CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the Doug K. Martin Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

TABLE OF PERIODIC PROPERTIES OF THE ELEMENTS

Percent Ionic Character of a Single Chemical Bond

Difference in electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Percent ionic character %	0.5	1	2	4	6	9	12	15	19	22	26	30	34	39	43	47	51	55	59	63	67	70	74	76	79	82	84	86	88	89	91	92

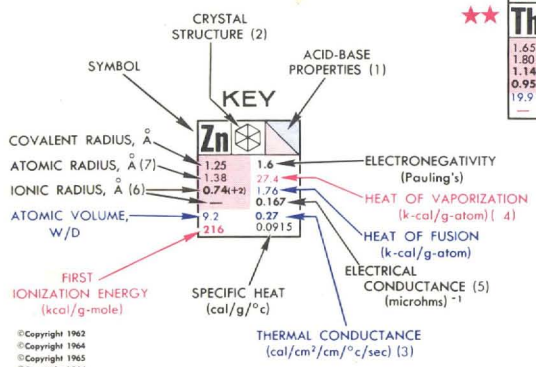
Sub-Atomic Particles

	Electron	Positron	Proton	Neutron	Photon	Neutrino	Meson					Hyperon				
Symbol	e^-, β^-	e^+, β^+	†p	†n	γ	†ν	$\mu^\pm$	$\pi^\pm$	†π^0	†K^+	†K^0	†Λ^0	†Σ^+	†Σ^-	†Ξ^-	Ω^-
Mass*	1	1	1836.12	1838.65	0	~0	206.84	273.23	264.4	966.6	974.4	2181.4	2327.7	2343.2	2584	1686
Charge**	−1	+1	+1	0	0	0	±1	±1	0	+1	0	0	+1	−1	−1	−1
Spin	½	½	½	½	1	½	½	0	0	0	0	½	½-integral	½-integral	½-integral	
Magnetic Moment	1.00 B.m.	1.00 B.m.	2.793 n.m.	−1.913 n.m.	0	~0		0	0							
Mean Life (sec.)	stable	stable	stable	1.11×10^{3}	stable	stable	2.22×10^{-6}	2.54×10^{-8}	$\sim10^{-15}$	$\sim10^{-8}$	$\sim10^{-10}$—10^{-7}	2.8×10^{-10}	$\sim5\times10^{-11}$	$\sim10^{-10}$	$\sim10^{-10}$	$\sim10^{-9}$
Decay Modes				$\rightarrow p+e^-+\bar{\nu}$			$\rightarrow e^\pm+\nu+\bar{\nu}$	$\rightarrow\mu^\pm+\nu$	$\rightarrow\gamma+\gamma$; $\rightarrow e^++e^-+\gamma$	complex	complex	$\rightarrow p+\pi^-$; $\rightarrow n+\pi^0$	$\rightarrow p+\pi^0$; $\rightarrow n+\pi^+$	$\rightarrow n+\pi^-$	$\rightarrow\Lambda^0+\pi^-$	$\pi^-+\Xi$

B.m. = Bohr magneton n.m. = Nuclear magneton *In units of 9.1083×10^{-31} kg. **In units of 4.80286×10^{-10} esu. †Exists as an antiparticle not listed.

GROUP IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
H																	He
Li	Be	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca											Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac**															

★	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
★★	Th	Pa	U	NP	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lw



©Copyright 1962
©Copyright 1964
©Copyright 1965
©Copyright 1966
©Copyright 1968 SARGENT-WELCH SCIENTIFIC COMPANY

NOTES:

(1) For representative oxides (higher valence) of group. Oxide is acidic if color is red, basic if color is blue and amphoteric if both colors are shown. Intensity of color indicates relative strength.

(2) Cubic, face centered; cubic, body centered; diamond; cubic; hexagonal; rhombohedral; tetragonal; orthorhombic; monoclinic.

(3) At room temperature. (4) At boiling point. (5) From 0° to 20°C.

(6) Ionic (crystal) radii for coordination number 6.

(7) Metallic radii for coordination number of 12.

SARGENT-WELCH
SARGENT-WELCH SCIENTIFIC COMPANY
7300 LINDER AVENUE, SKOKIE, ILLINOIS 60076
CHICAGO • CINCINNATI • CLEVELAND • DETROIT • DALLAS • DENVER
BIRMINGHAM • SPRINGFIELD, N. J. • ANAHEIM, CALIF. • TORONTO, CANADA

Catalog Number S-18806 SIDE 2

PERIODIC TABLE OF THE ELEMENTS

Table of Radioactive Isotopes

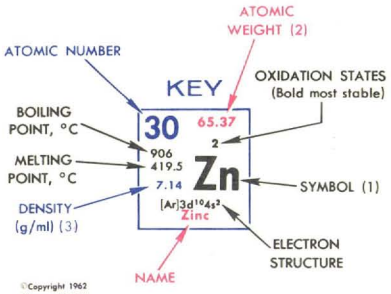
Naturally occurring radioactive isotopes are indicated by a blue mass number. Half lives are in parentheses where s, m, h, d and y stand for seconds, minutes, hours, days and years respectively. The symbols describing the mode of decay and resulting radiation are defined as follows:

α	alpha particle	L	L-electron capture
β^-	beta particle	SF	spontaneous fission
β^+	positron	γ	gamma ray
K	K-electron capture	e^-	internal electron conversion

Ac 227(22y)β^-,α
Ag 110(24s)β^-,γ; 111(7.5d)β^-,γ
Am 241(458y)α,γ,e^-; 242(16.0h)β^-,K,α,γ; 243(8000y)α,γ
As 76(26.7h)β^-,γ; 77(39h)β^-,γ
At 210(8.3h)K,α,γ; 211(7.2h),Kα,γ
Au 198(2.69d)β^-,γ
Ba 131(12d)K,γ; 133(7.2y)K,γ,e^-
Bi 210(5d)β^-,α
Bk 245(4.9d)K,α,γ; 249(314d)β^-,α,SF
Br 82(36h)β^-,γ
C 14(5700y)β^-
Ca 41(8x10⁴y)K; 45(165d)β^-; 47(4.5d)β^-,γ
Cd 115(43d)β^-,γ
Ce 141(32d)β^-,γ; 143(33h)β^-,γ; 144(285d)β^-,γ
Cf 246(35h)α,γ,SF; 249(360y)α,γ,SF; 251(800y)γ
Cl 36(3x10⁵y)β^-
Cm 243(35y),α,γ; 245(9300y),α,γ; 247(10⁷y)
Co 58(71d),K,β^+,γ; 60(5.27y)β^-,γ
Cr 51(27d),K,γ
Cs 134(2.0y)β^-,γ; 135(3x10⁶y)β^-; 137(30y)β^-,γ
Cu 64(12.8h)K,β^-,β^+,γ
Es 253(20d)α,γ,SF; 254(1y)α,SF
Eu 154(16y)β^-,γ; 155(1.8y)β^-,γ
Fe 55(2.6y)K; 59(45d)β^-,γ
Fm 255(20h)α
Fr 223(22m)β^-,γ,α
Ga 72(14.1h),β^-,γ
Gd 153(236d)K,γ,e^-; 159(18h)β^-,γ
Ge 71(11d)K
H 3(12.3y)β^-
Hf 181(45d)β^-,γ,e^-
Hg 197(65h)K,γ,e^-; 203(47d)β^-,γ,e^-
Ho 166(27.3h)β^-,γ
I 129(10⁷y)β^+,γ,e; 131(8.05d)β^-,γ
In 114(50d)γ
Ir 192(74.4d)β^-,γ
K 40(10⁹y)β^+,K,γ; 42(12.4h),β^-,γ
La 140(40.2h)β^-,γ
Lu 176(10¹⁰y)β^-,K,γ; 177(6.8d)β^-,γ
Md 256(90m)K,SF
Mo 99(67h)β^-,γ
Na 22(2.6y)β^+,K,γ; 24(15h)β^-,γ
Nd 147(11.1d)β^-,γ
Ni 63(125y)β^-; 59(8x10⁴y),K
Np 237(2.2x10⁶y)α,γ; 239(2.33d)β^-,γ
Os 191(15d)β^-,γ,e^-
P 32(14.2d)β^-
Pa 231(34000y)α,γ
Pb 210(19.4y)β^-,γ,e^-; 202(10⁵y)L
Pd 103(17d)K,γ
Pm 147(2.6y)β^-
Po 210(138.4d)α,γ; 209(103y)α,K,γ
Pr 143(13.8d)β^-
Pt 197(18h)β^-,γ
Pu 242(3.8 x 10⁵y)α,SF; 241(13y)β^-,α,γ; 239(24300y)α,γ,SF
Ra 226(1620y)α,γ
Rb 86(18.6d)β^-,γ
Re 188(16.7h)β^-,γ; 186(3.7d)β^-,γ
Rn 222(3.82d)α
Ru 103(40d)β^-,γ; 97(2.9d),K,γ,e^-
S 35(88d)β^-
Sb 122(2.8d)β^-,K,β^+,γ; 124(60d)β^-,γ
Sc 46(84d)β^-,γ
Se 75(120d)K,γ
Sm 153(47h)β^-,γ; 145(340d)K,γ
Sn 113(119d)K,L,γ,e^-
Sr 90(28y)β^-; 89(51d)β^-,γ; 85(64d)K,γ
Ta 182(115d)β^-,γ
Tb 160(73d)$\beta^-\gamma$
Tc 99(2x10⁵y)β^-; 97(10⁶y)K
Te 127(9.3h)β^-
Th 232(1.4x10¹⁰y)α,γ,SF; 228(1.91y)β^-
Tl 204(3.81y)β^-,K
Tm 170(134d)β^-,γ,e^-
U 238(4.5x10⁹y)α,γ,SF; 234(2.5x10⁵y)α,γ,SF; 235(7.1x10⁸y)α,γ,SF; 233(1.6x10⁵y)α,γ
W 185(75d)β^-
Y 90(64h)β^-,e^-
Yb 175(4.2d)β^-,γ; 169(31d)K,γ,e^-
Zn 65(245d)K,β^+,γ
Zr 95(65d)β^-,γ,e^-; 93(9x10⁵y)β^-,γ

GROUP IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 1.00797 1 −252.7 −259.2 0.071 1s¹ H Hydrogen																	2 4.0026 −268.9 −269.7 0.126 1s² He Helium
3 6.939 1 1330 180.5 0.53 1s²2s¹ Li Lithium	4 9.0122 2 2770 1277 1.85 1s²2s² Be Beryllium											5 10.811 3 — (2030) 2.34 1s²2s²2p¹ B Boron	6 12.01115 ±4,2 4830 3727 9 2.26 1s²2s²2p² C Carbon	7 14.0067 ±3,5,4,2 −195.8 −210 0.81 1s²2s²2p³ N Nitrogen	8 15.9994 −2 −183 −218.8 1.14 1s²2s²2p⁴ O Oxygen	9 18.9984 −1 −188.2 −219.6 1.505 1s²2s²2p⁵ F Fluorine	10 20.183 −246 −248.6 1.20 1s²2s²2p⁶ Ne Neon
11 22.9898 1 892 97.8 0.97 [Ne]3s¹ Na Sodium	12 24.312 2 1107 650 1.74 [Ne]3s² Mg Magnesium											13 26.9815 3 2450 660 2.70 [Ne]3s²3p¹ Al Aluminum	14 28.086 4 2680 1410 2.33 [Ne]3s²3p² Si Silicon	15 30.9738 ±3,5,4 280w 44.2w 1.82w [Ne]3s²3p³ P Phosphorus	16 32.064 ±2,4,6 444.6 119.0 2.07 [Ne]3s²3p⁴ S Sulfur	17 35.453 ±1,3,5,7 −34.7 −101.0 1.56 [Ne]3s²3p⁵ Cl Chlorine	18 39.948 −185.8 −189.4 1.40 [Ne]3s²3p⁶ Ar Argon
19 39.102 1 760 63.7 0.86 [Ar]4s¹ K Potassium	20 40.08 2 1440 838 1.55 [Ar]4s² Ca Calcium	21 44.956 3 2730 1539 3.0 [Ar]3d¹4s² Sc Scandium	22 47.90 4,3 3260 1668 4.51 [Ar]3d²4s² Ti Titanium	23 50.942 5,4,3,2, 3450 1900 6.1 [Ar]3d³4s² V Vanadium	24 51.996 6,3,2 2665 1875 7.19 [Ar]3d⁵4s¹ Cr Chromium	25 54.938 7,6,4,2,3 2150 1245 7.43 [Ar]3d⁵4s² Mn Manganese	26 55.847 2,3 3000 1536 7.86 [Ar]3d⁶4s² Fe Iron	27 58.933 2,3 2900 1495 8.9 [Ar]3d⁷4s² Co Cobalt	28 58.71 2,3 2730 1453 8.9 [Ar]3d⁸4s² Ni Nickel	29 63.54 2,1 2595 1083 8.96 [Ar]3d¹⁰4s¹ Cu Copper	30 65.37 2 906 419.5 7.14 [Ar]3d¹⁰4s² Zn Zinc	31 69.72 3 2237 29.8 5.91 [Ar]3d¹⁰4s²4p¹ Ga Gallium	32 72.59 4 2830 937.4 5.32 [Ar]3d¹⁰4s²4p² Ge Germanium	33 74.922 ±3,5 613* 817 5.72 [Ar]3d¹⁰4s²4p³ As Arsenic	34 78.96 −2,4,6 685 217 4.79 [Ar]3d¹⁰4s²4p⁴ Se Selenium	35 79.909 ±1,5 58 −7.2 3.12 [Ar]3d¹⁰4s²4p⁵ Br Bromine	36 83.80 −152 −157.3 2.6 [Ar]3d¹⁰4s²4p⁶ Kr Krypton
37 85.47 1 688 38.9 1.53 [Kr]5s¹ Rb Rubidium	38 87.62 2 1380 768 2.6 [Kr]5s² Sr Strontium	39 88.905 3 2927 1509 4.47 [Kr]4d¹5s² Y Yttrium	40 91.22 4 3580 1852 6.49 [Kr]4d²5s² Zr Zirconium	41 92.906 5,3 3300 2468 8.4 [Kr]4d⁴5s¹ Nb Niobium	42 95.94 6,5,4,3,2 5560 2610 10.2 [Kr]4d⁵5s¹ Mo Molybdenum	43 (98) 7 — 2140 11.5 [Kr]4d⁵5s² Tc Technetium	44 101.07 2,3,4,6,8 4900 2500 12.2 [Kr]4d⁷5s¹ Ru Ruthenium	45 102.905 2,3,4 4500 1966 12.4 [Kr]4d⁸5s¹ Rh Rhodium	46 106.4 2,4 3980 1552 12.0 [Kr]4d¹⁰5s⁰ Pd Palladium	47 107.870 1 2210 960.8 10.5 [Kr]4d¹⁰5s¹ Ag Silver	48 112.40 2 765 320.9 8.65 [Kr]4d¹⁰5s² Cd Cadmium	49 114.82 3 2000 156.2 7.31 [Kr]4d¹⁰5s²5p¹ In Indium	50 118.69 4,2 2270 231.9 7.30 [Kr]4d¹⁰5s²5p² Sn Tin	51 121.75 ±3,5 1380 630.5 6.62 [Kr]4d¹⁰5s²5p³ Sb Antimony	52 127.60 −2,4,6 989.8 449.5 6.24 [Kr]4d¹⁰5s²5p⁴ Te Tellurium	53 126.904 ±1,5,7 183 113.7 4.94 [Kr]4d¹⁰5s²5p⁵ I Iodine	54 131.30 −108.0 −111.9 3.06 [Kr]4d¹⁰5s²5p⁶ Xe Xenon
55 132.905 1 690 28.7 1.90 [Xe]6s¹ Cs Cesium	56 137.34 2 1640 714 3.5 [Xe]6s² Ba Barium	57 138.91 3 3470 920 6.17 [Xe]5d¹6s² La Lanthanum ★	72 178.49 4 5400 2222 13.1 [Xe]4f¹⁴5d²6s² Hf Hafnium	73 180.948 5 5425 2996 16.6 [Xe]4f¹⁴5d³6s² Ta Tantalum	74 183.85 6,5,4,3,2 5930 3410 19.3 [Xe]4f¹⁴5d⁴6s² W Wolfram	75 186.2 7,6,4,2,−1 5900 3180 21.0 [Xe]4f¹⁴5d⁵6s² Re Rhenium	76 190.2 2,3,4,6,8 5500 3000 22.6 [Xe] 4f¹⁴5d⁶6s² Os Osmium	77 192.2 2,3,4,6 5300 2454 22.5 [Xe]4f¹⁴5d⁷6s² Ir Iridium	78 195.09 2,4 4530 1769 21.4 [Xe] 4f¹⁴ 5d⁹ 6s¹ Pt Platinum	79 196.967 3,1 2970 1063 19.3 [Xe]4f¹⁴5d¹⁰6s¹ Au Gold	80 200.59 2,1 357 −38.4 13.6 [Xe]4f¹⁴5d¹⁰6s² Hg Mercury	81 204.37 3,1 1457 303 11.85 [Xe]4f¹⁴5d¹⁰6s²6p¹ Tl Thallium	82 207.19 4,2 1725 327.4 11.4 [Xe]4f¹⁴5d¹⁰6s²6p² Pb Lead	83 208.980 3,5 1560 271.3 9.8 [Xe]4f¹⁴5d¹⁰6s²6p³ Bi Bismuth	84 (210) 2,4 — 254 (9.2) [Xe]4f¹⁴5d¹⁰6s²6p⁴ Po Polonium	85 (210) ±1,3,5,7 — (302) — [Xe]4f¹⁴5d¹⁰6s²6p⁵ At Astatine	86 (222) (−61.8) (−71) — [Xe]4f¹⁴5d¹⁰6s²6p⁶ Rn Radon
87 (223) 1 — (27) — [Rn]7s¹ Fr Francium	88 (226) 2 — 700 5.0 [Rn]7s² Ra Radium	89 (227) 3 ★★ — 1050 — [Rn]6d¹7s² Ac Actinium	104														

★	58 140.12 3,4 3468 795 6.67 [Xe]4f²5d⁰6s² Ce Cerium	59 140.907 3,4 3127 935 6.77 [Xe] 4f³5d⁰6s² Pr Praseodymium	60 144.24 3 3027 1024 7.00 [Xe] 4f⁴5d⁰6s² Nd Neodymium	61 (147) 3 — (1027) — [Xe] 4f⁵5d⁰6s² Pm Promethium	62 150.35 3,2 1900 1072 7.54 [Xe] 4f⁶5d⁰6s² Sm Samarium	63 151.96 3,2 1439 826 5.26 [Xe] 4f⁷5d⁰6s² Eu Europium	64 157.25 3 3000 1312 7.89 [Xe]4f⁷5d¹6s² Gd Gadolinium	65 158.924 3,4 2800 1356 8.27 [Xe]4f⁹5d⁰6s² Tb Terbium	66 162.50 3 2600 1407 8.54 [Xe] 4f¹⁰5d⁰6s² Dy Dysprosium	67 164.930 3 2600 1461 8.80 [Xe]4f¹¹5d⁰6s² Ho Holmium	68 167.26 3 2900 1497 9.05 [Xe]4f¹²5d⁰6s² Er Erbium	69 168.934 3,2 1727 1545 9.33 [Xe]4f¹³5d⁰6s² Tm Thulium	70 173.04 3,2 1427 824 6.98 [Xe]4f¹⁴5d⁰6s² Yb Ytterbium	71 174.97 3 3327 1652 9.84 [Xe] 4f¹⁴5d¹ 6s² Lu Lutetium
★★	90 232.038 4 3850 1750 11.7 [Rn] 5f⁰ 6d² 7s² Th Thorium	91 (231) 5,4 — (1230) 15.4 [Rn]5f²6d¹7s² Pa Protactinium	92 238.03 6,5,4,3 3818 1132 19.07 [Rn]5f³6d¹7s² U Uranium	93 (237) 6,5,4,3 — 637 19.5 [Rn] 5f⁴ 6d¹ 7s² Np Neptunium	94 (242) 6,5,4,3 3235 640 — [Rn]5f⁶6d⁰7s² Pu Plutonium	95 (243) 6,5,4,3 — — 11.7 [Rn]5f⁷6d⁰7s² Am Americium	96 (247) 3 — — — [Rn]5f⁷6d¹7s² Cm Curium	97 (247) 4,3 — — — [Rn] 5f⁹ 6d⁰ 7s² Bk Berkelium	98 (249) 3 — — — [Rn] 5f¹⁰ 6d⁰ 7s² Cf Californium	99 (254) — — — — [Rn] 5f¹¹ 6d⁰ 7s² Es Einsteinium	100 (253) — — — — [Rn] 5f¹² 6d⁰ 7s² Fm Fermium	101 (256) — — — — [Rn] 5f¹³ 6d⁰ 7s² Md Mendelevium	102 (254) — — — — [Rn] 5f¹⁴ 6d⁰ 7s² No Nobelium	103 (257) — — — — [Rn] 5f¹⁴ 6d¹ 7s² Lw Lawrencium



©Copyright 1962
©Copyright 1964
©Copyright 1965
©Copyright 1966
©Copyright 1968 SARGENT-WELCH SCIENTIFIC COMPANY

NOTES:

(1) Black — solid.
Red — gas.
Blue — liquid.
Outline — synthetically prepared.

(2) Based upon carbon – 12. ( ) indicates most stable or best known isotope.

(3) Values for gaseous elements are for liquids at the boiling point.

SARGENT-WELCH
SARGENT-WELCH SCIENTIFIC COMPANY
7300 LINDER AVENUE, SKOKIE, ILLINOIS 60076
CHICAGO • CINCINNATI • CLEVELAND • DETROIT • DALLAS • DENVER
BIRMINGHAM • SPRINGFIELD, N. J. • ANAHEIM, CALIF. • TORONTO, CANADA

I METALLIC LUSTER

COLOR	STREAK	SG	H	ACID	CLEAVAGE	FRACTURE	CRYSTAL HABIT	LUSTER		NAME
RED-BROWN (14)	metallic Cu Red RED-BROWN	8-9	2½-3	NITRIC	NO	HACKLY			DUCTILE	COPPER
RED BROWN YELLOW BROWN ANY (92)	RED BROWN yellow BROWN white DAK GRAY-BLACK	3.9-4.1	3½-4		(6) RHOMBODODECAHY	DRY CONCHOIDAL	CUBIC	MICA-GLASSY RESINOUS	"TREACHEROUS"	SPHALERITE
LT GRAY-MET WHITE GRAY-BLACK (82)										[(Fe,Mn)WO4]
Brown RED-ORANGE	BROWN	7.0-7.5	5-5½		1-PERFECT	UNEVEN	PRISMATIC TABULAR MONOCLINIC	SUB METALLIC	BLADED-MASSIVE (w/ Cu, Pb, Zn)	WOLFRAMITE
DARK GREY-BLACK (36)	BLACK-BROWN	4.6-5.1	3-4½		NO	SUB CONCHOIDAL UNEVEN	TETRAHEDRAL CUBIC		BRITTLE	(Cu,Fe)12(Sb,As)4 S13 TETRAHEDRITE
STEEL GRAY-BLACK (42)	RED-RED BRWN	4.9-5.3	5-6		NO	UNEVEN	TABULAR or RHOMBOHEDRAL TRIGONAL	EARTHY-DULL	Sometimes BOTRIODIAL STRIATED FACES-MASSIVE-BRITTLE	(IRON ORE) HEMATITE (Fe2O3)
PALE BLUISH-LEAD GRY OPAQUE, BLACK (32)	LITE GREY-MET WHITE GREEN BLACK	4.6-4.8	1-1½	NITRIC	PERFECT BASAL EASILY		TABULAR HEXAGONAL		HEAVIER THAN GRAPHITE SECTILE BLUISH, PLATY-WEATHERS YELLOW	LOOKS LIKE GRAPHITE (MoS2) MOLYBDENITE
DRK GREY (24)	LEAD GREY	7.4-7.6	2½		PERFECT CUBIC (3)		CUBES ISOMETRIC		BRITTLE	GALENA (PbS)
BLACK (14)	SILVER WHITE	10-11	2½-3	NITRIC	NO	HACKLY			MALLEABLE	SILVER
(LT GRAY-MET WHITE) DRK GREY-BLACK	LITE GRY-MET WHITE BLACK OR DARK GREY	5.5-5.8	2½-3	NITRIC		SILVERY CONCHOIDAL	ORTHORHMBIC		BRITTLE-SOMEWHAT SECTILE	(Cu2S) CHALCOCITE
BLACK OPAQUE (20)	BLACK SHINY	7.2-7.4	2-2½		POOR-CUBIC	SUB CONCHOIDAL	OCTOHEDRAL CUBIC		GROUPS OF CRYSTALS IN PARALLEL ALIGNMENT SECTILE-	ARGENTITE (Ag2S)
LITE GREY-MET WHITE LEAD GRY (28)	LEAD GREY	4.5-4.6	2	—	BLADED PARALLEL TO LENGTH 1-PERFECT	SUB CONCHOIDAL	PRISMATIC STRIATED ORTHORHOMBIC	RADIATE	MELTS w/MATCH BRITTLE-SOMEWHAT SECTILE	STIBNITE (Sb2S3)
BLACK (40)	DRK GREY-BLACK	5.2	5½-6½		NO	UNEVEN SUB CONCHOIDAL	OCTOHEDRAL CUBIC	MASSIVE-GRANULAR	MAGNETIC-BRITTLE	MAGNETITE (Fe3O4)
BLACK-BROWNISH BLACK (50)	BROWNISH BLACK OR GREY	8-10 massive 6.5-8.5	5-6	NITRIC	NO		CUBIC- MASSIVE	GREASY	RADIOACTIVE (PITCHBLEND) BRITTLE	URANINITE (UO2)
BRONZE (29)	PALE GRY-BLACK	5-5.1	3	NITRIC	NO	UNEVEN CONCHOIDAL	CUBIC		PEACOCK BRITTLE-SOMEWHAT SECTILE	BORNITE (Cu5FeS4)
BRASSY (30)	GREENISH BLACK TO BROWNISH BLACK	4.9-5.2	6-6½		NO	UNEVEN	CUBES- STRIATIONS CUBIC		GOOD CRYSTALS-MASSIVE	PYRITE (FeS2)
BLACK-GREENISH BRASSY yellow (30)	GRAYISH BLACK GREEN BLACK	4.8-4.9	6-6½		SOMETIMES	UNEVEN			"COCKS COMB"	MARCASITE (FeS2)
YELLOW (14)	Gold yellow	19.3	2½-3			HACKLY			MALLEABLE-SECTILE	GOLD (Au)
DEEP YELLOW (22)	GREENISH-BLACK	4.1-4.3	3½-4	NITRIC	POOR		TETRAHEDRAL TETRAGONAL BOTRYOIDAL MASSES		TARNISHES EASILY	(CuFeS2) CHALCOPYRITE
LIGHT GREY-DRK GRY (16)	LITE GREY	5.6-5.8	3½		BASAL-PERFECT		TRIGONAL MASSIVE		Smells like GARLIC	ARSENIC (As)
LIGHT GREY (16)	GREY	6.6-6.7	3-3½		BASAL PERFECT		TRIGONAL MASSIVE-GRANULAR			ANTIMONY (Sb)
(16) SILVER WHITE-REDDISH w/TARNISH	SILVER-WHITE SHINY	9.7-9.8	2-2½		BASAL PERFECT		TRIGONAL COLUMNAR- BLADED-TABULAR MASSIVE			BISMUTH (Bi)
DRK GREY-BLACK (36)	BLACK	4.4-			(2) PRISMATIC-PERFECT	UNEVEN	ORTHORHMBIC		melt w/MATCH	ENARGITE (Cu3AsS4)
7 BLACK-OPAQUE (19)	BLACK	2.1-2.3	1-2		BASAL-PERFECT		FLAT-TABULAR HEXAGONAL		GREASY FOLIATED-EARTHY	GRAPHITE (C)
OPAQUE 6 SILVER GRY-white (32)	DRK GREY BLACK	5.9-6.2	5½-6		INDISTINCT PRISMATIC	UNEVEN	PRISMATIC CRYSTALS STRIATED MONOCLINIC		MASSIVE-	(FeAsS) ARSENOPYRITE
5 DRK RED-BLACK (38)	BROWNISH RED	5.8-6.1	3½-4		NO	UNEVEN	OCTAHEDRA ASICULAR CUBIC	almost ADAMANTINE SUB	MASSIVE-GRANULAR	CUPRITE (Cu2O)
BLACK-OPAQUE (38)	DRK BROWN REDDISH BROWN	5.0-5.2	5½-6½		NO	UNEVEN	OCTAHEDRAL CUBIC		SLIGHTLY MAGNETIC MASSIVE-GRANULAR (SPINEL)	(Zn,Mn2Fe2)(Fe3Mn2)O4 FRANKLINITE
3 BLACK-BROWNISH-BLACK (42)	DRK BROWN	4.1-5.1	6½		NO	UNEVEN	OCTAHEDRAL		WEAK MAGNETITE (CHROME ORE)	CHROMITE (FeCr2O4)
REDDISH BRWN-BLACK 2 YELLOW (48)	WHITE-GREY	6.8-7.1	6-7		PRISMATIC IMPERFECT	UNEVEN	SHORT PRISMATIC TETRAGONAL		(WOOD TIN) (SUB METALLIC LUSTER) (TIN ORE)	(SnO2) CASSITERITE

FORM 1431 PRINTED BY THE STANDARD REGISTER COMPANY, U.S.A.

II RESINOUS LUSTER

COLOR	STREAK	SG	H	ACID	CLEAVAGE	FRACTURE	CRYSTAL	LUSTER			NAME
BRIGHT YELLOW (18) TRANSPARENT - OPAQUE	WHITE	2.0 - 2.1	1½ - 2½		NONE	UNEVEN	TABULAR MASSIVE ORTHORHOMBIC			MASSIVE	SULPHUR (S)
YELLOW - BROWN - BLACK (22) TRANSPARENT - TRANSLUCENT	LITE YELLOW - WHITE BROWN	3.9 - 4.1	3½ - 4		PERFECT RHOMDODECTRAHEDRAL	CONCOIDAL	TETRIHEDRAL RHOMBODECHEDRAL CUBIC			BOTRYOIDAL GRANULAR (W/GALENA PYRITE ETC) (W/ORPIMENT)	(ZnS) SPHALERITE
RED TO ORANGE-YELLOW (28) TRANSPARENT - TRANSLUCENT	ORANGE-RED	3.5 -	1½ - 2		GOOD PENACHOIDAL	CONCHOIDAL	SHORT PRISMATIC MONOCLINIC			GRANULAR COMPACT	REALGAR (AsS)
LEMON YELLOW - BROWNISH YELLOW (28)	PALE YELLOW	3.4 - 3.5	1½ - 2		1 - PERFECT		FOLIATED COLUMINATED MASSES MONOCLINIC		PEARLY ON CLEAVAGE	W/ORPIMENT	ORPIMENT (As_2S_3)
OLIVE GREEN - BROWN ORANGE - YELLOW (32)	WHITE	6.5 - 7.0	3		DISTINCT PYRAMIDAL	SUB CONCHOIDAL	SQUARE PLATES TETRAGONAL SHARP PRISMATIC			MASSIVE GRANULAR	WULFENITE ($PbMoO_4$)
BROWNISH RED - YELLOW ORANGE - RED (38)	WHITE - YELLOWISH	6.7 - 7.1	3			SUB CONCHOIDAL	HEXAGONAL			RARE	VANADINITE $Pb_5(VO_4)_3Cl$

FORM T431 PRINTED BY THE STANDARD REGISTER COMPANY, U.S.A.

III ADAMANTINE LUSTER

COLOR	STREAK	SG	H	ACID	CLEAVAGE	FRACTURE	CRYSTAL	LUSTER				
TRANSPARENT (18)	WHITE	3.5	10		PERFECT OCTAHEDRAL	CONCHOIDAL	OCTOHEDRAL CUBIC		GREASY LOOKING UNCUT			DIAMOND (C)
TRANSPARENT - OPAQUE SCARLET RED - BROWNISH RED (26)	Vermillion	8.0 - 8.2	2 - 2½		PERFECT PRISMATIC	UNEVEN	RHOMBOHEDRAL TRIGONAL		MASSIVE - GRANULAR			CINNABAR (H_2S)
RED to BLACK (38)	BROWNISH RED	5.8 - 6.1	3½ - 4		NO	UNEVEN	OCTAHEDRAL ASICULAR CUBIC	Sub METALLIC	MASSIVE - GRANULAR			CUPRITE (Cu_2O)
YELLOW BROWN GREEN BLUE - TRANSPARENT TRANSLUCENT (44)	WHITE	3.9 - 4.1	9		NO	CONCHOIDAL UNEVEN TO	TAPERED TRIGONAL	(SAPHIRE)				CORUNDUM (Al_2O_3)
REDDISH BROWN - BLACK yellow (48)	WHITE - GREY	6.8 - 7.1	6 - 7		PRISMATIC IMPERFECT	UNEVEN	SHORT PRISMATIC TETRAGONAL		(WOOD TIN) (SUB METALLIC LUSTER)	(TIN ORE)		CASSITERITE (SnO_2)
yellowish RED or BLACK REDISH - BROWN (46)	Pale Brown	4.2 - 4.4	6 - 6½		DISTINCT PRISMATIC	UNEVEN	PRISMATIC → Bi, PYRAMIDS TETRAGONAL		STRIATED - MASSIVE (Sub metallic)	(SECONDARY ORE)		RUTILE (TiO_2)
DARK BROWN (54)	Brownish yellow	3.3 - 4.3	5 - 5½		1-PERFECT	UNEVEN	ORTHORHOMBIC		FIBROUS — RADIAL GROWTH (WITH LIMONITE) BOTROIDAL - MALAMITED - STALTIC			GEOTHITE $FeO(OH)$
WHITE - GREY (90)	WHITE	6.4 - 6.6	3 - 3½	NITRIC	DISTINCT PRISMATIC IN 2 DIRECTIONS	CONCHOIDAL	PRISMATIC TABULAR ORTHORHOMBIC		MASSIVE COMPACT ASICULAR (STAR LIKE TWINS)			CERUSSITE ($PbCO_3$)
yellow GRAY - BLUE TINT COLORLESS - WHITE (76)	WHITE	6.2 - 6.4	2½ - 3	—	DISTINCT GOOD PRISMATIC BASAL	CONCHOIDAL	TABULAR PRISMATIC ORTHORHOMBIC		MASSIVE COMPACT GRANULAR	SUBROUND GALENA		ANGLESITE ($PbSO_4$)
OLIVE GREEN - BROWN ORANGE - yellow (82)	WHITE	6.5 - 7.0	3		DISTINCT PYRIMIDAL	SUB CONCHOIDAL	SQUARE PLATES TETRAGONAL		MASSIVE - GRANULAR			($PbMoO_4$) WULFENITE

FORM 1491 PRINTED BY THE STANDARD REGISTER COMPANY, U.S.A.

IV VITRIOUS - NON METALLIC

COLOR	STREAK	S.G.	H.	ACID	CLEAVAGE	FRACTURE	CRYSTAL		NAME
GREEN & YELLOW (44)	WHITE	3.5-3.8	8½		POOR PRISMATIC	CONCHOIDAL UNEVEN	TABULAR ORTHORHOMBIC	IN GRANITE & MICA SHIST	($BeAl_2O_4$) CHRYSOBERYL
BLUE TRANSPARENT - TRANSLUCENT Yellow Brown-Green (44)	WHITE	3.9-4.1	9		NO	UNEVEN TO CONCHOIDAL	TAPERED TRIGONAL	(SAPHIRE)	CORUNDOM (Al_2O_3)
Grey Brown ORCHRE Yellow (54)						UNEVEN TO CONCHOIDAL		EARTHY - MIXTURE of MINERALS	($Al(OH)_3$) BAUXITE
WHITE - Colorless (56)	WHITE	2.1-2.2	2½	WATER	CUBIC PERFECT	CONCHOIDAL	CUBES CUBIC	SALT	HALITE (NaCl)
WHITE - Colorless (56)	WHITE	2.0	2	WATER	PERFECT CUBIC	UNEVEN	CUBIC	Bitter	SYLVITE (KCl)
Sometimes STAIN colorless - white (56)	WHITE	3.0	2½		NO	UNEVEN	PSEUDOCUBIC MONOCLINIC	ICE LIKE APPEARANCE MASSIVE & GRANULAR - GREASY LUSTER	CRYOLITE (Na_3AlF_6)
Yellow - Green - Blue Purple - Black TRANSPARENT other shades (60)	WHITE	3.2	4	Sulfuric Acid H_2SO_4	PERFECT OCTAHEDRAL	SUB CONCHOIDAL	CUBIC	(FLUORSPAR) - FLORESCENT (IRON FLUX)	FLUORITE (CaF_2)
colorless - WHITE (62)	WHITE	2.7	3	COLD HCl	RHOMBOHEDRAL PERFECT	RARE CONCHOIDAL	VARIED TRIGONAL	DOUBLE REFRACTION (CARBONATES) (MARBLE) (LIMESTONE)	CALCITE ($CaCO_3$)
SHADES WHITE - COLORISH (64)	WHITE	3.0-3.2	3½-4½	WARM HCl	RHOMBOHEDRAL PERFECT	CONCHOIDAL	PRISMATIC TRIGONAL	SIMILAR TO CALCITE	MAGNESITE ($MgCO_3$)
Grey - Grey Brown Yellowish Brown (64)	WHITE	3.8-4.0	3½-4½	WARM HCl FAST COLD HCl SLOW	RHOMBOHEDRAL PERFECT	UNEVEN	RHOMBOHEDRAL TRIGONAL	CURVED FACES BROWN COLOR IN CLAY & VEINS	SIDERITE ($FeCO_3$)
PINK - LITE GREY TO BROWN (64)	WHITE	3.4-3.7	3½-4½	Hot HCl	RHOMBOHEDRAL PERFECT	UNEVEN	TRIGONAL	RARE CRYSTALS - BROWN OR BLACK CRUST W/AIR	($MnCO_3$) RHODOCHROSITE
Grey Brown GREEN Brown Yellow GREEN (66)	WHITE	4.3-4.5	4-4½	HCl	RHOMBOHEDRAL PERFECT	UNEVEN	TRIGONAL	W/ ZINC OXIDATION ZONES BOTRYOIDAL {MASSIVE OR RENIFORM	($ZnCO_3$) SMITHSONITE
PINK - Yellowish - Brown White - Colorless (66)	WHITE	2.8-2.9	3½-4	Hot HCl FAST COLD HCl SLOW	RHOMBOHEDRAL PERFECT	SUB CONCHOIDAL	RHOMBOHEDRAL TRIGONAL	MASSIVE GRANULAR - PEARLY - CRYSTALS diff FROM CALCITE	DOLOMITE ($CaMg(CO_3)_2$)
GREY - WHITE - YELLOWISH (68)	WHITE	2.9-	3½-4	HCl	PENACHOIDAL IMPERFECT	SUB CONCHOIDAL	ORTHORHOMBIC	FIBROUS INCRUSTING MASSES	ARAGONITE ($CaCO_3$)
GREY WHITE - Yellowish - Green (68)	WHITE	4.3-4.6	3-3½	HCl	DISTINCT PINACHOIDAL	UNEVEN	ORTHORHOMBIC	GREEN flame	WITHERITE ($BaCO_3$)
PALE Yellow WHITE - GREEN - GRAY (68)	WHITE	3.7-	3½-4	HCl	GOOD PRISMATIC	UNEVEN	PRISMATIC ASICULAR ORTHORHOMBIC	CRIMSON flame MASSIVE FIBER COLUMNAR GRANULAR	($SrCO_3$) STRONTIANITE
BRIGHT GREEN (70)	PALE GREEN	3.9-4.0	3½-4	HCl	PERFECT PINACHOIDAL	UNEVEN SUB CONCOIDAL	MONOCLINIC	BOTRIODIAL - MASSIVE - FIBROUS - GRANULATED - EARTHY	SECONDARY COPPER ORE ($Cu_2CO_3(OH)_2$) MALACHITE
SHADES of DEEP AZURE BLUE (70)	LITE BLUE	3.8-3.9	3½-4	HCl NITRIC	PRISMATIC PERFECT	CONCHOIDAL	TABULAR PRISMATIC MONOCLINIC	FAN LIKE MASSIVE - EARTHY - CRYSTAL	AZURITE $Cu_3(CO_3)_2(OH)_2$
TINTED Colorless - WHITE (74)	WHITE	4.3-4.6	2½-3½	INSOLUABLE	BASAL - PERFECT 3 Cleavages	UNEVEN	ORTHORHOMBIC	FIBROUS - "COCKS COMB" STALLITIC (DESERT ROSE)	BARYTE ($BaSO_4$)
Tint - Bluish - Reddish Colorless - WHITE (74)	WHITE	3.9-4.0	3-3½		3 DIRECTIONS PERFECT BASAL	UNEVEN	TABULAR ORTHORHOMBIC	(CRYSTALS LOOKS LIKE BARITE) CRIMSON flame (in Dolomite) (W/SULFUR)	CELESTITE ($SrSO_4$)
BLUISH TINT Colorless - WHITE (76)	WHITE	2.9-3.0	3-3½		3 @ RT L'S	SPLINTERY UNEVEN	↑ ORTHORHOMBIC	PEARLY MASSIVE GRANULAR FIBROUS - W/GYPSUM & HALITE	ANHYDRITE ($CaSO_4$)
TINTS - Yellow Grey Red Brown Colorless - white (76)	WHITE	2.3	2		IMPERFECT 2 OTHERS GOOD	TABULAR CURVED FACES MONOCLINIC	MONOCLINIC BI PYRAMIDAL	MASSIVE - GRANULAR GLASSY - PEARLY on Cleavage	GYPSUM ($CaSO_4 \cdot 2H_2O$)
Shades of Yellow Green Brown Yellow WHITE (82)	WHITE	5.9-6.1	4½-5		DISTINCT PYRAMIDAL		TETRAGONAL	MASSIVE - GRANULAR - FLOURESCENT	(TUNGSTEN ORE) SCHEELITE ($CaWO_4$)
BLUISH WHITE WHITE - PALE GREEN (84)	WHITE	3.0-3.1	5½-6		2 GOOD	UNEVEN	TRICLINIC	MASSIVE - CLEAVABLE MASSES - VITREOUS TO GREASY	(RARE) ($(Li,Na)Al(PO_4)(F,OH)$) AMBLYGONITE
TINTS Shades of GREEN (86)	WHITE	3.1-3.3	5		IMPERFECT BASAL	UNEVEN CONCHOIDAL	PRISMATIC TABULAR HEXAGONAL	MASSIVE - GRANULAR IN LIMESTONE	(DECEIVES) ((F,Cl,OH)) APATITE $Ca_5(PO_4)_3$
GREEN - BLUE (88)	white or GREENISH	2.6-2.8	5-6			CONCHOIDAL	TRICLINIC	MASSIVE - GRANULAR - WAXY	$CuAl_6(PO_4)_4(OH)_8 \cdot 5H_2O$ TURQUOISE
Reddish Brown Yellowish GREEN - Green (92)	colorless	4.3-4.4	3½				WEDGE SHAPED ORTHORHOMBIC	florescent → Yellow INCRUSTING (ON LIMONITE) OILY BRITTLE	$Zn_2(OH)(AsO_4)$ ADAMITE

FORM 1431 PRINTED BY THE STANDARD REGISTER COMPANY U.S.A.

CRYSTAL GROWTH

Generally speaking, if a saturated solution can be made of a chemical compound which you would like to grow in crystal form, it will be possible to grow a crystal. However, most compounds are either too-insoluble to get into solution or too-soluble to last as good crystals. Once the solution is saturated, the compound will come out of solution by either evaporating away some of the water or by adding additional material at a higher temperature and allowing the solution to supersaturate by cooling to the normal room temperature. In either case, if a "seed" crystal of the same compound is placed in the solution, it will act as a center of crystallization and additional material from the solution will deposit in continuation of its regular internal lattice structure. The growing crystal and the solution should be placed somewhere with a uniform temperature, preferably, somewhat lower than the temperature at which the seed crystal was placed in the solution. If Evaporation is the means whereby the solution is to be concentrated, it is better not to have anything on the surface of the solution, so a wire may be bent in a snake-like form to act as a holder for the thread on which the seed crystal will be suspended. The crystal should be approximately one inch from the bottom of the jar. The cover of the jar must be left off and a protective gauze placed over the open end to prevent too many dust particles from settling on the surface and forming the nuclei of additional crystals. If the solution is Supersaturated by means of the additional material, the seed crystal should be suspended by a thread from a holder on top of the jar and the cover put on to hold it in place and prevent evaporation. While extra crystals will probably form on the thread, most of the new crystallization will occur on the seed crystal itself. Any impurities may act as the nuclei of additional crystals and these often settle on the side of the primary seed. If, as frequently happens, the temperature goes up, or if the solution is not really saturated, the seed crystal may dissolve in the solution. A new one may be procured by taking a small amount of the solution and letting it evaporate in an open dish. As small crystals are formed, choose the most perfect of them to act as "seeds" and remove the others so that the selected seed can grow. When one is between 1/3" & 1/4", it is large enough to be tied on a thread and placed in the solution.

Several formulas for growing solutions are listed below. The weight of material necessary to saturate a given volume of water is shown. After this amount has been in solution for several hours, there may be excess material deposited on the bottom of the jar. If so, pour the solution into another container before trying to seed the solution or before warming the solution and supersaturating it with the excess material. After cooling the supersaturated solution to room temperature, if any material comes out of solution, the solution should be poured into a fresh container before the seed crystal is placed in it. In most cases, crystals will grow even under poor conditions, but the finest ones are produced when the temperature is kept constant and the solution is kept free of foreign substances.

Formulas for crystal-growing solutions:

1. "Rochelle Salt" Sodium Tartrate Tetrahydrate $KNaC_4H_4O_6 \cdot 4H_2O$

227 grams of Rochelle Salt in 175 cc. of Water.
Supersaturate by adding 15 grams of Rochelle Salt.

2. "Alum" Potassium Aluminum Sulfate Dodecahydrate $KAl(SO_4) \cdot 12\ H_2O$

114 grams of Alum in 567 cc. of Water.
Supersaturate with 22 grams of Alum.

3. Nickel Sulfate Hexahydrate $NiSO_4 \cdot H_2O$

120 grams of Nickel Sulfate in 100 cc. of Water.
Supersaturate with 7 grams of Nickel Sulfate.

4. "Niter" Sodium Nitrate $NaNO_3$

120 grams of Niter in 104 cc. of Water.
Supersaturate with 3 grams of Niter

5. "Red Prussiate of Potash" Potassium Ferrocyanide $K_3Fe(CN)_3$

91 grams of Red Prussiate in 200 cc. of Water.
Supersaturate with 5 grams of Red Prussiate.

6. "Chrome Alum" Potassium Chromium Sulfate Dodecahydrate $KCr(SO_4) \cdot 12\ H_2O$

120 grams of Chrome Alum in 200 cc. of Water.
Supersaturate by adding 10 grams of Chrome Alum.

COURSE OUTLINE
Geology 102 - Mineralogy

SPRING Semester, 1974-75
Mon. nite @ 7:05-9:45
Room F-116

Textbook: Sinkankis, Mineralogy for Amateurs, Van Nostrand, 1964.

Week	Date	Reading Assignment (Class Discussion)	Problem Assignment
1.	Jan. 13 ✓	Descriptive Mineralogy, pp. 434-435, Review Chapters 6 & 7 Physical Properties of Minerals. Discussion of Gemstones. Work with Mineral Specimens.	
2.	Jan. 20	Descriptive Mineralogy pp. 436-449 (Quartz). Review Chapter 5 Crystal Systems and Mineral Classes. Discussion of Miller "Indices". Lapidary Techniques. Work with Mineral Specimens.	
3.	Jan. 27	Chapter 8, pp. 193-235 Optical Properties of Minerals. Discussion of Igneous Rocks and their component Minerals. Identification Quiz.	
4.	Feb. 3	Chapters 9 & 10, pp. 236-257. Guest Speaker on "Silica". (ART BLOYD, Cur., Ariz. Min. Mus.) Discussion of Mineral Associations. Work with Mineral Specimens.	
5.	Feb. 10	Descriptive Mineralogy, pp. 449-459 (Feldspars). Importance of the Orthoclase & Plagioclase Feldspars. Discussion of Orthoclase, Albite, Anorthite, & Microcline. Identification Quiz.	
6.	Feb. 17	President's Day. Vacation. No Classes.	
7.	Feb. 24	Descriptive Mineralogy, pp. 459-464 (Feldspathoids). Discussion of Leucite, Nepheline, Sodalite, & Scapolite. Work with Mineral Specimens. Identification Quiz.	
8.	March 3	Descriptive Mineralogy, pp. 464-474 (Zeolites). Mid-Term Examination. Discussion of Stilbite, Chabazite, Analcime, & Natrolite. Work with Mineral Specimens.	
9.	March 10	Descriptive Mineralogy, pp. 475-486 (Phyllosilicates). Discussion of Apophyllite, Serpentine, Talc, & "Mica". Identification Quiz.	
	March 15	Possible Field Trip to Camp Verde Salt Mines.	
10.	March 17	Spring Recess. No Classes. Read pp. 486-490 (Amphiboles).	
11.	March 24	Descriptive Mineralogy, pp. 490-497 (Pyroxenes). Discussion of Amphiboles & Pyroxenes). Commence work on Rock "Thin-Sections". Identification Quiz.	

CHEMICAL ELEMENTS

Listed in decreasing order of abundance* in Earth's Crust. (ppm)

Name	Symbol	Atom. Wt.	Abundance*	Name	Symbol	Atom. Wt.	Abundance*
Oxygen	O	16.00	466,000	Germanium	Ge	72.6	7.0
Silicon	Si	28.06	277,200	Beryllium	Be	9.02	6.0
Aluminum	Al	26.97	81,300	Samarium	Sm	150.43	6.5
Iron	Fe	55.84	50,000	Gadolinium	Gd	157.3	6.4
Calcium	Ca	40.08	36,300	Praseodymium	Pr	140.92	5.5
Sodium	Na	22.99	28,300	Scandium	Sc	45.10	5.0
Potassium	K	39.09	25,900	Arsenic	As	74.91	5.0
Magnesium	Mg	24.32	20,000	Hafnium	Hf	178.6	4.5
Titanium	Ti	47.9	4,400	Dysprosium	Dy	162.46	4.5
Hydrogen	H	1.0078	1,400	Uranium	U	238.14	4.0
Phosphorus	P	31.02	1,800	Boron	B	10.82	3.0
Manganese	Mn	54.93	1,000	Ytterbium	Yb	173.04	2.7
Sulfur	S	32.06	520	Erbium	Er	167.64	2.5
Carbon	C	12.00	320	Tantalum	Ta	180.88	2.1
Chlorine	Cl	35.5	314	Bromine	Br	79.92	1.6
Rubidium	Rb	85.44	310	Holmium	Ho	163.5	1.2
Fluorine	F	19.00	300	Europium	Eu	152.0	1.1
Strontium	Sr	87.63	300	Antimony	Sb	121.76	1. ?
Barium	Ba	137.36	250	Terbium	Tb	159.2	0.9
Zirconium	Zr	91.22	220	Lutecium	Lu	175.0	0.8
Chromium	Cr	52.01	200	Thallium	Tl	204.39	0.6
Vanadium	V	50.95	150	Mercury	Hg	200.61	0.5
Zinc	Zn	65.38	132	Iodine	I	126.92	0.3
Nickel	Ni	58.69	80	Bismuth	Bi	209.00	0.2
Copper	Cu	63.57	70	Thulium	Tm	169.4	0.2
Tungsten	W	184.0	69	Cadmium	Cd	112.41	0.15
Lithium	Li	6.94	65	Silver	Ag	107.88	0.1
Nitrogen	N	14.008	46	Indium	In	114.76	0.1
Cerium	Ce	140.13	46	Selenium	Se	78.96	0.09
Tin	Sn	118.7	40	Argon	A	39.94	0.04
Yttrium	Y	88.92	28	Palladium	Pd	106.7	0.01
Neodymium	Nd	144.27	24	Platinum	Pt	195.23	0.005
Columbium	Cb	92.91	24	Gold	Au	197.2	0.005
Cobalt	Co	58.94	23	Helium	He	4.002	0.003
Lanthanum	La	138.92	18	Tellurium	Te	127.61	0.002 ?
Lead	Pb	207.22	16	Rhedium	Rh	102.91	0.001
Gallium	Ga	69.72	15	Rhenium	Re	186.31	0.001
Molybdenum	Mo	96.0	15	Iridium	Ir	193.1	0.001
Thorium	Th	232.12	12	Osmium	Os	191.5	0.001 ?
Cesium	Cs	132.91	7	Ruthenium	Ru	101.7	0.001 ?

*Abundance indicated in grams per metric ton, or parts per million

Element	Wt. %	Atom %	Ionic Radius (Ångstrom Units)	Volume
Oxygen	46.60	62.55	1.40 (O^{--})	91.97
Silicon	27.72	21.22	0.41 (Si^{++++})	0.80
Aluminum	8.13	6.47	0.50 (Al^{+++})	0.77
Iron	5.00	1.92	0.75 (Fe^{++}) 0.64 (Fe^{+++})	0.68
Calcium	3.63	1.94	0.99 (Ca^{++})	1.48
Sodium	2.83	2.64	.95 (Na^{+})	1.60
Potassium	2.59	1.42	1.33 (K^{+})	2.14
Magnesium	2.09	1.84	0.65 (Mg^{++})	0.56

Note: Isotopes of elements are written with weight as subscript. (e. g. C_{14} is Carbon with an atomic weight of fourteen.)

TYPE OF CRYSTALS

ACICULAR	-	NEEDLE LIKE
ARBORESENT	-	TREE LIKE
BOTRYOIDAL	-	LIKE GRAPES
EARTHY	-	LIKE SOIL
ENCRUSTING	-	ENCASING - SURROUNDING COATING
FIBEROUS	-	STRINGY
FILIFORM	-	WIRY
FOLIATED	-	LIKE BRANCH OF TREE
GRANULAR	-	LIKE SAND
LEMULAR	-	PAGES IN BOOK
MAMMULAR	-	LIKE BREASTS
MASSIVE	-	LARGE CRYSTALS
RADIATING	-	EXTENDING OUTWARD FROM ONE POINT
RENEFORM	-	KIDNEY SHAPED
SPHEROIDAL	-	ROUND
STALICTITIC	-	HANGS DOWN
TABULAR	-	TAB LIKE

MICA

Geo 102 — Mineralogy

I - METALLIC LUSTER:

STREAK	COLOR	HARDNESS	SPEC. GRAVITY	NAME	REMARKS
Red or Red-Brown	Red-Brown	2.5-3	Except. High	Copper	Ductile; weathers Green
		3.5-4	Above Aver.	Sphalerite	Resinous luster. 6 Cleav.
		5.5-6.5	High	Hematite	Fibrous, Bright, or Earthy
	Dark Gray-Black	3-4.5	Very High	Tetrahedrite	
				Tennantite	Brittle, complex Cu ores
		3.5-4	Above Aver.	Sphalerite	Resinous luster. 6 Cls.
		5.5-6.5	High	Hematite	Shiny, Platy, Scaly
Yellow Brown	Yellow	2.5-3	Extr. High	Gold	Malleable, Sectile
	Y-Black	3.5-4	Above Aver.	Sphalerite	Resinous luster, 6 Cleavs.
Green-Black	Black	1-1.5	Very High	Molybdenite	Bluish, Platy. Weathers Yellow
	Greenish	6-6.5	High	Marcasite	Cockscomb pyrites
White	Any	3.5-4	Above Aver.	Sphalerite	Resinous luster. Per. Cleav.
Dark Gray or Black	Dark Gray or Black	2.5	Except. High	Galena	Cubic (3) Cleavage, Perfect
		2.5-3	Extr. High	Silver	Silver color, weathers Black
		2.5-3	Very High	Chalcocite	Silvery on conchoidal fract.
		3-4.5	Very High	Tetrahedrite	Brittle. Copper ore
		2-2.5	Except. High	Argentite	Sectile. Shiny streak
	Lt. Gray to Met. Whi	1-1.5	Very High	Molybdenite	Bluish overtones, Platy
		2.5	Except. High	Galena	Perfect Cubic Cleavage
		2	High	Stibnite	Bladed crystals. 1 Cleavage
		2.5-3	Very High	Chalcocite	Conchoidal fracture. Silvery
		5-5.5	Very High	Wolframite	1 Perfect Cleavage. Tungsten
	Brassy Yellow	6-6.5	High	Pyrite	Good crystals or massive
		3.5-4	Above Aver.	Chalcopyrite	Tarnishes easily. Greenish St.
	Bronze	3	Very High	Bornite	Bluish-Purple Tarnish. Copper
	Blue	1.5-2	High	Covellite	Bluish, Platy. Copper ore
	Brown	5-5.5	Very High	Wolframite	1 Perfect Cleav. Tungsten ore
	Black	6	Very High	Magnetite	Strongly Magnetic. Iron ore
		5.5	Extr. High	Uraninite	Radio-active. Grainy

II - NON-METALLIC LUSTER:

STREAK	COLOR	HARDNESS	SPEC. GRAVITY	NAME	REMARKS
Gray-Black-Brown	Black	1-6.5	Low-High	Wad, MnO_2	Earthy-compact. Pyrolusite
	Black-Brown	1-1.5	Low	Graphite	Greasy feel. 1 Per. Cleav.
		5-5.5	Very High	Wolframite	Bladed crystals. 1 Cleav.
Red or Red-Brown		2.5	Extr. High	Cinnabar	Granular or massive. Mercury
	Red	3.5-4	Very High	Cuprite	High luster. Purplish
		5-6.5	Very High	Hematite	May be soft, red ochre
	Black	5-6.5	Very High	Hematite	Shiny, Platy, Scaly
Orange	Red	1.5-2	Above Aver.	Realgar	1 Cleavage. Arsenic ore
		3	Except. High	Vanadinite	6-sided prisms. High luster
Yellow or Yellow-Brown	Yellow	1.5-2	Above Aver.	Orpiment	Platy, 1Cleav. with Realgar
		1.5-2.5	Low	Sulphur	Pale color, burns Blue flame
	Yellow-Brown	1-5.5	High	Limonite	Earthy and/or compact. Iron
		1-2	High	Carnotite	Powdery, radio-active
		3	Average	Jarosite	Micaceous plates & scales
		3	Except. High	Vanadinite	Hollow, 6-sided prisms
	Dark Br.	3.5-4	Above Aver.	Siderite	Weathers Black. 3 Cleavs.
	Red-Br.	1-5.5	High	Limonite	Iron ore. Loose to compact
Green	Green	3.5-4	High	Malachite	Effervesces in acid. Copper
	Bluish	6	Average	Turquoise	Massive or disseminated
Blue	Blue	3.5-4	High	Azurite	Radiating, fibrous. Malachite
Light or Faint Colors	White	1	Very Low	Ulexite	Satiny or "Cotton-balls"
		2	Low	Gypsum	1 Perfect & other Cleavages
		2-2.5	Average	Muscovite	1 perfect Cleavage, Tabular
		2-2.5	Extr. Low	Borax	Chalky. 1 Cleavage
		2.5	Average	Kaolin	Clay minerals, feel soapy
		2.5	Low	Halite	Cubic Cleavage. Tastes Salty
		3	Except. High	Anglesite	Massive. Lead ore
		3	Average	Calcite	3 Per. Cls., Eff. in acid
		3-3.5	Except. High	Cerussite	Adamantine luster, Lead ore
		3-3.5	High	Barite	Tabular crystals, 3 Cleavs.
		3.5-4	Above Aver.	Aragonite	Radiating. 3 Cleavs. Calcite
		3.5-4	Average	Dolomite	Curved crystals & massive
		3.5-4	Above Aver.	Sphalerite	Resinous, 6 Cleavages
		3.5-5	Above Aver.	Magnesite	Massive deposits. Chalky
		4	Average	Fluorite	4 Cleavages. Color changes
		4.5-5	Very High	Scheelite	Imp. Cleav. Ultra-violet
		5-6	Average	Tremolite	Bladed crystals or fibrous
		6	Average	Feldspar	Cleavable masses. Crystals
		7	Average	Quartz	6-sided crystals, clear, massive
		7.5-8	Average	Beryl	6-sided crystals, colored
		8	High	Spinel	Octahedrons. Many colors
		8	Above Aver.	Topaz	Per. Basal Cleav. on prisms

DETERMINATIVE MINERAL TABLE

II - NON-METALLIC LUSTER (Continued):

STREAK	COLOR	HARDNESS	SPEC. GRAVITY	NAME	REMARKS
Pale or Faintly Colored	Light Gray	2	Low	Gypsum	1 Per. Cleav. Clear, Selenite
		2.5	Low	Halite	Cubic Cleav. Salty taste
		2.5	Average	Kaolin	Soapy feel. Clay minerals
		2-3	Very High	Cerargyrite	Waxy crusts. Tiny crystals
		3	Average	Calcite	Rhombic Cleav. Eff. in acid
		3	Except. High	Anglesite	Massive. Banded with Galena
		3-3.5	Except. High	Cerussite	High Luster. Eff. in acid CLEAVAGES
		3-3.5	High	Barite	Tabular crystals. Good Cl.
		3.5	High	✓Witherite	Twin crystals. Vitreous
		3.5-4	Above Aver.	Aragonite	6-sided twin crystals. Rad.
		4	Average	Fluorite	Various colors. 4 Cleavs.
		4.5-5	Above Aver.	Hemimorphite	Faintly colored. Zinc ore
		6	Average	Feldspar	Cleavable masses. Crystals
		7	Average	✓Quartz	6-sided crystals & massive
		8	High	✓Spinel	Many colors. Octahedral
		9	Above Aver.	✓Corundum	Rhombic fracture. 6-sided
	Yellow, Brown, Orange	2-2.5	Average	"Mica"	Basal Cleav., Tabular, Platy
		2-3	Very High	Cerargyrite	Waxy, small cubic crystals
		3-3.5	High	Barite	Tabular crystals. Good Cl.
		3.5-4	Above Aver.	Sphalerite	Resinous. 6 Perfect Cleavs.
		3.5-4	Average	✓Dolomite	Massive, curved crystals
		3.5-4	Above Aver.	Aragonite	Radiating crystals. Stalactite
		4.5-5	Above Aver.	Hemimorphite	Translucent. Pyroelectric
		4.5-5	Very High	Scheelite	Ultra-violet. Weak Cleav.
		5	Above Aver.	✓Apatite	6-sided crystals & massive
		5.5	High	Willemite	Resinous. Ultraviolet-green
		6.5-7.5	High	Garnet	Dodecahedrons & massive
		7-7.5	Average	✓Tourmaline	Striated, Trigonal crystals
		7.5	High	Zircon	Good, Tetragonal crystals
		8	Above Aver.	Topaz	Prisms, Perfect Basal Cleav.
		3	Except. High	✓Wulfenite	Tabular, thin crystals
	Pink to Red	3	Average	Calcite	Eff. in acid. Rhombic Cleav.
		3.5	Above Aver.	✓Rhodochrosite	3 Cleavs. Eff. in acid, Mn.
		3	Except. High	Wulfenite	Thin, square, tabular cryst.
		6.5-7.5	High	Garnet	Well-formed crystals & mass.
		7	Average	"Rose" Quartz	Massive & granular
		7	Average	Amethyst	6-sided crystals. Purple Qtz.
		7-7.5	Average	Tourmaline	3 or 6-sided prismatic cryst.
		9	Above Aver.	Corundum	Gem material - Ruby
Pale or Faintly Colored	Green	1	Average	✓Talc	Greasy feel. Basal Cleav.
		2-2.5	Average	Chlorite	Tiny flakes, micaceous Cleav.
		2-3	Very High	Cerargyrite	Waxy crusts, small crystals
		2-4	Low	Chrysocolla	Sticky on tongue. Waxy
		2-5	Low Aver.	Serpentine	Massive & fibrous. Slippery
		3.5-4	Above Aver.	Sphalerite	6 Per. Cleavs. Resinous
		4	Average	Fluorite	4 Per. cleavs. Many colors
		4-6	Average	"Asbestos"	Fibrous, hydrous, Mg. Silicate
		5	High	✓Smithsonite	Appears "fatty". Reniform
		5	Above Aver.	Apatite	6-sided crystals. Phosphate
		5-6	Average	Hornblende	Fibrous, prismatic crystals
		5-6	Average	Augite	4 or 8-sided crystals.
		6	Average	Amazonite	Green Feldspar. Cleavable
		6.5	Above Aver.	Epidote	Per. Basal Cleav. Translucent
		6.5-7.5	High	Garnet	Dodecahedral crystals
		6.5-7	Average	Olivine	Grainy crystals in masses
		6.5-7	Above Aver.	"Jade"	Tough, compact masses
		7-7.5	Average	Tourmaline	Striated, triangular crystals
		7.5-8	Average	Beryl	6-sided crystals. Emerald
	Blue	2-4	Low	Chrysocolla	Waxy luster. Sticks to tongue
		3-3.5	Above Aver.	✓Celestite	3 Perfect Cleavages. Ortho.
		3-3.5	High	Barite	Tabular. 3 Per. Cleavs.
		4	Average	Fluorite	4 Perfect Cleavages.
		5-7	Above Aver.	Kyanite	Bladed Crystals. Dir. Hardness
		5	Above Aver.	Apatite	Massive or Hexagonal crystals
		6	Average	✓Tourquoise	Amorphous, waxy, nodular
		7.5-8	Average	Beryl	Hexagonal. Aquamarine
		9	Above Aver.	Corundum	6-sided crystals. Sapphire
	Brown-Black	2-2.5	Average	Biotite	Basal Cleav. Black Mica
		3.5-4	Above Aver.	Siderite	Rhombic Cleav. Iron ore
		6-7	Except. High	✓Cassiterite	Stream Tin. Reniform
		7.5	High	Zircon	Small, square prisms
	Black	5-6	Average	Augite	2 Cleavs @ 90. Granular
		5-6	Average	Hornblende	2 Cleavs @ 60. Fibrous
		6.5-7.5	High	Garnet	Massive or well-formed xls.
		7-7.5	Average	Schorlite	Trigonal. Black Tourmaline

DETERMINATIVE MINERAL TABLE

I - METALLIC LUSTER:

STREAK	COLOR	HARDNESS	SPEC. GRAVITY	NAME	REMARKS
Red or Red-Brown	Red-Brown	2.5-3	Except. High	Copper	Ductile; weathers Green
		3.5-4	Above Aver.	Sphalerite	Resinous luster. 6 Cleav.
		5.5-6.5	High	Hematite	Fibrous, Bright, or Earthy
	Dark Gray-Black	3-4.5	Very High	Tetrahedrite-Tennantite	Brittle, complex Cu ores
		3.5-4	Above Aver.	Sphalerite	Resinous luster. 6 Cls.
		5.5-6.5	High	Hematite	Shiny, Platy, Scaly
Yellow Brown	Yellow Y-Black	2.5-3	Extr. High	Gold	Malleable, Sectile
		3.5-4	Above Aver.	Sphalerite	Resinous luster, 6 Cleavs.
Green-Black	Black	1-1.5	Very High	Molybdenite	Bluish, Platy. Weathers Yellow
	Greenish	6-6.5	High	Marcasite	Cockscomb pyrites
White	Any	3.5-4	Above Aver.	Sphalerite	Resinous luster. Per. Cleav.
Dark Gray or Black	Dark Gray or Black	2.5	Except. High	Galena	Cubic (3) Cleavage, Perfect
		2.5-3	Extr. High	Silver	Silver color, weathers Black
		2.5-3	Very High	Chalcocite	Silvery on conchoidal fract.
		3-4.5	Very High	Tetrahedrite	Brittle. Copper ore
		2-2.5	Except. High	Argentite	Sectile. Shiny streak
	Lt. Gray to Met. Whi	1-1.5	Very High	Molybdenite	Bluish overtones, Platy
		2.5	Except. High	Galena	Perfect Cubic Cleavage
		2	High	Stibnite	Bladed crystals. 1 Cleavage
		2.5-3	Very High	Chalcocite	Conchoidal fracture. Silvery
		5-5.5	Very High	Wolframite	1 Perfect Cleavage. Tungsten
	Brassy Yellow	6-6.5	High	Pyrite	Good crystals or massive
		3.5-4	Above Aver.	Chalcopyrite	Tarnishes easily. Greenish St.
	Bronze	3	Very High	Bornite	Bluish-Purple Tarnish. Copper
	Blue	1.5-2	High	Covellite	Bluish, Platy. Copper ore
	Brown	5-5.5	Very High	Wolframite	1 Perfect Cleav. Tungsten ore
	Black	6	Very High	Magnetite	Strongly Magnetic. Iron ore
		5.5	Extr. High	Uraninite	Radio-active. Grainy

II - NON-METALLIC LUSTER:

STREAK	COLOR	HARDNESS	SPEC. GRAVITY	NAME	REMARKS
Gray-Black-Brown	Black	1-6.5	Low-High	Wad, MnO_2	Earthy-compact. Pyrolusite
	Black-Brown	1-1.5	Low	Graphite	Greasy feel. 1 Per. Cleav.
		5-5.5	Very High	Wolframite	Bladed crystals. 1 Cleav.
Red or Red-Brown	Red	2.5	Extr. High	Cinnabar	Granular or massive. Mercury
		3.5-4	Very High	Cuprite	High luster. Purplish
		5-6.5	Very High	Hematite	May be soft, red ochre
	Black	5-6.5	Very High	Hematite	Shiny, Platy, Scaly
Orange	Red	1.5-2	Above Aver.	Realgar	1 Cleavage. Arsenic ore
		3	Except. High	Vanadinite	6-sided prisms. High luster
Yellow or Yellow-Brown	Yellow	1.5-2	Above Aver.	Orpiment	Platy, 1Cleav. with Realgar
		1.5-2.5	Low	Sulphur	Pale color, burns Blue flame
	Yellow-Brown	1-5.5	High	Limonite	Earthy and/or compact. Iron
		1-2	High	Carnotite	Powdery, radio-active
		3	Average	Jarosite	Micaceous plates & scales
		3	Except. High	Vanadinite	Hollow, 6-sided prisms
	Dark Br.	3.5-4	Above Aver.	Siderite	Weathers Black. 3 Cleavs.
	Red-Br.	1-5.5	High	Limonite	Iron ore. Loose to compact
Green	Green	3.5-4	High	Malachite	Effervesces in acid. Copper
	Bluish	6	Average	Turquoise	Massive or disseminated
Blue	Blue	3.5-4	High	Azurite	Radiating, fibrous. Malachite
Light or Faint Colors	White	1	Very Low	Ulexite	Satiny or "Cotton-balls"
		2	Low	Gypsum	1 Perfect & other Cleavages
		2-2.5	Average	Muscovite	1 perfect Cleavage, Tabular
		2-2.5	Extr. Low	Borax	Chalky. 1 Cleavage
		2.5	Average	Kaolin	Clay minerals, feel soapy
		2.5	Low	Halite	Cubic Cleavage. Tastes Salty
		3	Except. High	Anglesite	Massive. Lead ore
		3	Average	Calcite	3 Per. Cls., Eff. in acid
		3-3.5	Except. High	Cerussite	Adamantine luster, Lead ore
		3-3.5	High	Barite	Tabular crystals, 3 Cleavs.
		3.5-4	Above Aver.	Aragonite	Radiating. 3 Cleavs. Calcite
		3.5-4	Average	Dolomite	Curved crystals & massive
		3.5-4	Above Aver.	Sphalerite	Resinous, 6 Cleavages
		3.5-5	Above Aver.	Magnesite	Massive deposits. Chalky
		4	Average	Fluorite	4 Cleavages. Color changes
		4.5-5	Very High	Scheelite	Imp. Cleav. Ultra-violet
		5-6	Average	Tremolite	Bladed crystals or fibrous
		6	Average	Feldspar	Cleavable masses. Crystals
		7	Average	Quartz	6-sided crystals, clear, massive
		7.5-8	Average	Beryl	6-sided crystals, colored
		8	High	Spinel	Octahedrons. Many colors
		8	Above Aver.	Topaz	Per. Basal Cleav. on prisms

II - NON-METALLIC LUSTER (Continued):

STREAK	COLOR	HARDNESS	SPEC. GRAVITY	NAME	REMARKS
Pale or Faintly Colored	Light Gray	2	Low	Gypsum	1 Per. Cleav. Clear, Selenite
		2.5	Low	Halite	Cubic Cleav. Salty taste
		2.5	Average	Kaolin	Soapy feel. Clay minerals
		2-3	Very High	Cerargyrite	Waxy crusts. Tiny crystals
		3	Average	Calcite	Rhombic Cleav. Eff. in acid
		3	Except. High	Anglesite	Massive. Banded with Galena
		3-3.5	Except. High	Cerussite	High Luster. Eff. in acid
		3-3.5	High	Barite	Tabular crystals. Good Cl.
		3.5	High	Witherite	Twin crystals. Vitreous
		3.5-4	Above Aver.	Aragonite	6-sided twin crystals. Rad.
		4	Average	Fluorite	Various colors. 4 Cleavs.
		4.5-5	Above Aver.	Hemimorphite	Faintly colored. Zinc ore
		6	Average	Feldspar	Cleavable masses. Crystals
		7	Average	Quartz	6-sided crystals & massive
		8	High	Spinel	Many colors. Octahedral
		9	Above Aver.	Corundum	Rhombic fracture. 6-sided
	Yellow, Brown, Orange	2-2.5	Average	"Mica"	Basal Cleav., Tabular, Platy
		2-3	Very High	Cerargyrite	Waxy, small cubic crystals
		3-3.5	High	Barite	Tabular crystals. Good Cl.
		3.5-4	Above Aver.	Sphalerite	Resinous. 6 Perfect Cleavs.
		3.5-4	Average	Dolomite	Massive, curved crystals
		3.5-4	Above Aver.	Aragonite	Radiating crystals. Stalactite
		4.5-5	Above Aver.	Hemimorphite	Translucent. Pyroelectric
		4.5-5	Very High	Scheelite	Ultra-violet. Weak Cleav.
		5	Above Aver.	Apatite	6-sided crystals & massive
		5.5	High	Willemite	Resinous. Ultraviolet-green
		6.5-7.5	High	Garnet	Dodecahedrons & massive
		7-7.5	Average	Tourmaline	Striated, Trigonal crystals
		7.5	High	Zircon	Good, Tetragonal crystals
		8	Above Aver.	Topaz	Prisms, Perfect Basal Cleav.
		3	Except. High	Wulfenite	Tabular, thin crystals
	Pink to Red	3	Average	Calcite	Eff. in acid. Rhombic Cleav.
		3.5	Above Aver.	Rhodochrosite	3 Cleavs. Eff. in acid. Mn.
		3	Except. High	Wulfenite	Thin, square, tabular cryst.
		6.5-7.5	High	Garnet	Well-formed crystals & mass.
		7	Average	"Rose" Quartz	Massive & granular
		7	Average	Amethyst	6-sided crystals. Purple Qtz.
		7-7.5	Average	Tourmaline	3 or 6-sided prismatic cryst.
		9	Above Aver.	Corundum	Gem material - Ruby
Pale or Faintly Colored	Green	1	Average	Talc	Greasy feel. Basal Cleav.
		2-2.5	Average	Chlorite	Tiny flakes, micaceous Cleav.
		2-3	Very High	Cerargyrite	Waxy crusts, small crystals
		2-4	Low	Chrysocolla	Sticky on tongue. Waxy
		2-5	Low Aver.	Serpentine	Massive & fibrous. Slippery
		3.5-4	Above Aver.	Sphalerite	6 Per. Cleavs. Resinous
		4	Average	Fluorite	4 Per. cleavs. Many colors
		4-6	Average	"Asbestos"	Fibrous, hydrous, Mg. Silicate
		5	High	Smithsonite	Appears "fatty". Reniform
		5	Above Aver.	Apatite	6-sided crystals. Phosphate
		5-6	Average	Hornblende	Fibrous, prismatic crystals
		5-6	Average	Augite	4 or 8-sided crystals.
		6	Average	Amazonite	Green Feldspar. Cleavable
		6.5	Above Aver.	Epidote	Per. Basal Cleav. Translucent
		6.5-7.5	High	Garnet	Dodecahedral crystals
		6.5-7	Average	Olivine	Grainy crystals in masses
		6.5-7	Above Aver.	"Jade"	Tough, compact masses
		7-7.5	Average	Tourmaline	Striated, triangular crystals
		7.5-8	Average	Beryl	6-sided crystals. Emerald
	Blue	2-4	Low	Chrysocolla	Waxy luster. Sticks to tongue
		3-3.5	Above Aver.	Celestite	3 Perfect Cleavages. Ortho.
		3-3.5	High	Barite	Tabular. 3 Per. Cleavs.
		4	Average	Fluorite	4 Perfect Cleavages.
		5-7	Above Aver.	Kyanite	Bladed Crystals. Dir. Hardness
		5	Above Aver.	Apatite	Massive or Hexagonal crystals
		6	Average	Tourquoise	Amorphous, waxy, nodular
		7.5-8	Average	Beryl	Hexagonal. Aquamarine
		9	Above Aver.	Corundum	6-sided crystals. Sapphire
	Brown-Black	2-2.5	Average	Biotite	Basal Cleav. Black Mica
		3.5-4	Above Aver.	Siderite	Rhombic Cleav. Iron ore
		6-7	Except. High	Cassiterite	Stream Tin. Reniform
		7.5	High	Zircon	Small, square prisms
	Black	5-6	Average	Augite	2 Cleavs @ 90. Granular
		5-6	Average	Hornblende	2 Cleavs @ 60. Fibrous
		6.5-7.5	High	Garnet	Massive or well-formed xls.
		7-7.5	Average	Schorlite	Trigonal. Black Tourmaline

STUDENT REFERENCE MINERAL COLLECTION
(M.I.T. Mineral Collection)

45 W 0120

Arranged According to Dana's System of Mineralogy
Seventh Edition

NATIVE ELEMENTS

1.	Sulfur	Sulfur, Nevada
2.	Graphite	Colombo, Island of Ceylon

SULFIDES

3.	Chalcocite	Butte, Montana
4.	Bornite	Superior, Arizona
5.	Galena	Galena, Kansas
6.	Sphalerite	Ottawa County, Oklahoma
7.	Chalcopyrite	Rouyn District, Quebec, Canada
8.	Niccolite	Cobalt, Ontario
9.	Pyrrhotite	Falconbridge, Ontario
10.	Covellite	Butte, Montana
11.	Cinnabar	Winnemucca, Nevada
12.	Realgar	Manhattan, Nevada
13.	Orpiment	Manhattan, Nevada
14.	Stibnite	San Benito, California
15.	Pyrite	Sonora, Mexico
16.	Marcasite	Pough's Quarry, Mexico
17.	Arsenopyrite	Gold Hill, Utah
18.	Molybdenite	Salt Lake City, Utah
19.	Smaltite	Cobalt, Ontario

SULFOSALTS

20.	Tetrahedrite with Siderite	Coeur d'Alene District, Idaho
21.	Enargite	Butte, Montana

OXIDES

22.	Cuprite with Chrysocolla	Butte, Montana
23.	Zincite, etc.	Franklin, New Jersey
24.	Corundum	Zoutpansberg District, Transvaal
25.	Hematite	Ironton, Minnesota
26.	Ilmenite	St. Urbain, Quebec
27.	Hausmannite	Huehue Tanango, Guatemala
28.	Rutile	Clay County, North Carolina
29.	Cassiterite	Mexico
30.	Pyrolusite	Dona Ana County, New Mexico
31.	Bauxite	Little Rock, Arkansas
32.	Psilomelane	Amapa, Brazil

OXIDES - continued

33.	Limonite	Tuscaloosa County, Alabama
34.	Magnetite	Iron County, Utah
35.	Franklinite	Franklin, New Jersey
36.	Chromite	Selukwe, Southern Rhodesia

HALIDES

37.	Halite	Detroit, Michigan
38.	Fluorite	Rosiclare, Illinois
39.	Cryolite	Ivigtut, Greenland

CARBONATES

40.	Calcite	Cherokee County, Kansas
41.	Magnesite	Stevens County, Washington
42.	Siderite	Nova Scotia
43.	Rhodochrosite	Argentina
44.	Smithsonite	Kelly, New Mexico
45.	Aragonite	England
46.	Strontianite	Hamm, Germany
47.	Cerussite	Coeur d'Alene District, Idaho
48.	Dolomite	Selesvaan, Norway
49.	Malachite	Congo
50.	Azurite	Bisbee, Arizona

NITRATE

51.	Soda-Niter	Tarapaca, Chile

BORATE

52.	Colemanite	Inyo County, California

SULFATES

53.	Barite	Kings Creek, South Carolina
54.	Celestite	Torreon, Coahuila, Mexico
55.	Anglesite	Dividend, Utah
56.	Anhydrite	Bancroft, Ontario
57.	Gypsum	Grand Rapids, Michigan
58.	Alunite	Marysvale, Utah

PHOSPHATES

59.	Apatite	Perth, Ontario
60.	Collophanite	Conda, Idaho
61.	Vanadinite	Gila County, Arizona

TUNGSTATES

62.	Ferberite	Boulder County, Colorado
63.	Scheelite	Porcupine, Ontario
64.	Wulfenite	Gailuro Mountains, Arizona

SILICATES

Nesosilicates

65.	Willemite with Franklinite, etc.	Franklin, New Jersey
66.	Olivine	Jackson Co., North Carolina
67.	Garnet (Almandine)	Warren County, New York
68.	Zircon	Brazil
69.	Andalusite	Mineral County, Nevada
70.	Sillimanite	Australia
71.	Kyanite	Minas Gerais, Brazil
72.	Topaz	Stoneham, Maine
73.	Staurolite	Abilene, Virginia
74.	Titanite (Sphene)	Westport, Ontario

Sorosilicates

75.	Hemimorphite	Newton County, Missouri
76.	Epidote	Calumet, Colorado
77.	Allanite	Essex County, New York
78.	Idocrase (Vesuvianite)	Crestmore, California

Cyclosilicates

79.	Beryl	Argentina
80.	Cordierite	Kragero, Norway
81.	Tourmaline	Brazil
82.	Chrysocolla	Miami, Arizona

Inosilicates

83.	Enstatite	Bamble, Norway
84.	Diopside	Minas Gerais, Brazil
85.	Spodumene	near Keystone, South Dakota
86.	Augite	Otter Lake, Quebec
87.	Rhodonite	Silverton, Colorado
88.	Tremolite	Balmat, New York
89.	Actinolite	Chester, Vermont
90.	Hornblende	Otter Lake, Quebec

Phyllosilicates

91.	Kaolin	Dry Branch, Georgia
92.	Serpentine	Thurman, New York
93.	Garnierite	near Riddle, Oregon
94.	Talc	St. Lawrence Co., New York
95.	Muscovite	Eau Claire, Ontario
96.	Phlogopite	Burgess, Ontario
97.	Biotite	Bancroft, Ontario
98.	Lepidolite	Keystone, South Dakota
99.	Chlorite (Prochlorite)	Chester, Vermont

Tectosilicates

100.	Milky Quartz	Park County, Colorado
101.	Chalcedony	Riverside, Washington
102.	Opal	Virgin Valley, Nevada
103.	Orthoclase (Microcline)	Parry Sound District, Ontario
104.	Plagioclase (Labradorite)	Lake St. John Co., Quebec
105.	Leucite	Civita Castellana, Italy
106.	Nepheline	Dungannon Township, Ontario
107.	Sodalite	Bancroft, Ontario
108.	Scapolite	Bolton, Massachusetts
109.	Natrolite	Oregon
110.	Stilbite	Nova Scotia

Prepared by:

WARD'S NATURAL SCIENCE ESTABLISHMENT, INC.
P.O. Box 1712
Rochester, New York, 14603