

MAJOR NATURAL ISOTOPES

WITH % OF OCCURRENCE

MAJOR NATURAL ISOTOPES																														
H 1 - 99.98% 2 - 0.02%	Be 9 - 100%	F 19 - 100%	Ar 36 - 0.3% 40 - 99.6%	Mn 55 - 100%	Ge 70 - 21.2% 72 - 27.7%	Rb 85 - 72.2% 87 - 27.8%	Ru 96 - 5.5% 98 - 1.9% 99 - 12.7% 100 - 12.6% 101 - 17.1% 102 - 31.6% 104 - 18.6%	In 113 - 4.3% 115 - 95.7%	Xe 128 - 1.9% 129 - 26.4% 130 - 4.1% 131 - 21.2% 132 - 26.9% 134 - 10.4% 136 - 8.9%	Nd 142 - 27.1% 143 - 12.2% 144 - 23.8% 145 - 8.3% 146 - 17.2% 148 - 5.8% 150 - 5.6%	Gd 154 - 2.2% 155 - 14.8% 156 - 20.5% 157 - 15.7% 158 - 24.8% 160 - 21.9%	Yb 170 - 3.1% 171 - 14.3% 172 - 21.9% 173 - 16.1% 174 - 31.8% 176 - 12.7%	Ta 180 - 0.01%	Os 186 - 1.6% 187 - 1.6% 188 - 13.3% 189 - 16.1% 190 - 26.4% 192 - 41.0%	Hg 198 - 10.0% 199 - 16.9% 200 - 23.1% 201 - 13.2% 202 - 29.9% 204 - 6.9%	Bi 209 - 100%	Th 232 - 100%													
He 4 - ~100%	B 10 - 19.9% 11 - 80.1%	Ne 20 - 90.5% 21 - 0.3% 22 - 9.3%	K 39 - 93.3% 41 - 6.7%	Ca 40 - 96.9% 42 - 0.7% 44 - 2.1%	Fe 54 - 5.9% 56 - 91.7% 57 - 2.1%	Sr 86 - 9.9% 87 - 7.0% 88 - 82.6%	Y 89 - 100%	Zr 90 - 51.5% 91 - 11.2% 92 - 17.2% 94 - 7.4% 96 - 2.8%	Rh 103 - 100%	Pd 102 - 1.02% 104 - 11.1% 105 - 22.3% 106 - 27.3% 108 - 26.5% 110 - 11.7%	Cs 133 - 100%	Ba 134 - 2.4% 135 - 6.6% 136 - 7.9% 137 - 11.2% 138 - 71.7%	Sm 144 - 3.1% 147 - 15.0% 148 - 11.3% 149 - 13.8% 150 - 7.4% 152 - 26.7% 154 - 22.7%	Dy 160 - 2.3% 161 - 18.9% 162 - 25.6% 163 - 24.9% 164 - 28.2%	Ho 165 - 100%	Er 164 - 1.6% 166 - 33.6% 167 - 23.0% 168 - 26.8% 170 - 14.9%	Eu 151 - 47.8% 153 - 52.2%	Pr 141 - 100%												
Li 6 - 7.5% 7 - 92.5%	C 12 - 98.9% 13 - 1.1%	Na 23 - 100%	Mg 24 - 79.0% 25 - 10.0% 26 - 11.0%	Al 27 - 100%	Si 28 - 92.2% 29 - 4.7% 30 - 3.1%	P 31 - 100%	S 32 - 95.0% 33 - 0.8% 34 - 4.2%	Cl 35 - 75.8% 37 - 24.2%	Cr 50 - 0.3% 51 - 99.7%	V 50 - 0.3% 51 - 99.7%	Cr 50 - 0.3% 51 - 99.7%	Ga 69 - 60.1% 71 - 39.9%	Zn 64 - 48.6% 66 - 27.9% 67 - 4.1% 68 - 18.8%	Br 79 - 50.7% 81 - 49.3%	Mo 92 - 14.8% 94 - 9.3% 95 - 15.9% 96 - 16.7% 97 - 9.6% 98 - 24.1% 100 - 9.6%	Tc 93 - synthetic	Se 74 - 0.9% 76 - 9.4% 77 - 7.6% 78 - 23.8% 80 - 49.6% 82 - 8.7%	Nb 93 - 100%	Ag 107 - 51.8% 109 - 48.2%	Cd 106 - 0.9% 108 - 0.9% 110 - 12.5% 111 - 12.8% 112 - 24.1% 113 - 12.2% 114 - 28.7%	Te 122 - 2.6% 123 - 0.9% 124 - 4.8% 125 - 7.1% 126 - 18.9% 128 - 31.7% 130 - 33.9%	I 127 - 100%	Sb 121 - 57.4% 123 - 42.6%	Ba 134 - 2.4% 135 - 6.6% 136 - 7.9% 137 - 11.2% 138 - 71.7%	Sm 144 - 3.1% 147 - 15.0% 148 - 11.3% 149 - 13.8% 150 - 7.4% 152 - 26.7% 154 - 22.7%	Dy 160 - 2.3% 161 - 18.9% 162 - 25.6% 163 - 24.9% 164 - 28.2%	Ho 165 - 100%	Er 164 - 1.6% 166 - 33.6% 167 - 23.0% 168 - 26.8% 170 - 14.9%	Eu 151 - 47.8% 153 - 52.2%	Pr 141 - 100%
1 1.008 1s ¹ Hydrogen	2 4.003 1s ² Helium	3 6.94 1s ² 2s ¹ Lithium	4 9.01 1s ² 2s ² Beryllium	5 10.81 1s ² 2s ² 2p ¹ Boron	6 12.01 1s ² 2s ² 2p ² Carbon	7 14.01 1s ² 2s ² 2p ³ Nitrogen	8 16.00 1s ² 2s ² 2p ⁴ Oxygen	9 19.00 1s ² 2s ² 2p ⁵ Fluorine	10 20.18 1s ² 2s ² 2p ⁶ Neon	11 22.99 [Ne]3s ¹ Sodium	12 24.31 [Ne]3s ² Magnesium	13 26.98 [Ne]3s ² 3p ¹ Aluminum	14 28.09 [Ne]3s ² 3p ² Silicon	15 30.97 [Ne]3s ² 3p ³ Phosphorus	16 32.07 [Ne]3s ² 3p ⁴ Sulfur	17 35.45 [Ne]3s ² 3p ⁵ Chlorine	18 39.95 [Ne]3s ² 3p ⁶ Argon													

19 39.10 [Ar]4s ¹ Potassium	20 40.08 [Ar]4s ² Calcium	21 44.96 [Ar]3d ¹ 4s ² Scandium	22 47.87 [Ar]3d ² 4s ² Titanium	23 50.94 [Ar]3d ³ 4s ² Vanadium	24 52.00 [Ar]3d ⁴ 4s ² Chromium	25 54.94 [Ar]3d ⁵ 4s ¹ Manganese	26 55.85 [Ar]3d ⁶ 4s ² Iron	27 58.93 [Ar]3d ⁷ 4s ² Cobalt	28 58.69 [Ar]3d ⁸ 4s ² Nickel	29 63.55 [Ar]3d ⁹ 4s ¹ Copper	30 65.39 [Ar]3d ¹⁰ 4s ¹ Zinc	31 69.72 [Ar]3d ¹⁰ 4s ² Gallium	32 72.61 [Ar]3d ¹⁰ 4s ² Germanium	33 74.92 [Ar]3d ¹⁰ 4s ² Arsenic	34 78.96 [Ar]3d ¹⁰ 4s ² Selenium	35 79.90 [Ar]3d ¹⁰ 4s ² Bromine	36 83.80 [Ar]3d ¹⁰ 4s ² Krypton
37 85.47 [Kr]5s ¹ Rubidium	38 87.62 [Kr]5s ² Strontium	39 88.91 [Kr]4d ¹ 5s ² Yttrium	40 91.22 [Kr]4d ² 5s ² Zirconium	41 92.91 [Kr]4d ³ 5s ² Niobium	42 95.94 [Kr]4d ⁴ 5s ² Molybdenum	43 98 [Kr]4d ⁵ 5s ¹ Technetium	44 101.1 [Kr]4d ⁶ 5s ² Ruthenium	45 102.9 [Kr]4d ⁷ 5s ² Rhodium	46 106.4 [Kr]4d ⁸ 5s ¹ Palladium	47 107.9 [Kr]4d ⁹ 5s ¹ Silver	48 112.4 [Kr]4d ¹⁰ 5s ¹ Cadmium	49 114.8 [Kr]4d ¹⁰ 5s ² Indium	50 118.7 [Kr]4d ¹⁰ 5s ² Tin	51 121.8 [Kr]4d ¹⁰ 5s ² Antimony	52 127.6 [Kr]4d ¹⁰ 5s ² Tellurium	53 126.9 [Kr]4d ¹⁰ 5s ² Iodine	54 131.3 [Kr]4d ¹⁰ 5s ² Xenon
55 132.9 [Xe]6s ¹ Cesium	56 137.3 [Xe]6s ² Barium	57 138.9 [Xe]5d ¹ 6s ² Lanthanum	72 178.5 [Xe]4f ¹ 5d ¹ 6s ² Hafnium	73 180.9 [Xe]4f ¹ 5d ² 6s ² Tantalum	74 183.8 [Xe]4f ¹ 5d ³ 6s ² Tungsten	75 186.2 [Xe]4f ¹ 5d ⁴ 6s ² Rhenium	76 190.2 [Xe]4f ¹ 5d ⁵ 6s ² Osmium	77 192.2 [Xe]4f ¹ 5d ⁶ 6s ² Iridium	78 195.1 [Xe]4f ¹ 5d ⁷ 6s ² Platinum	79 197.0 [Xe]4f ¹ 5d ⁸ 6s ¹ Gold	80 200.6 [Xe]4f ¹ 5d ⁹ 6s ¹ Mercury	81 204.4 [Xe]4f ¹ 5d ¹⁰ 6s ¹ Thallium	82 207.2 [Xe]4f ¹ 5d ¹⁰ 6s ² Lead	83 209.0 [Xe]4f ¹ 5d ¹⁰ 6s ² Bismuth	84 209 [Xe]4f ¹ 5d ¹⁰ 6s ² Polonium	85 210 [Xe]4f ¹ 5d ¹⁰ 6s ² Astatine	86 222 [Xe]4f ¹ 5d ¹⁰ 6s ² Radon
87 223 [Rn]7s ¹ Francium	88 226 [Rn]7s ² Radium	89 227 [Rn]6d ¹ 7s ² Actinium	104 261 disc.1964 [Rn]5f ¹ 6d ¹ 7s ² Rutherfordium	105 262 disc.1967 [Rn]5f ¹ 6d ² 7s ² Dubnium	106 266 disc.1974 [Rn]5f ¹ 6d ³ 7s ² Seaborgium	107 264 disc.1981 [Rn]5f ¹ 6d ⁴ 7s ² Borhrium	108 269 disc.1984 [Rn]5f ¹ 6d ⁵ 7s ² Hassium	109 268 disc.1982 [Rn]5f ¹ 6d ⁶ 7s ² Meitnerium	110 271 disc.1994 [Rn]5f ¹ 6d ⁷ 7s ² Ununnilium	111 272 disc.1994 [Rn]5f ¹ 6d ⁸ 7s ² Unununium	112 277 disc.1996 [Rn]5f ¹ 6d ⁹ 7s ² Ununbium	113 ? disc.1999 [Rn]5f ¹ 6d ¹⁰ 7s ² Not discov	114 289 disc.1999 [Rn]5f ¹ 6d ¹⁰ 7s ² Ununquadium	115 ? disc.1999 [Rn]5f ¹ 6d ¹⁰ 7s ² Not discov	116 289 disc.1999 [Rn]5f ¹ 6d ¹⁰ 7s ² Ununhexium	117 ? disc.1999 [Rn]5f ¹ 6d ¹⁰ 7s ² Not discov	118 293 disc.1999 [Rn]5f ¹ 6d ¹⁰ 7s ² Ununoctium

Atomic Number	90	232.0	Atomic Weight
Symbol	Th		Radioactive Element
Oxidation States	4	6.08	1st Ionization Potential
Name	Thorium		Electron Configuration
	[Rn]6d ² 7s ²		

58 140.1 [Xe]4f ¹ 5d ¹ 6s ² Cerium	59 140.9 [Xe]4f ¹ 5d ² 6s ² Praseodymium	60 144.2 [Xe]4f ¹ 5d ³ 6s ² Neodymium	61 145 [Xe]4f ¹ 5d ⁴ 6s ² Promethium	62 150.4 [Xe]4f ¹ 5d ⁵ 6s ² Samarium	63 152.0 [Xe]4f ¹ 5d ⁶ 6s ² Europium	64 157.3 [Xe]4f ¹ 5d ⁷ 6s ² Gadolinium	65 158.9 [Xe]4f ¹ 5d ⁸ 6s ² Terbium	66 162.5 [Xe]4f ¹ 5d ⁹ 6s ² Dysprosium	67 164.9 [Xe]4f ¹ 5d ¹⁰ 6s ² Holmium	68 167.3 [Xe]4f ¹ 5d ¹¹ 6s ² Erbium	69 169.9 [Xe]4f ¹ 5d ¹² 6s ² Thulium	70 173.0 [Xe]4f ¹ 5d ¹³ 6s ² Ytterbium	71 175.0 [Xe]4f ¹ 5d ¹⁴ 6s ² Lutetium
90 232.0 [Rn]6d ² 7s ² Thorium	91 231.0 [Rn]5f ¹ 6d ¹ 7s ² Protactinium	92 238.0 [Rn]5f ¹ 6d ² 7s ² Uranium	93 237 [Rn]5f ¹ 6d ³ 7s ² Neptunium	94 244 [Rn]5f ¹ 6d ⁴ 7s ² Plutonium	95 243 [Rn]5f ¹ 6d ⁵ 7s ² Americium	96 247 [Rn]5f ¹ 6d ⁶ 7s ² Curium	97 247 [Rn]5f ¹ 6d ⁷ 7s ² Berkelium	98 251 [Rn]5f ¹ 6d ⁸ 7s ² Californium	99 252 [Rn]5f ¹ 6d ⁹ 7s ² Einsteinium	100 257 [Rn]5f ¹ 6d ¹⁰ 7s ² Fermium	101 258 [Rn]5f ¹ 6d ¹¹ 7s ² Mendelevium	102 259 [Rn]5f ¹ 6d ¹² 7s ² Nobelium	103 262 [Rn]5f ¹ 6d ¹³ 7s ² Lawrencium

atomic number

BASICS

solids

PERIODIC TABLE

ACADEMIC
Study
Charts, Inc.

WORLD'S #1 ACADEMIC CHART

MEASUREMENT AND UNITS

mass: kilogram (kg) = 1000 g = 2.2046 pound
length: meter (m) = 100 cm = 1.0936 yard = 10^{10} Å
time: second (s)
temperature: Kelvin, (K)
volume: liter (L) = 1000 mL = 1.0567 quart
pressure: Pascal, Pa (N/m²); 1 atm = 101,325 Pa
force: Newton, N (J/m); charge: coulomb, C
energy: Joule, J (kg m²/s²) = 0.23901 calorie

PHYSICAL CONSTANTS

	$T(^{\circ}\text{F}) = T(^{\circ}\text{C}) + 273.15$	$T(^{\circ}\text{F}) = 9/5 \times T(^{\circ}\text{C}) + 32$	
Boiling water	212°F	100°C	373 K
Body temp.	98°F	37°C	310 K
Room temp.	68°F	20°C	293 K
Freezing water	32°F	0°C	273 K
	Fahrenheit	Celsius	Kelvin

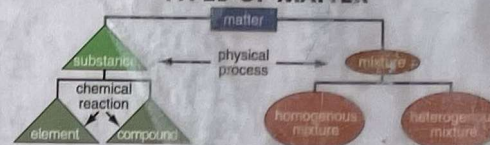
Prefixes:

tera T (10¹²)
kilo k (10³)
micro μ (10⁻⁶)

giga G (10⁹)
centi c (10⁻²)
nano n (10⁻⁹)

mega M (10⁶)
milli m (10⁻³)
pico p (10⁻¹²)

TYPES OF MATTER



FUNDAMENTAL CONSTANTS

$R = 8.314 \text{ J mole}^{-1} \text{ K}^{-1}$ (for energy calculation)
 $R = 0.082 \text{ l atm mole}^{-1} \text{ K}^{-1}$ (for gas property calculation)
Avogadro's Number: $N_A = 6.022 \times 10^{23} \text{ mole}^{-1}$
Boltzmann constant: $k = R/N_A = 1.381 \times 10^{-23} \text{ J molecule}^{-1} \text{ K}^{-1}$
Elementary charge of the electron, $e: 1.602 \times 10^{-19} \text{ C}$
Faraday Constant, $\mathcal{F}$: charge of N_A electrons
Force: Newton, $N = \text{Jm}^{-1} = \text{kg m s}^{-2}$
Mass of a proton, $m_p = 1.673 \times 10^{-27} \text{ kg}$
Mass of a neutron, $m_n = 1.675 \times 10^{-27} \text{ kg}$
Mass of an electron, $m_e = 9.110 \times 10^{-31} \text{ kg}$
Planck's Constant, $h: 6.626 \times 10^{-34} \text{ J s}$
Speed of light in a vacuum, $c: 2.9979 \times 10^8 \text{ m s}^{-1}$

gas	He
0.008	0.08
1.78	-
-269	-

rhombic	hexagonal	gas	gas	gas	gas
B	C	N ₂	O ₂	F ₂	Ne
10 480.0	200 711.0	19 5.67	461000 8.82	585 6.62	0.005 1.71
2.34 50.2	2.26 117	1.25 0.71	1.43 0.44	1.70 0.51	99 0.33
4000 2075	3825 4492p	-195 -210	-183 -219	-186 -220p	-245 -249
fcc	fcc	cubic	ortho	gas	gas
Al	Si	P	S	Cl ₂	Ar
82300 294.0	282000 383.0	1050 13.4p	350 45.5	146 20.41	3.5 6.43
2.70 10.71	2.33 50.21	1.82 0.66	2.07 1.12	3.12 8.4	1.78 1.16
2519 660	3265 1414	280 44	445 120	-36 -10	-186 -189
ortho	fcc	rhombic	hex	liquid	gas
Ga	Ge	As	Se	Br ₂	Kr
19 254.0	1.5 334.0	1.8 31.9	0.05 95.48	2.4 39.96	<0.001 9.06
5.91 5.59	5.32 36.94	5.72 24.44	4.80 6.69	3.12 10.57	3.73 1.64
2204 30	2833 939	603sp 817p	685 221	59 -	-153 -157p
tetra	tetra	rhombic	hex	ortho	gas
In	Sn	Sb	Te	I ₂	Xe
0.25 226.4	2.3 290.4	0.2 67.9	0.001 114.1	0.45 41.57	<0.001 12.57
7.31 3.28	7.26 7.03	6.68 19.87	6.24 17.49	4.93 15.52	5.89 2.27
2072 157	2602 232	1587 631	988 460	134 114	598 11
hex	fcc	rhombic	cubic	gas	gas
Tl	Pb	Bi	Po	At	Rn
0.85 162.1	-14 179.5	0.009 153.0	<0.001 101.8	<0.001 18.1	<0.001 18.1
11.8 4.14	11.3 4.77	9.79 -11.3	9.2 -	9.73 2.86	9.73 2.86
1473 304	1749 328	1564 271	962 254	-302 -	-62 -71
?	Uuq	?	RETRACTED	?	RETRACTED
not disc.	disc.1999	not disc.	disc.1999	not disc.	disc.1999
	Dubna, Russia		Berkeley, CA		Berkeley, CA

quickstudy

crystal structures

cubic=simple cubic
hex=hexagonal
tetra=tetragonal

bcc=body centered cubic
ortho=orthorhombic
mono=monoclinic

fcc=face centered cubic
rhomb=RHOMBOHEDRAL
-unknown

fcc Ce 66.5 314.0 6.77 5.46 3443 796	hex Pr 9.2 333.0 6.77 6.89 3520 931	hex Nd 41.5 284.0 7.01 7.14 3074 1021	hex Pm <0.001 - 7.26 7.7 3000 1042	rhomb Sm 7.05 192.0 7.52 8.62 1794 1074	bcc Eu 2.0 176.0 5.24 9.21 1529 822	hex Gd 6.2 312.0 7.90 10.0 3273 1313	hex Tb 1.2 391.0 8.23 10.15 3230 1356	hex Dy 5.2 293.0 8.55 11.06 2567 1412	hex Ho 1.3 251.0 8.80 17.0 2700 1474	hex Er 3.5 293.0 9.07 19.9 2868 1529	hex Tm 0.52 247.0 9.32 16.84 1950 1545	fcc Yb 3.2 159.0 6.90 7.66 1196 819	hex Lu 0.8 428.0 9.84 22.0 3402 1663
fcc Th 9.6 543.9 11.7 13.81 4788 1750	tetra Pa <0.001 481.0 15.4 12.34 - 1572	ortho U 2.7 423.0 19.1 9.14 4131 1135	ortho Np synthetic 337.0 20.2 3.20 - 644	mono Pu synthetic 344.0 19.7 2.82 3228 640	hex Am synthetic - 13.6 14.39 2011 1176	hex Cm synthetic 387.0 13.5 15.0 3100 1345	hex Bk synthetic 310.0 14.8 - - 1050	hex Cf synthetic 196.0 - - - 900	hex Es synthetic 133.0 - - - 860	- Fm synthetic - - - - 1527	- Md synthetic - - - - 827	- No synthetic - - - - 827	- Lr synthetic - - - - 1627

Natural Form

solid liquid gas

Elemental Abundance
mg per kg of crust

Density
solid, liquid: g/cm³ (20°C & 1 atm)
gas: g/liter (0°C & 1 atm)

Boiling Point
°C and 1 atm;
Liquid→Gas
tp=triple point

Symbol

Enthalpy of Vaporization
kJ/mole
Liquid→Gas

Enthalpy of Fusion
kJ/mole
Solid→Liquid
ΔH_f at T_m
tp=triple point

Melting Point
°C and 1 atm
Solid→Liquid

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