± .17	± .004	± .009		
Vaterite	100.089	6	hex.	375.80	37.72	.9016	2.653	r	157, 150
$CaCO_3$				± .61	± .06	± .0015	± .004		
Witherite	197.349	4	orth.	304.24	45.81	1.095	4.308	26	255
$BaCO_3$				± .41	± .06	± .002	± .006		
Aragonite	100.089	4	orth.	226.85	34.15	.8164	2.930	26	256
$CaCO_3$				± .33	± .05	± .0012	± .004		
Cerussite	267.199	4	orth.	269.61	40.59	.9702	6.582	26	255
$PbCO_3$				± .38	± .06	± .0014	± .009		
Strontianite	147.629	4	orth.	259.07	39.01	.9323	3.785	26	256, 230
$SrCO_3$				± .37	± .06	± .0014	± .005		
Shortite	306.168	2	orth.	389.6	117.3	2.804	2.610	r	169
$Na_2Ca_2(CO_3)_3$				± 1.0	± .3	± .007	± .007		
Malachite	221.104	4	mon.	364.35	54.86	1.311	4.030	25	263
$Cu_2(OH)_2CO_3$				± .54	± .08	± .002	± .006		
Azurite	344.653	2	mon.	302.22	91.01	2.1752	3.787	25	263
$Cu_3(OH)_2(CO_3)_2$				± .43	± .13	± 0031	± .005		
Niter	101.107	4	orth.	319.07	48.04	1.148	2.105	26	256
KNO_3				± .42	± .06	± .002	± .003		
Soda Niter	84.995	6	hex-R	374.57	37.598	.89866	2.2606	25	259
$NaNO_3$				± .19	± .019	± .00049	± .0011		
Gerhardite	240.107	4	orth.	469.21	70.65	1.689	3.399	r	184
$Cu_2(NO_3)(OH)_3$				± .53	± .08	± .002	± .004		

Sulfates and borates

Barite	233.402	4	orth.	346.05	52.10	1.245	4.480	26	256
$BaSO_4$				± .40	± .06	± .002	± .005		
Anhydrite	136.142	4	orth.	305.09	45.94	1.098	2.964	26	257, 45
$CaSO_4$				± .39	± .06	± .002	± .004		
Anglesite	303.252	4	orth.	318.50	47.95	1.146	6.324	25	256
$PbSO_4$				± .38	± .06	± .002	± .008		

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Sulfates and borates—Continued									
Celestite $SrSO_4$	183.682	4	orth.	307.17 ± .41	46.25 ± .06	1.105 ± .002	3.972 ± .005	26	97, 255
Zinkosite $ZnSO_4$	161.432	4	orth.	276.10 ± .46	41.57 ± .07	.9936 ± .0017	3.883 ± .006	25	260
Arcanite K_2SO_4	174.266	4	orth.	435.03 ± .49	65.50 ± .07	1.566 ± .002	2.661 ± .003	25	256
Mascagnite $(NH_4)_2SO_4$	132.139	4	orth.	496.04 ± .57	74.68 ± .09	1.7851 ± .0021	1.7693 ± .0020	25	262
Thenardite Na_2SO_4	142.041	8	orth.	708.47 ± .76	53.33 ± .06	1.275 ± .002	2.663 ± .003	25	255
Gypsum $CaSO_4.2H_2O$*	172.172	4	mon.	496.1 ± 1.5	74.69 ± .22	1.785 ± .005	2.305 ± .007	r	186
Epsomite $MgSO_4.7H_2O$	246.481	4	orth.	975.22 ± 1.53	146.83 ± .23	3.5094 ± .0055	1.679 ± .003	25	260
Goslarite $ZnSO_4.7H_2O$	287.539	4	orth.	968.29 ± .72	145.79 ± .11	3.4845 ± .0026	1.9723 ± .0015	25	261
Mirabilite $Na_2SO_4.10H_2O$	322.195	4	mon.	1459.9 ± 2.6	219.8 ± .4	5.253 ± .009	1.466 ± .003	24	215
Chalcanthite $CuSO_4.5H_2O$	249.678	2	tri.	361.88 ± .72	108.97 ± .22	2.6045 ± .0052	2.2912 ± .0046	r	85
Brochantite $Cu_4SO_4(OH)_6$*	452.266	4	mon.	754.3 ± 1.8	113.6 ± .2	2.715 ± .006	3.982 ± .009	r	67
Syngenite $K_2Ca(SO_4)_2.H_2O$	328.423	2	mon.	424.27 ± .68	127.76 ± .20	3.0535 ± .0049	2.5707 ± .0041	r	7
Alunite $KAl_3(SO_4)_2(OH)_6$	414.214	3	hex-R	731.2 ± 1.1	146.8 ± .2	3.508 ± .005	2.822 ± .004	r	22, 188 281

Natroalunite	398.102	3	hex-R	702.99	141.1	3.373	2.821	r	188
$NaAl_3(SO_4)_2(OH)_6$				± 1.09	± .2	± .005	± .004		
Hexahydrite	228.466	8	mon.	1761.2	132.58	3.1689	1.7232	r	298
$MgSO_4.6H_2O$				± 1.6	± .12	± .0029	± .0015		
Leonhardtite	192.435	4	mon.	636.78	95.88	2.2915	2.0071	r	13
$MgSO_4.4H_2O$				± .78	± .12	± .0029	± .0025		
Melanterite	278.016	4	mon.	973.29	146.54	3.5025	1.8972	r	14
$FeSO_4.7H_2O$				± 1.69	± .25	± .0061	± .0033		
Vanthoffite	546.497	2	mon.	678.96	204.45	4.8866	2.6730	r	86
$MgSO_4.3Na_2SO_4$				± .65	± .20	± .0047	± .0025		
Dolerophanite	239.141	4	mon.	380.77	57.33	1.3703	4.171	r	87
$Cu_2O(SO_4)$				± .70	± .11	± .0026	± .008		
Retgersite	262.864	4	tet.	840.80	126.59	3.0257	2.076	25	260
$NiSO_4.6H_2O$				± 1.09	± .16	± .0040	± .003		
Colemanite	205.548	4	mon.	564.26	84.957	2.0306	2.4194	r	47
$CaB_3O_4(OH)_3.H_2O$*				± .49	± .073	± .0018	± .0021		
Borax	381.373	4	mon.	1478.8	222.66	5.3217	1.7128	r	163
$Na_2B_4O_7.10H_2O$				± 1.1	± .17	± .0041	± .0013		
Kernite	273.281	4	mon.	953.40	143.55	3.4309	1.9038	r	213
$Na_2B_4O_7.4H_2O$				± 1.61	± .24	± .0058	± .0032		
Hambergite	93.841	8	orth.	526.79	39.658	.9479	2.3663	r	297
$Be_2BO_3.(OH,F)$*				± .14	± .011	± .0003	± .0006		

Phosphates, molybdates, and tungstates

Berlinite	121.953	3	hex.	232.03	46.58	1.113	2.618	25	263
$AlPO_4$				± .50	± .10	± .002	± .006		
Xenotime	183.876	4	tet.	283.57	42.69	1.020	4.307	26	261, 142
YPO_4				± .48	± .07	± .002	± .008		
Hydroxylapatite	502.322	2	hex.	528.7	159.2	3.805	3.155	r	158, 204
$Ca_5(PO_4)_3OH$				± .5	± .2	± .004	± .004		
Fluorapatite	504.313	2	hex.	523.25	157.56	3.7659	3.2007	25	266
$Ca_5(PO_4)_3F$				± .41	± .12	± .0030	± .0025		

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Phosphates—Continued									
Chlorapatite $Ca_5(PO_4)_3Cl$	520.767	2	hex.	544.16 ± .61	163.86 ± .19	3.916 ±.004	3.178 ±.004	r	67
Carbonate-apatite $Ca_{10}(PO_4)_6CO_3H_2O$	1048.653	1	hex.	530.74 ± 1.36	319.6 ± .8	7.640 ±.020	3.281 ±.008	r	239
Turquois $CuAl_6(PO_4)_4(OH)_8.4H_2O$*	813.435	1	tri.	461.40 ± 1.12	277.9 ± .7	6.6416 ±.0162	2.927 ±.007	r	48
Powellite $CaMoO_4$	200.018	4	tet.	312.17 ± .63	47.00 ± .09	1.1234 ±.0023	4.256 ±.009	25	259
Wulfenite $PbMoO_4$	367.128	4	tet.	357.72 ± .69	53.859 ± .104	1.2873 ±.0025	6.816 ±.013	25	260
Scheelite $CaWO_4$	287.928	4	tet.	312.49 ± .61	47.049 ± .092	1.1245 ±.0023	6.120 ±.012	25	259
Stolzite $PbWO_4$	455.038	4	tet.	359.32 ± .42	54.100 ± .064	1.2931 ±.0016	8.4110 ±.0099	25	260
Ferberite $FeWO_4$	303.695	2	mon.	134.11 ± .17	40.38 ± .05	.9652 ±.0013	7.520 ±.010	r	222
Huebnerite $MnWO_4$	302.768	2	mon.	139.11 ± .20	41.89 ± .06	1.001 ±.002	7.228 ±.010	r	222, 265
Wolframite $Fe_{.5}Mn_{.5}WO_4$	303.240	2	mon.	136.53 ± .18	41.11 ± .06	.9826 ±.0014	7.376 ±.010	r	222
Sanmartinite $ZnWO_4$	313.218	2	mon.	132.14 ± .14	39.79 ± .04	.9511 ±.0010	7.872 ±.008	25	265
Ortho and ring structure silicates									
Forsterite Mg_2SiO_4	140.708	4	orth.	290.81 ± .18	43.786 ± .027	1.0465 ±.0007	3.2136 ±.0020	25	230, 118

Fayalite	203.778	4	orth.	308.11	46.389	1.1088	4.3928	r	295
Fe_2SiO_4				± .62	± .093	± .0023	± .0088		
Tephroite	201.960	4	orth.	322.87	48.612	1.1619	4.1545	r	125
Mn_2SiO_4*				± .45	± .067	± .0017	± .0058		
Lime Olivine	172.244	4	orth.	392.61	59.11	1.4129	2.914	r	240
γCa_2SiO_4				± 1.19	± .18	± .0043	± .009		
Nickel Olivine	209.504	4	orth.	282.98	42.61	1.0184	4.917	r	179, 203
Ni_2SiO_4				± .21	± .03	± .0008	± .004		
Cobalt Olivine	209.950	4	orth.	295.70	44.52	1.0642	4.716	r	181, 203
Co_2SiO_4				± .21	± .03	± .0008	± .003		
Monticellite	156.476	4	orth.	341.13	51.362	1.2276	3.046	r	219
$CaMgSiO_4$				± .47	± .071	± .0017	± .004		
Kerschsteinite	188.011	4	orth.	350.39	52.756	1.2609	3.564	r	219
$CaFeSiO_4$				± .67	± .101	± .0025	± .007		
Knebelite	202.869	4	orth.	317.11	47.74	1.1412	4.249	r	57
$MnFeSiO_4$*				± .88	± .13	± .0032	± .012		
Glauchroite	187.102	4	orth.	361.2	54.38	1.2997	3.441	r	42
$CaMnSiO_4$				± .9	± .14	± .0032	± .009		
Fluor--Norbergite	203.016	4	orth.	422.09	63.551	1.5190	3.194	25	263
$Mg_2SiO_4.MgF_2$				± .51	± .077	± .0019	± .004		
Chondrodite	343.724	2	mon.	364.0	109.6	2.620	3.136	r	218, 57
$2Mg_2SiO_4.MgF_2$*				± 2.4	± .7	± .017	± .021		
Fluor-Humite	484.432	4	orth.	1004.9	151.31	3.6163	3.2017	25	264, 218
$3Mg_2SiO_4.MgF_2$				± 1.2	± .18	± .0042	± .0037		
Clinohumite	625.139	2	mon.	655.5	197.4	4.717	3.167	r	218, 57
$4Mg_2SiO_4.MgF_2$*				± 3.8	± 1.1	± .027	± .018		
Grossularite	450.454	8	cubic	1664.43	125.30	2.9948	3.595	25	226, 2
$Ca_3Al_2Si_3O_{12}$				± .42	± .03	± .0008	± .001		
Uvarovite	500.483	8	cubic	1727.57	130.05	3.1084	3.848	26	263
$Ca_3Cr_2Si_3O_{12}$				± .86	± .07	± .0016	± .002		
Andradite	508.185	8	cubic	1748.82	131.65	3.1466	3.860	25	226
$Ca_3Fe_2Si_3O_{12}$				± .44	± .03	± .0008	± .001		

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Ortho and ring structure silicates—Continued									
Goldmanite $Ca_3V_2Si_3O_{12}$	498.375	8	cubic	1758.42 ± 2.19	132.38 ± .16	3.1639 ± .0040	3.765 ± .005	r	253
Almandite $Fe_3Al_2Si_3O_{12}$	497.755	8	cubic	1531.21 ± .40	115.27 ± .04	2.7551 ± .0008	4.318 ± .001	25	226
Pyrope $Mg_3Al_2Si_3O_{12}$	403.150	8	cubic	1504.67 ± .39	113.27 ± .03	2.7074 ± .0008	3.559 ± .001	25	226, 100
Spessartite $Mn_3Al_2Si_3O_{12}$	495.028	8	cubic	1569.39 ± .41	118.15 ± .03	2.8238 ± .0008	4.190 ± .001	25	226
Zircon $ZrSiO_4$*	183.304	4	tet.	260.76 ± .45	39.261 ± .068	.9384 ± .0017	4.669 ± .008	25	257, 146
Thorite $ThSiO_4$	324.122	4	tet.	322.82 ± .39	48.60 ± .06	1.1617 ± .0015	6.668 ± .008	r	95
Coffinite $USiO_4$	330.114	4	tet.	306.45 ± .43	46.140 ± .064	1.103 ± .002	7.155 ± .010	r	95
Kyanite Al_2SiO_5*	162.046	4	tri.	292.83 ± .45	44.09 ± .07	1.054 ± .002	3.675 ± .006	25	236, 34
Andalusite Al_2SiO_5*	162.046	4	orth.	342.25 ± .27	51.530 ± .040	1.2316 ± .0010	3.145 ± .002	25	236, 38
Sillimanite Al_2SiO_5*	162.046	4	orth.	331.42 ± .30	49.899 ± .044	1.1927 ± .0011	3.248 ± .003	25	236, 35
3.2 Mullite $3Al_2O_3.2SiO_2$	426.053	3/4	orth.	167.56 ± .09	134.55 ± .07	3.2159 ± .0016	3.166 ± .002	r	4
2.1 Mullite $2Al_2O_3.SiO_2$	264.007	6/5	orth.	168.35 ± .09	84.492 ± .043	2.0195 ± .0011	3.125 ± .002	r	4, 36 216
Staurolite $Fe_2Al_9Si_4O_{22}(OH)_2$*	852.873	2	mon.	740.5 ± 17.5	223.0 ± 5.3	5.330 ± .126	3.825 ± .090	r	57

Topaz	184.043	4	orth.	343.10	51.66	1.2347	3.563	26	264, 146
$Al_2(SiO_4)(OH)$*				± .41	± .06	± .0015	± .005		
Phenacite	110.108	18	hex-R	1111.6	37.194	.8890	2.960	25	261
Be_2SiO_4*				± 1.1	± .037	± .0009	± .003		
Willemite	222.824	18	hex-R	1566.6	52.42	1.253	4.251	25	260
Zn_2SiO_4				± 2.3	± .08	± .002	± .006		
Dioptase	156.632	18	hex-R	1441.9	48.24	1.153	3.247	r	119
CuH_2SiO_4*				± 4.4	± .15	± .004	± .010		
Larnite	172.244	4	mon.	342.7	51.60	1.233	3.338	r	161
β-Ca_2SiO_4*				± 1.8	± .27	± .006	± .017		
Akermanite	272.640	2	tet.	308.22	92.812	2.2183	2.9375	r	6, 174
$Ca_2MgSi_2O_7$				± .30	± .090	± .0022	± .0029		182, 77
Gehlenite	274.205	2	tet.	299.67	90.239	2.1568	3.0387	r	6, 174
$Ca_2Al_2SiO_7$				± .29	± .088	± .0022	± .0030		182, 77
Fe-Gehlenite	331.936	2	tet.	276.01	83.12	1.9865	3.994	r	182
$Ca_2Fe_2SiO_7$				± .79	± .24	± .0057	± .011		
Hardystonite	313.698	2	tet.	310.3	93.44	2.233	3.357	r	67
$Ca_2ZnSi_2O_7$*				± 2.7	± .80	± .019	± .029		
Sodium Melilite	258.219	2	tet.	348.35	104.90	2.507	2.462	r	182
$NaCaAlSi_2O_7$				± .46	± .14	± .003	± .003		
Beryl	537.505	2	hex.	675.98	203.55	4.8651	2.641	25	262
$Be_3Al_2(Si_6O_{18})$*				± .82	± .25	± .0060	± .003		
Indialite high Cordierite	584.969	2	hex.	773.02	232.78	5.5636	2.513	25	223, 264
$Mg_2Al_3(AlSi_5O_{18})$				± .54	± .16	± .0039	± .002		
Low Cordierite	584.969	4	orth.	1548.96	233.22	5.5741	2.508	25	264, 223
$Mg_2Al_3(AlSi_5O_{18})$				± .88	± .13	± .0032	± .001		73, 99
Fe-Indialite	648.039	2	hex.	781.75	235.40	5.6264	2.753	r	162, 57
$Fe_2Al_3(AlSi_5O_{18})$				± 1.80	± .54	± .0130	± .006		
Fe-Cordierite	648.039	4	orth.	1541.40	232.08	5.5468	2.792	r	73
$Fe_2Al_3(AlSi_5O_{18})$				± 2.47	± .37	± .0089	± .005		
Mn-Indialite	646.221	2	hex.	793.11	238.8	5.708	2.706	r	73
$Mn_2Al_3(AlSi_5O_{18})$				± .81	± .5	± .013	± .006		

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Ortho and ring structure silicates—Continued									
Sapphirine	344.630	8	mon.	1321.7	99.50	2.378	3.464	r	57
$Mg_2Al_4O_6SiO_4$*				± 9.7	± .73	±.017	±.025		
Elbaite	1000.198	3	hex-R	1523.4	305.82	7.3093	3.271	r	74, 32
$NaLiAl_{7.67}B_3Si_6O_{27}(OH)_4$*				± 2.9	± .58	±.0140	±.006		
Schorl	1053.382	3	hex-R	1591.3	319.45	7.635	3.297	r	74
$NaFe_3Al_6B_3Si_6O_{27}(OH)_4$*				± 3.0	± .60	±.014	±.006		
Dravite	958.777	3	hex-R	1589.99	319.19	7.629	3.004	r	74, 209
$NaMg_3Al_6B_3Si_6O_{27}(OH)_4$				± 2.97	± .60	±.014	±.006		32
Uvite	973.198	3	hex-R	1566.3	314.4	7.515	3.095	r	209
$CaMg_4Al_5B_3Si_6O_{27}(OH)_4$				± 2.9	± .6	±.014	±.006		
Sphene	196.063	4	mon.	369.61	55.65	1.330	3.523	r	67
$CaTiSiO_5$*				± 1.13	± .17	±.004	±.011		
Datolite	159.982	4	mon.	353.9	53.28	1.273	3.003	r	127
$CaBSiO_4(OH)$*				± 2.3	± .35	±.008	±.020		
Euclase	145.085	4	mon.	309.30	46.57	1.113	3.116	r	170
$AlBeSiO_4(OH)$*				± .64	± .10	±.002	±.007		
Chloritoid	251.908	8	mon.	924.6	69.61	1.664	3.619	r	116
$H_2FeAl_2SiO_7$*				± 2.2	± .16	±.004	±.008		
Hemimorphite	481.678	2	orth.	459.36	138.32	3.306	3.482	25	255
$Zn_4(OH)_2Si_2O_7.H_2O$*				± .57	± .17	±.004	±.004		
Zoisite	454.363	4	orth.	906.74	136.52	3.263	3.328	r	202
$Ca_2Al_3(SiO_4)_3OH$				± 1.34	± .20	±.005	±.005		
Clinozoisite	454.363	2	mon.	452.30	136.20	3.255	3.336	r	202
$Ca_2Al_3(SiO_4)_3OH$				± 1.45	± .44	±.010	±.011		
Epidote	497.660	2	mon.	460.72	138.7	3.316	3.587	r	224
$Ca_2Al_{1.5}Fe_{1.5}(SiO_4)_3OH$*				± 1.97	± .6	±.014	±.015		

Piemontite	496.297	2	mon.	432.56	130.3	3.113	3.810	r	57
$Ca_2Al_{1.5}Mn_{1.5}(SiO_4)_3OH$*				± 2.38	± .7	± .017	± .021		
Lawsonite	314.241	4	orth.	672.96	101.32	2.4217	3.101	r	201, 185
$CaAl_2Si_2O_7(OH)_2.H_2O$				± .80	± .12	± .0029	± .004		
Chain and band structure silicates									
Enstatite	100.396	16	orth.	835.21	31.44	.7514	3.194	r	52, 259
$MgSiO_3$*				± 1.32	± .05	± .0012	± .005		122
Clinoenstatite	100.396	8	mon.	418.10	31.47	.7523	3.190	r	164
$MgSiO_3$				± .66	± .05	± .0012	± .005		
Protoenstatite	100.396	8	orth.	430.10	32.38	.7739	3.101	r	24
$MgSiO_3$				± 1.05	± .08	± .0019	± .008		
High Clinoenstatite	100.396	8	tri.	433.72	32.65	.7804	3.075		200
$MgSiO_3$				± .40	± .03	± .0008	± .003		
Clinoferrosilite	131.931	8	mon.	437.60	32.943	.7874	4.005	r	37
$FeSiO_3$				± .15	± .011	± .0003	± .002		
Orthoferrosilite	131.931	16	orth.	876.6	33.00	.7887	3.998	r	37, 287
$FeSiO_3$				± .54	± .02	± .0008	± .004		
Diopside	216.560	4	mon.	438.97	66.09	1.580	3.277	r	220, 49
$CaMg(SiO_3)_2$				± .69	± .10	± .003	± .005		
Hedenbergite	248.095	4	mon.	453.64	68.30	1.632	3.632	r	145
$CaFe(SiO_3)_2$*				± 1.28	± .19	± .005	± .010		
Johannsenite	247.186	4	mon.	452.35	68.11	1.628	3.629	r	58
$CaMn(SiO_3)_2$*				± 2.87	± .43	± .010	± .023		
Ureyite	227.154	4	mon.	418.6	63.02	1.506	3.605	r	91
$NaCr(SiO_3)_2$				± 1.1	± .16	± .004	± .009		
Jadeite	202.140	4	mon.	401.15	60.40	1.444	3.347	r	205
$NaAl(SiO_3)_2$*				± .67	± .10	± .002	± .006		
Acmite (Aegirine)	284.968	4	mon.	429.06	64.60	1.544	4.411	r	180
$NaFe(SiO_3)_2$				± .70	± .11	± .003	± .007		
Ca Tschermak Molecule	218.125	4	mon.	421.77	63.50	1.518	3.435	r	49
$CaAl_2SiO_6$				± .59	± .09	± .002	± .005		

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Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Chain and band structure silicates—Continued									
Spodumene	186.090	4	mon.	387.7	58.37	1.395	3.188	r	249, 58
$LiAl(SiO_3)_2$				± .1	± .02	±.001	±.001		
β-Spodumene	186.090	4	tet.	519.48	78.215	1.8694	2.379	r	238
$LiAl(SiO_3)_2$				± .12	± .018	±.0005	±.001		
Pectolite	332.410	2	tri.	383.84	115.58	2.763	2.876	r	33, 31
$Ca_2NaH(SiO_3)_3$*				± .99	± .30	±.007	±.007		
Wollastonite	116.164	6	tri.	397.82	39.93	.9544	2.909	r	31, 190
$CaSiO_3$*				± 1.03	± .10	±.0025	±.008		33
Parawollastonite	116.164	12	mon.	793.98	39.85	.9524	2.915	r	271, 190
$CaSiO_3$*				± .47	± .02	±.0006	±.002		
Pseudowollastonite	116.164	24	tri.	1597.0	40.08	.9579	2.899	r	132
$CaSiO_3$*				± 5.6	± .14	±.0034	±.010		
Rhodonite	131.022	10	tri.	583.77	35.158	.8403	3.727	r	196
$MnSiO_3$*				± .31	± .019	±.0005	±.002		
Bustamite	247.186	6	tri.	740.38	74.32	1.776	3.326	r	197, 195
$CaMn(SiO_3)_2$*				± 1.08	± .11	±.003	±.005		
Pyroxmangite	262.953	7	tri.	800.77	68.90	1.647	3.817	r	151
$MnFe(SiO_3)_2$*				± 4.29	± .36	±.009	±.020		
Tremolite	812.410	2	mon.	906.34	272.92	6.523	2.977	r	248, 301
$Ca_2Mg_5[Si_8O_{22}](OH)_2$*				± 2.43	± .73	±.018	±.008		58
Fluor-tremolite	816.392	2	mon.	898.18	270.46	6.464	3.018	20	52, 58
$Ca_2Mg_5[Si_8O_{22}]F_2$				± 1.56	± .47	±.011	±.005		
Ferrotremolite	970.085	2	mon.	938.24	282.53	6.753	3.434	r	76
$Ca_2Fe_5[Si_8O_{22}](OH)_2$				± 2.92	± .69	±.017	±.008		
Grunerite	1001.619	2	mon.	923.08	277.96	6.644	3.603	r	138, 278
$Fe_7[Si_8O_{22}](OH)_2$				± 1.63	± .49	±.012	±.006		

Cummingtonite (hypo.)	780.874	2	mon.	878.97	264.68	6.326	2.950	r	278, 98
$Mg_7[Si_8O_{22}](OH)_2$				± 1.58	± .47	± .011	± .005		
Riebeckite	935.904	2	mon.	912.29	274.71	6.566	3.407	r	75
$Na_2Fe_3Fe_2[Si_8O_{22}](OH)_2$				± 2.89	± .87	± .021	± .011		
Magnesioriebeckite	841.299	2	mon.	900.74	271.24	6.483	3.102	r	75
$Na_2Mg_3Fe_2[Si_8O_{22}](OH)_2$				± 2.37	± .71	± .017	± .008		
Gaucophane I	783.568	2	mon.	898.04	270.42	6.463	2.898	r	75
$Na_2Mg_3Al_2[Si_8O_{22}](OH)_2$				± 2.35	± .71	± .017	± .008		
Glaucophane II	783.568	2	mon.	876.79	264.02	6.310	2.968	r	75, 58
$Na_2Mg_3Al_2[Si_8O_{22}](OH)_2$				± 2.17	± .65	± .016	± .007		
Fluor-edenite	838.277	2	mon.	905.03	272.53	6.514	3.076	r	140, 58
$NaCa_2Mg_5[AlSi_7O_{22}]F_2$				± 1.51	± .46	± .011	± .005		
Fluor-richterite	822.291	2	mon.	900.47	271.15	6.481	3.033	r	140, 58
$Na_2CaMg_5[Si_8O_{22}]F_2$				± 1.48	± .45	± .011	± .005		
Anthophyllite	780.874	4	orth.	1756.3	264.4	6.320	2.953	r	108
$Mg_7[Si_8O_{22}](OH)_2$				± 7.0	± 1.1	± .025	± .012		

Framework structure silicates

Microcline	278.337	4	tri.	722.06	108.72	2.5984	2.560	r	249, 84
$KAlSi_3O_8$				± .67	± .10	± .0025	± .002		280, 23
High Sanidine	278.337	4	mon.	724.28	109.05	2.6064	2.552	r	249, 66
$KAlSi_3O_8$				± .69	± .10	± .0025	± .002		
Orthoclase	278.337	4	mon.	719.25	108.29	2.5883	2.570	r	134
$KAlSi_3O_8$*				± 1.02	± .15	± .0037	± .004		
Fe-Sanidine	307.202	4	mon.	749.28	112.81	2.6964	2.723	r	291
$KFeSi_3O_8$				± 2.24	± .34	± .0081	± .008		
Fe-Microcline	307.202	4	tri.	748.09	112.63	2.692	2.727	r	291
$KFeSi_3O_8$				± 1.92	± .29	± .007	± .007		
Low Albite	262.224	4	tri.	664.65	100.07	2.3918	2.620	26	249, 82
$NaAlSi_3O_8$				± .60	± .09	± .0022	± .002		51, 280
High Albite (Analbite)	262.224	4	tri.	667.00	100.43	2.4003	2.611	r	249, 82
$NaAlSi_3O_8$				± .60	± .09	± .0022	± .002		148, 246

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Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Framework structure silicates—Continued									
Anorthite	278.210	8	tri.	1338.9	100.79	2.4090	2.760	r	249, 51
$CaAl_2Si_2O_8$				± .6	± .04	± .0011	± .001		159
Synthetic	278.210	2	hex.	331.57	99.85	2.386	2.786	r	267
$CaAl_2Si_2O_8$				± 2.64	± .79	± .019	± .022		
Synthetic	278.210	2	orth.	341.44	102.82	2.457	2.706	r	56
$CaAl_2Si_2O_8$				± 1.35	± .41	± .010	± .011		
Celsian	375.500	8	mon.	1467.1	110.45	2.640	3.400	r	178
$BaAl_2Si_2O_8$*				± 4.2	± .31	± .008	± .010		
Paracelsian	375.500	4	mon.	746.6	112.4	2.687	3.340	r	244, 60
$BaAl_2Si_2O_8$*				± 2.9	± .4	± .010	± .013		
Banalsite	659.580	4	orth.	1416.9	213.3	5.099	3.092	r	60
$BaNa_2Al_4Si_4O_{16}$*				± 5.1	± .8	± .018	± .011		
Danburite	245.869	4	orth.	545.8	82.17	1.964	2.992	r	133, 60
$CaB_2Si_2O_8$*				± 2.3	± .35	± .008	± .013		
Low Nepheline	142.055	8	hex.	719.38	54.16	1.294	2.623	r	68, 247
$NaAlSiO_4$				± .80	± .06	± .002	± .003		
High Carnegeite	142.055	4	cubic	393.03	59.18	1.414	2.401	750	247
$NaAlSiO_4$				± .64	± .10	± .002	± .004		
Kaliophilite natural	158.167	54	hex.	5352.4	59.69	1.427	2.650	r	247
$KAlSiO_4$*				± 4.7	± .05	± .001	± .002		
Kaliophilite synthetic	158.167	2	hex.	198.89	59.89	1.431	2.641	r	247
$KAlSiO_4$				± .18	± .05	± .001	± .002		
Kalsilite	158.167	2	hex.	200.66	60.424	1.4442	2.618	r	247, 199
$KAlSiO_4$				± .17	± .051	± .0013	± .002		
Leucite	218.252	16	tet.	2348.23	88.389	2.1126	2.469	25	81
$KAlSi_2O_6$				± 1.19	± .045	± .0011	± .001		

High Leucite $KAlSi_2O_6$*	218.252	16	cubic	2422.3 ± 27.1	91.18 ± 1.02	2.179 ± .024	2.394 ± .027	625	67
Fe-Leucite $KFeSi_2O_6$	247.117	16	tet.	2435.98 ± .91	91.692 ± .034	2.1915 ± .0009	2.695 ± .001	25	81
Petalite $LiAlSi_4O_{10}$*	306.258	2	mon.	426.41 ± 1.57	128.4 ± .5	3.069 ± .011	2.385 ± .009	r	67
Marialite $Na_4Al_3Si_9O_{24}Cl$	845.115	2	tet.	1093.6 ± 1.6	329.3 ± .5	7.871 ± .011	2.566 ± .004	r	78, 187
Meionite $Ca_4Al_6Si_6O_{24}CO_3$	934.719	2	tet.	1134.07 ± 2.68	341.5 ± .8	8.162 ± .019	2.737 ± .007	r	78

Sheet structure silicates

Muscovite $KAl_2[AlSi_3O_{10}](OH)_2$*	398.313	4	mon	934.57 ± 1.21	140.71 ± .18	3.363 ± .004	2.831 ± .004	r	294, 108
Paragonite $NaAl_2[AlSi_3O_{10}](OH)_2$*	382.201	4	mon.	877.52 ± 8.47	132.1 ± 1.3	3.158 ± .031	2.893 ± .028	r	79, 108
Lepidolite $K_2Al_3Li_2[AlSi_7O_{20}](OH)_4$*	784.627	2	mon.	965.7 ± 23.2	290.8 ± 7.0	6.950 ± .167	2.698 ± .065	r	59
Phlogopite $KMg_3[AlSi_3O_{10}](OH)_2$	417.286	2	mon.	497.83 ± 1.19	149.91 ± .36	3.5830 ± .0086	2.784 ± .007	r	290, 293
Fluor-phlogopite $KMg_3[AlSi_3O_{10}]F_2$	421.268	2	mon.	486.07 ± .60	146.37 ± .18	3.498 ± .004	2.878 ± .004	r	141
Annite $KFe_3[AlSi_3O_{10}](OH)_2$	511.891	2	mon.	512.40 ± 1.45	154.30 ± .44	3.688 ± .010	3.318 ± .009	r	79
Ferriannite $KFe_3[FeSi_3O_{10}](OH)_2$	540.757	2	mon.	519.92 ± .51	156.56 ± .15	3.7419 ± .0037	3.454 ± .003	r	289
Margarite $CaAl_2[Al_2Si_2O_{10}](OH)_2$*	398.187	4	mon.	888.9 ± 5.2	133.8 ± .8	3.199 ± .019	2.975 ± .017	r	59
Talc $Mg_3Si_4O_{10}(OH)_2$*	379.289	4	mon.	904.94 ± 1.71	136.25 ± .26	3.2565 ± .0062	2.784 ± .005	r	248
Pyrophyllite $Al_2Si_4O_{10}(OH)_2$*	360.316	4	mon.	835.9 ± 4.0	125.9 ± .6	3.008 ± .015	2.863 ± .014	r	114

Molar Volumes and Densities of Minerals

Name and formula	Formula weight grams	Z	Crystal system	Cell volume 10^{-24} cm^3	Molar volume cm^3	Molar volume cal bar^{-1}	X-Ray density grams cm^{-3}	Temp. °C	Ref.
Sheet structure silicates—Continued									
Minnesotaite	473.894	4	mon.	971.8	146.3	3.497	3.239	r	59
$Fe_3Si_4O_{10}(OH)_2$*				± 19.2	± 2.9	± .069	± .064		
Dickite	258.161	4	mon.	659.49	99.30	2.3733	2.600	r	175, 8
$Al_2Si_2O_5(OH)_4$*				± .49	± .07	± .0018	± .002		
Kaolinite	258.161	2	tri.	330.48	99.52	2.3785	2.594	r	104
$Al_2Si_2O_5(OH)_4$*				± .86	± .26	± .0062	± .007		
Nacrite	258.161	4	mon.	658.9	99.21	2.3713	2.602	r	8
$Al_2Si_2O_5(OH)_4$*				± 2.1	± .32	± .0076	± .008		
Zeolites									
Analcite	220.155	16	cubic	2589.98	97.49	2.3301	2.258	r	217
$NaAlSi_2O_6.H_2O$				± 2.83	± .11	± .0026	± .003		
Natrolite	380.225	8	orth.	2250.1	169.39	4.049	2.245	r	160
$Na_2Al_2Si_3O_{10}.2H_2O$*				± 4.8	± .37	± .009	± .005		

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