Honors Chemistry Data Booklet

Pre-IB Chemistry

Academic Year 2025 - 2026

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Constants

Avogadro's Number: 6.02×10^{23}
Gas constant (R): 8.31 J/mol K
Speed of light (c) = 3.00×10^{8} m/s
Planck's constant (h) = 6.63×10^{-34} J s
Standard ambient temperature and pressure (SATP) = 298 K and 100 kPa
Standard temperature and pressure (STP) = 273 K and 100 kPa
Volume of 1 mole of an ideal gas at STP: 22.7 L

Equations

$E = hf$
$c = \lambda f$
$M_1V_1 = M_2V_2$
$pH = -\log[H^+]$
$pOH = -\log[OH^-]$
$[H^+] = 10^{-pH}$
$[OH^-] = 10^{-pOH}$
$K = °C + 273$
$°C = K - 273$

Ideal Gas Law: $PV = nRT$
Combined Gas Law: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
Boyle's Law: $P_1V_1 = P_2V_2$
Charles' Law: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
Gay-Lussac's Law: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
Graham's Law of Effusion: $\frac{rate_A}{rate_B} = \frac{\sqrt{M_B}}{\sqrt{M_A}}$

SI Base Units

Base Quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

SI Derived Units

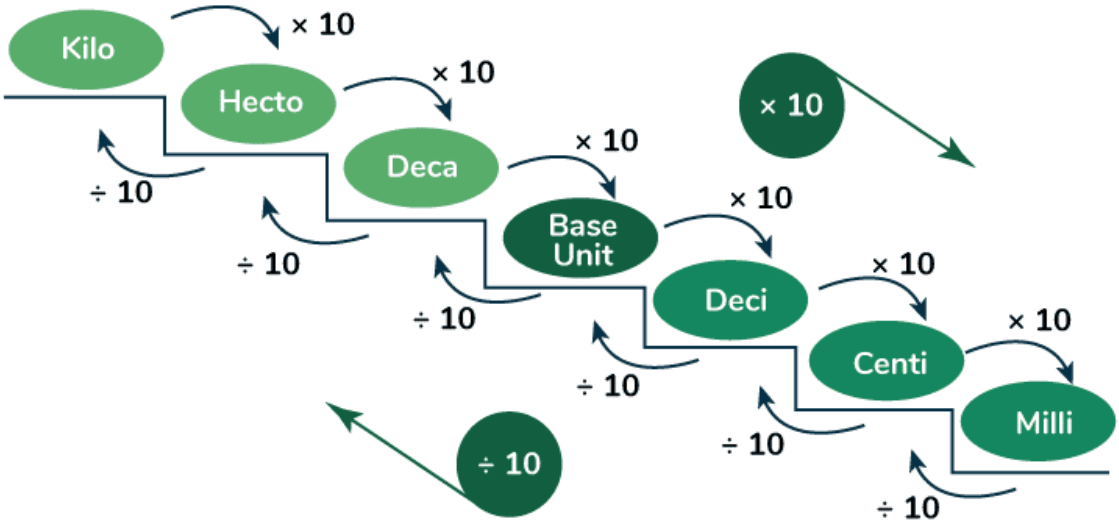
Derived Quantity	Name	Symbol	Equivalent SI Units
Frequency	hertz	Hz	s^{-1}
Force	newtown	N	$m \cdot kg \cdot s^{-2}$
Pressure	pascal	Pa	N/m^2
Energy	joule	J	$N \cdot m$
Power	watt	W	J/s
Electric charge	coulomb	C	$s \cdot A$
Electric potential	volt	V	W/A
Electric resistance	ohm	Ω	V/A
Celsius temperature	degree Celsius	°C	K*

*Unit degree Celsius is equal in magnitude to unit kelvin

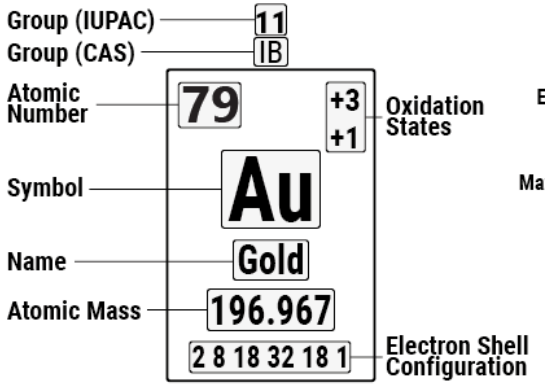
Metric System Conversions

SI Prefixes

Factor	Name	Symbol	Numerical Value
10^{12}	tera	T	1 000 000 000 000
10^{9}	giga	G	1 000 000 000
10^{6}	mega	M	1 000 000
10^{3}	kilo	k	1 000
10^{2}	hecto	h	100
10^{1}	deka	da	10
10^{-1}	deci	d	0.1
10^{-2}	centi	c	0.01
10^{-3}	milli	m	0.001
10^{-6}	micro	μ	0.000 001
10^{-9}	nano	n	0.000 000 001
10^{-12}	pico	p	0.000 000 000 001



PERIODIC TABLE OF THE ELEMENTS



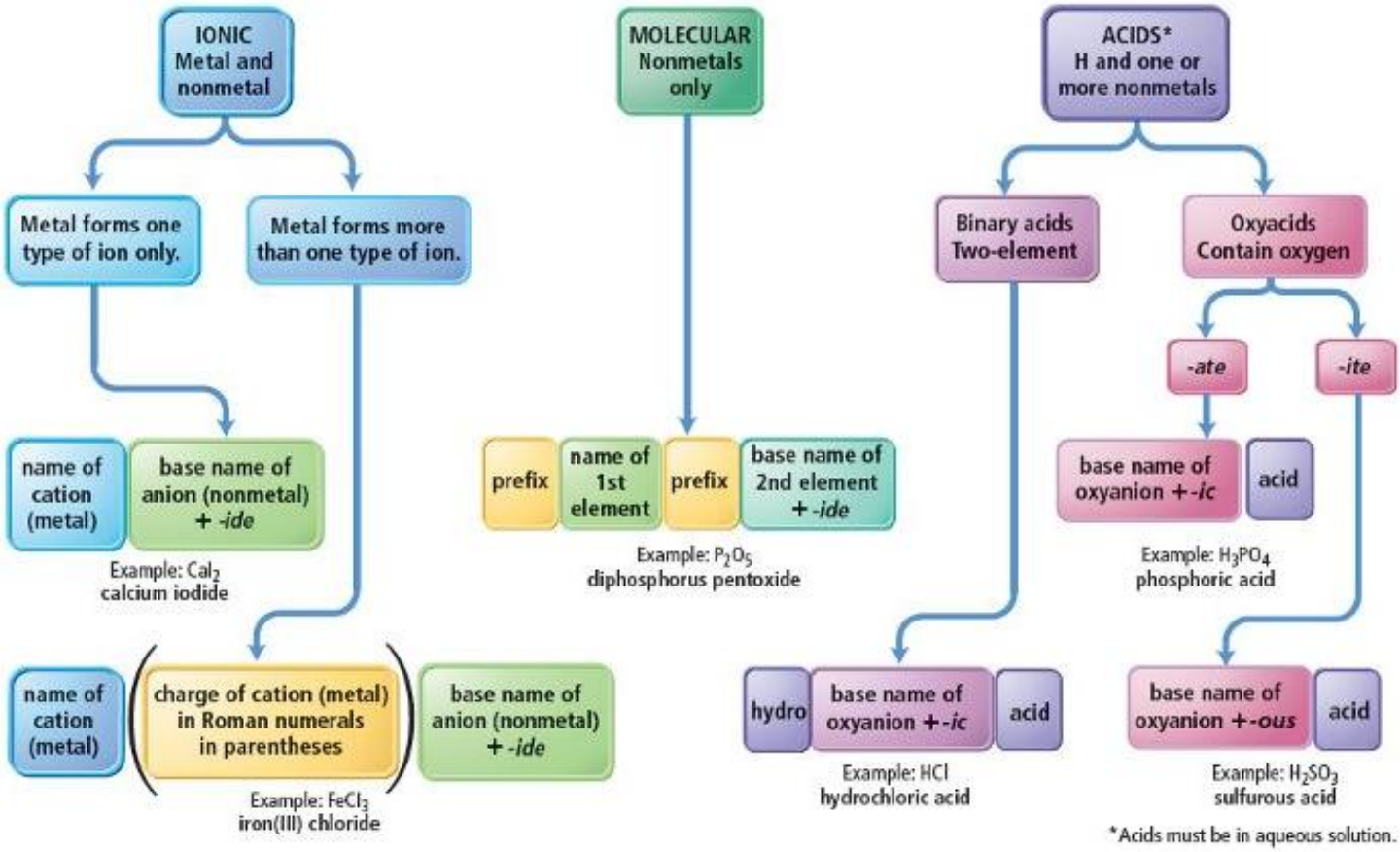
ELECTRON SHELLS

Energy Level	1	2	3	4	5	6	7	8
Shell Name	K	L	M	N	O	P	Q	R
Max. Electrons	2	8	18	32	32	18	8	2
s	2	2	2	2	2	2	2	2
p		6	6	6	6	6	6	
d			10	10	10	10		
f				14	14			

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H Hydrogen 1.008 1																	2 He Helium 4.003 2
2	3 Li Lithium 6.941 2 1	4 Be Beryllium 9.012 2 2											5 B Boron 10.811 2 3	6 C Carbon 12.011 2 4	7 N Nitrogen 14.007 2 5	8 O Oxygen 15.999 2 6	9 F Fluorine 18.998 2 7	10 Ne Neon 20.180 2 8
3	11 Na Sodium 22.990 2 8 1	12 Mg Magnesium 24.305 2 8 2											13 Al Aluminum 26.982 2 8 3	14 Si Silicon 28.086 2 8 4	15 P Phosphorus 30.974 2 8 5	16 S Sulfur 32.066 2 8 6	17 Cl Chlorine 35.453 2 8 7	18 Ar Argon 39.948 2 8 8
4	19 K Potassium 39.098 2 8 8 1	20 Ca Calcium 40.078 2 8 8 2	21 Sc Scandium 44.956 2 8 9 2	22 Ti Titanium 47.867 2 8 10 2	23 V Vanadium 50.942 2 8 11 2	24 Cr Chromium 51.996 2 8 13 1	25 Mn Manganese 54.938 2 8 13 2	26 Fe Iron 55.845 2 8 14 2	27 Co Cobalt 58.933 2 8 15 2	28 Ni Nickel 58.693 2 8 16 2	29 Cu Copper 63.546 2 8 18 1	30 Zn Zinc 65.38 2 8 18 2	31 Ga Gallium 69.723 2 8 18 3	32 Ge Germanium 72.631 2 8 18 4	33 As Arsenic 74.922 2 8 18 5	34 Se Selenium 78.971 2 8 18 6	35 Br Bromine 79.904 2 8 18 7	36 Kr Krypton 83.798 2 8 18 8
5	37 Rb Rubidium 85.468 2 8 18 8 1	38 Sr Strontium 87.62 2 8 18 8 2	39 Y Yttrium 88.906 2 8 18 9 2	40 Zr Zirconium 91.224 2 8 18 10 2	41 Nb Niobium 92.906 2 8 18 12 1	42 Mo Molybdenum 95.95 2 8 18 13 1	43 Tc Technetium 98.907 2 8 18 13 2	44 Ru Ruthenium 101.07 2 8 18 15 1	45 Rh Rhodium 102.906 2 8 18 16 1	46 Pd Palladium 106.42 2 8 18 18	47 Ag Silver 107.868 2 8 18 18 1	48 Cd Cadmium 112.414 2 8 18 18 2	49 In Indium 114.818 2 8 18 18 3	50 Sn Tin 118.711 2 8 18 18 4	51 Sb Antimony 121.760 2 8 18 18 5	52 Te Tellurium 127.6 2 8 18 18 6	53 I Iodine 126.904 2 8 18 18 7	54 Xe Xenon 131.293 2 8 18 18 8
6	55 Cs Cesium 132.905 2 8 18 18 8 1	56 Ba Barium 137.328 2 8 18 18 8 2	57-71 Lanthanoids	72 Hf Hafnium 178.49 2 8 18 32 10 2	73 Ta Tantalum 180.948 2 8 18 32 11 2	74 W Tungsten 183.84 2 8 18 32 12 2	75 Re Rhenium 186.207 2 8 18 32 13 2	76 Os Osmium 190.23 2 8 18 32 14 2	77 Ir Iridium 192.217 2 8 18 32 15 2	78 Pt Platinum 195.085 2 8 18 32 17 1	79 Au Gold 196.967 2 8 18 32 18 1	80 Hg Mercury 200.592 2 8 18 32 18 2	81 Tl Thallium 204.383 2 8 18 32 18 3	82 Pb Lead 207.2 2 8 18 32 18 4	83 Bi Bismuth 208.980 2 8 18 32 18 5	84 Po Polonium [208.982] 2 8 18 32 18 6	85 At Astatine 209.987 2 8 18 32 18 7	86 Rn Radon 222.018 2 8 18 32 18 8
7	87 Fr Francium 223.020 2 8 18 32 18 8 1	88 Ra Radium 226.025 2 8 18 32 18 8 2	89-103 Actinoids	104 Rf Rutherfordium [261] 2 8 18 32 32 10 2	105 Db Dubnium [262] 2 8 18 32 32 11 2	106 Sg Seaborgium [266] 2 8 18 32 32 12 2	107 Bh Bohrium [264] 2 8 18 32 32 13 2	108 Hs Hassium [269] 2 8 18 32 32 14 2	109 Mt Meitnerium [278] 2 8 18 32 32 15 2	110 Ds Darmstadtium [281] 2 8 18 32 32 16 2	111 Rg Roentgenium [280] 2 8 18 32 32 17 2	112 Cn Copernicium [285] 2 8 18 32 32 18 2	113 Nh Nihonium [286] 2 8 18 32 32 18 3	114 Fl Flerovium [289] 2 8 18 32 32 18 4	115 Mc Moscovium [289] 2 8 18 32 32 18 5	116 Lv Livermorium [293] 2 8 18 32 32 18 6	117 Ts Tennessine [294] 2 8 18 32 32 18 7	118 Og Oganesson [294] 2 8 18 32 32 18 8

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Lanthanoids	57 La Lanthanum 138.905 2 8 18 18 9 2	58 Ce Cerium 140.116 2 8 18 19 9 2	59 Pr Praseodymium 140.908 2 8 18 21 8 2	60 Nd Neodymium 144.243 2 8 18 22 8 2	61 Pm Promethium 144.913 2 8 18 23 8 2	62 Sm Samarium 150.36 2 8 18 24 8 2	63 Eu Europium 151.964 2 8 18 25 8 2	64 Gd Gadolinium 157.25 2 8 18 25 9 2	65 Tb Terbium 158.925 2 8 18 27 8 2	66 Dy Dysprosium 162.500 2 8 18 28 8 2	67 Ho Holmium 164.930 2 8 18 29 8 2	68 Er Erbium 167.259 2 8 18 30 8 2	69 Tm Thulium 168.934 2 8 18 31 8 2	70 Yb Ytterbium 173.055 2 8 18 32 8 2	71 Lu Lutetium 174.967 2 8 18 32 9 2
Actinoids	89 Ac Actinium 227.028 2 8 18 32 18 9 2	90 Th Thorium 232.038 2 8 18 32 18 10 2	91 Pa Protactinium 231.036 2 8 18 32 20 9 2	92 U Uranium 238.029 2 8 18 32 21 9 2	93 Np Neptunium 237.048 2 8 18 32 22 9 2	94 Pu Plutonium 244.064 2 8 18 32 24 8 2	95 Am Americium 243.061 2 8 18 32 25 8 2	96 Cm Curium 247.070 2 8 18 32 25 9 2	97 Bk Berkelium 247.070 2 8 18 32 27 8 2	98 Cf Californium 251.080 2 8 18 32 28 8 2	99 Es Einsteinium [254] 2 8 18 32 29 8 2	100 Fm Fermium 257.095 2 8 18 32 30 8 2	101 Md Mendelevium 258.1 2 8 18 32 31 8 2	102 No Nobelium 259.101 2 8 18 32 32 8 2	103 Lr Lawrencium [262] 2 8 18 32 32 8 3



DIATOMIC ELEMENTS
- Bromine
- Chlorine
- Fluorine
- Hydrogen
- Iodine
- Nitrogen
- Oxygen

PREFIXES
1. mono
2. di
3. tri
4. tetra
5. penta
6. hexa
7. hepta
8. octa
9. nona
10. deca

Polyatomic Ions

Polyatomic Anions (-1 charge)		**Formula**
acetate	(CH_3COO^-)	$C_2H_3O_2^-$
amide		NH_2^-
bicarbonate		HCO_3^-
bisulfate		HSO_4^-
bromate		BrO_3^-
chlorate		ClO_3^-
chlorite		ClO_2^-
cyanate		OCN^-
cyanide		CN^-
hydroxide		OH^-
hypochlorite		ClO^-
iodate		IO_3^-
nitrate		NO_3^-
nitrite		NO_2^-
perchlorate		ClO_4^-
permanganate		MnO_4^-
thiocyanate		SCN^-

Polyatomic Cation (+1 charge)	**Formula**
Ammonium	NH_4^+

Polyatomic Anions (-2 charge)	**Formula**
carbonate	CO_3^{2-}
chromate	CrO_4^{2-}
dichromate	$Cr_2O_7^{2-}$
manganate	MnO_3^{2-}
molybdate	MoO_4^{2-}
oxalate	$C_2O_4^{2-}$
peroxide	O_2^{2-}
selenate	SeO_4^{2-}
silicate	SiO_3^{2-}
sulfate	SO_4^{2-}
sulfite	SO_3^{2-}
thiosulfate	$S_2O_3^{2-}$

Polyatomic Anions (-3 charge)	**Formula**
arsenite	AsO_3^{3-}
arsenate	AsO_4^{3-}
borate	BO_3^{3-}
citrate	$C_6H_5O_7^{3-}$
phosphite	PO_3^{3-}
phosphate	PO_4^{3-}

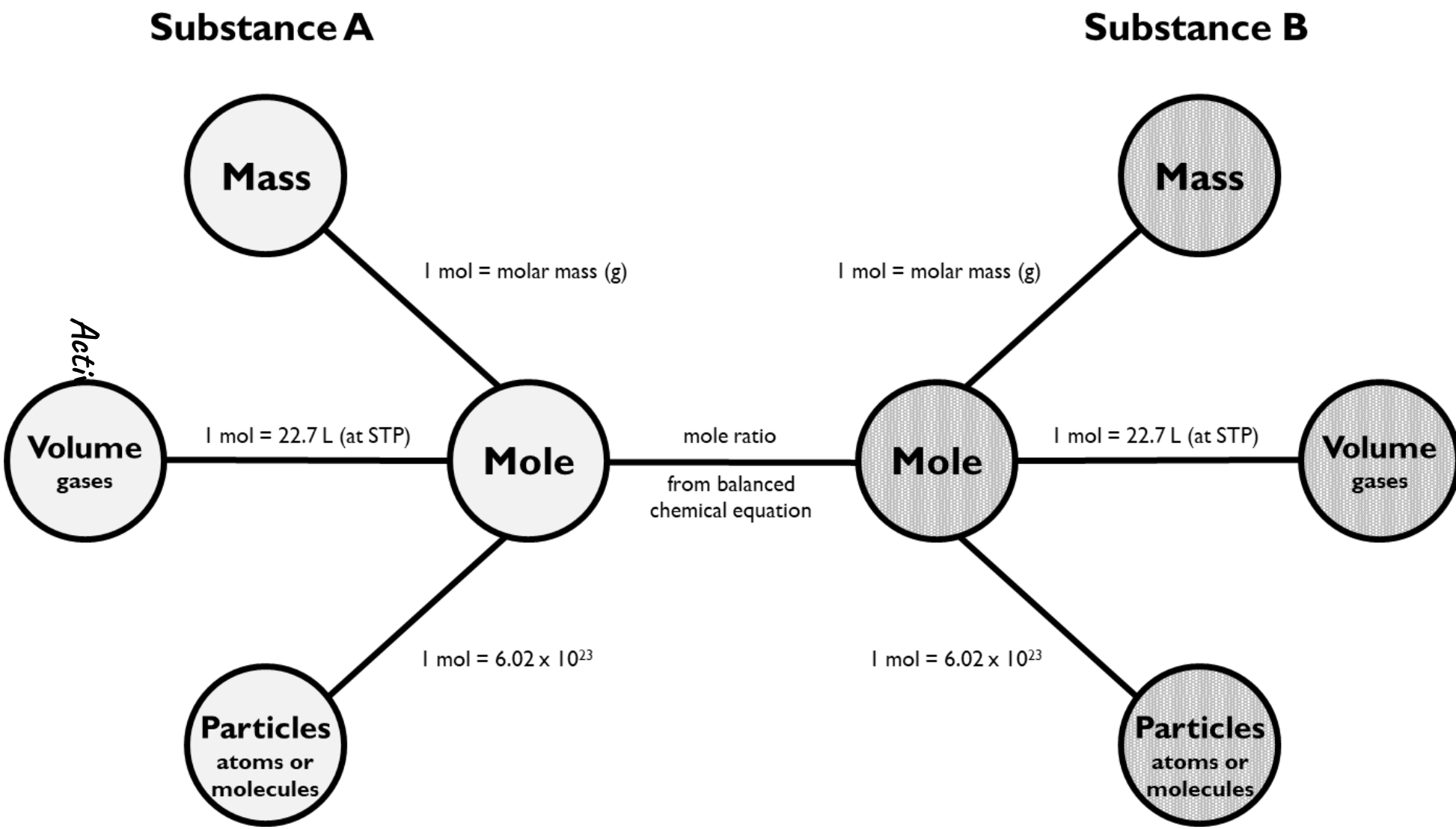
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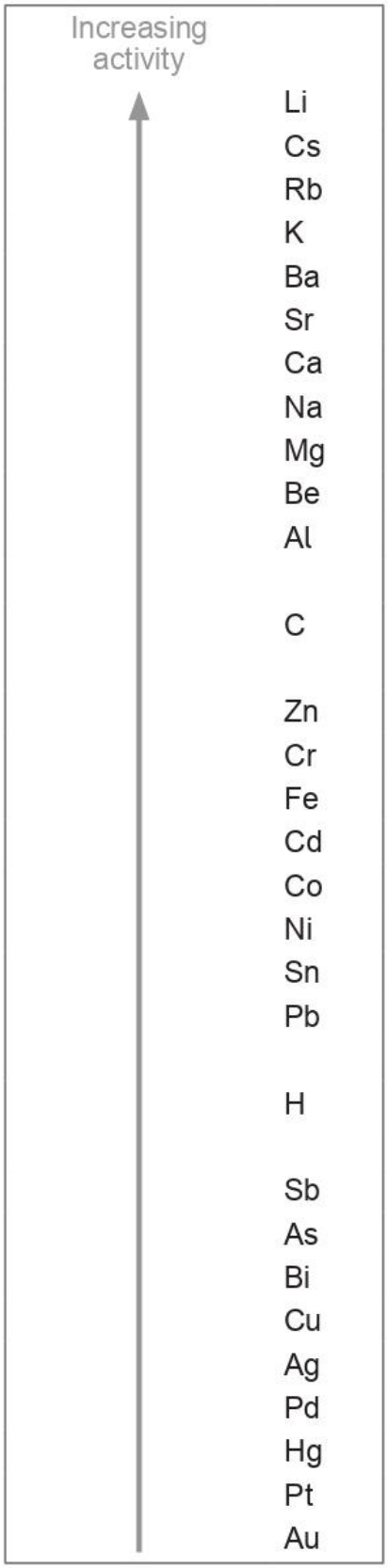
Select Monatomic Cations with More than One Oxidation Number

Co^{2+}, Co^{3+}	cobalt (II), cobalt (III)
Cr^{2+}, Cr^{3+}, Cr^{6+}	chromium (II), chromium (III), chromium (VI)
Cu^{+}, Cu^{2+}	copper (I), copper (II)
Au^{+}, Au^{3+}	gold (I), gold (III)
Fe^{2+}, Fe^{3+}	iron (II), iron (III)
Pb^{2+}, Pb^{4+}	lead (II), lead (IV)
Mn^{2+}, Mn^{3+}, Mn^{4+}, Mn^{7+}	manganese (II), manganese (III), manganese (IV), manganese (VII)
Ni^{2+}, Ni^{3+}	nickel (II), nickel (III)
Pt^{2+}, Pt^{4+}	platinum (II), platinum (IV)
Sn^{2+}, Sn^{4+}	tin (II), tin (IV)
Ti^{2+}, Ti^{3+}, Ti^{4+}	titanium (II), titanium (III), titanium (IV)
U^{3+}, U^{4+}, U^{5+}, U^{6+}	uranium (III), uranium (IV), uranium (V), uranium (VI)
V^{2+}, V^{3+}, V^{4+}, V^{5+}	vanadium (II), vanadium (III), vanadium (IV), vanadium (V)

Select Monatomic Cations with Only One Oxidation Number

Group 1 ions	+1
Group 2 ions	+2
Group 13 ions (except Thallium)	+3
Cadmium	+2
Silver	+1
Tungsten	+6
Zinc	+2


Substance A
Substance B
Mass
Mass
1 mol = molar mass (g)
1 mol = molar mass (g)
Volume
gases
1 mol = 22.7 L (at STP)
Mole
mole ratio
from balanced
chemical equation
Mole
1 mol = 22.7 L (at STP)
Volume
gases
1 mol = 6.02 x 10^23
1 mol = 6.02 x 10^23
Particles
atoms or
molecules
Particles
atoms or
molecules



Activity Series of the Halogens

F_2
Cl_2
Br_2
I_2

	on Ionic Compounds in Water
Solu	**Exceptions**

Group 1A cations (Li^+, Na^+, K^+, Rb^+, Cs^+), NH_4^+	No Exceptions
NO_3^-, ClO_4^-, CH_3COO^-, ClO_3^-	No Exceptions
Cl^-, Br^-, I^-	Halides of Ag^+, Hg_2^{2+}, Pb^{2+}
SO_4^{2-}	Sulfates of Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+}, Pb^{2+}, Ag^+
Insoluble Compounds	**Exceptions**
CO_3^{2-}	Group IA and NH_4^+
PO_4^{3-}	Group IA and NH_4^+
S^{2-}	Group IA, IIA*, NH_4^+
OH^-	Group IA, NH_4^+, Ca^{2+}*, Ba^{2+}, Sr^{2+}

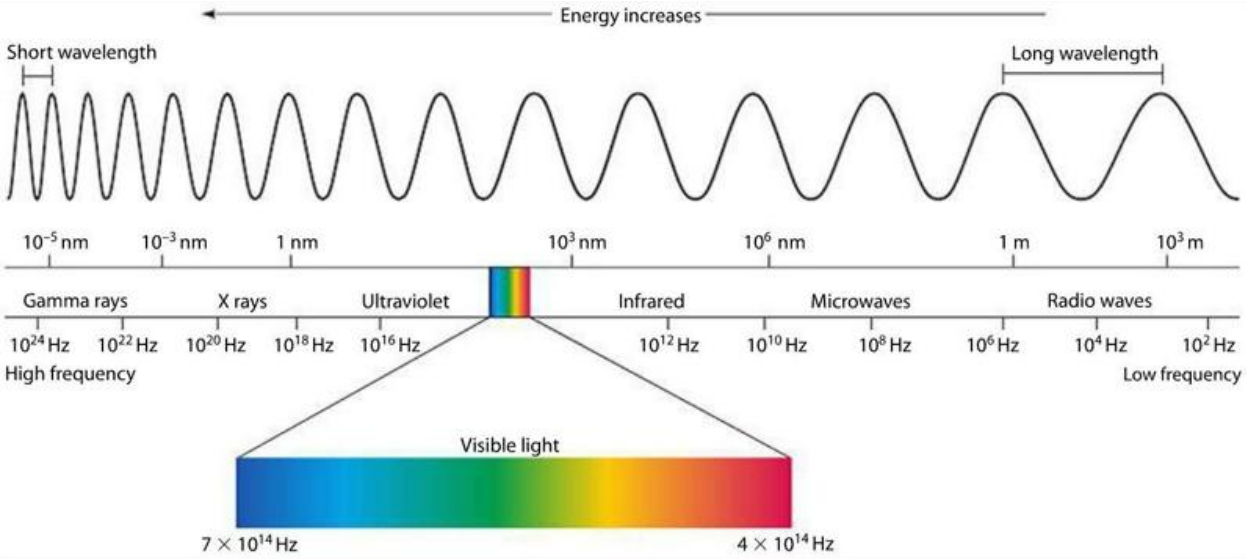
* Slightly soluble

S	soluble
I	insoluble
sS	slightly soluble
X	other

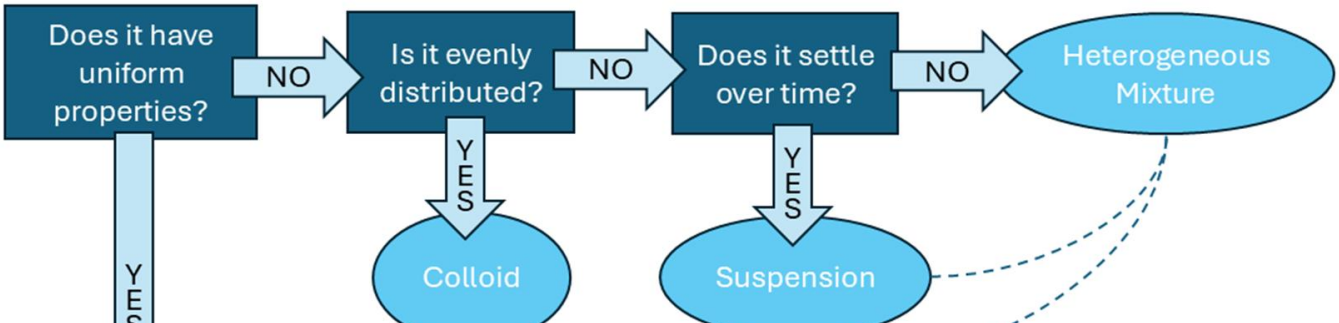
	Bromide Br^-	Carbonate CO_3^{2-}	Chloride Cl^-	Chlorates ClO_3^-	Hydroxide OH^-	Nitrate NO_3^-	Oxide O^{2-}	Phosphate PO_4^{3-}	Sulfate SO_4^{2-}	Dichromate $Cr_2O_7^{2-}$
Aluminium Al^{3+}	S	X	S	S	I	S	I	I	S	I
Ammonium NH_4^+	S	S	S	S	S	S	X	S	S	S
Calcium Ca^{2+}	S	I	S	S	sS	S	sS	I	sS	I
Copper(II) Cu^{2+}	S	I	S	S	I	S	I	I	S	I
Iron(II) Fe^{2+}	S	I	S	S	I	S	I	I	S	I
Iron(III) Fe^{3+}	S	X	S	S	I	S	I	I	sS	I
Magnesium Mg^{2+}	S	I	S	S	I	S	I	I	S	I
Potassium K^+	S	S	S	S	S	S	S	S	S	S
Silver Ag^+	I	I	I	S	X	S	I	I	sS	I
Sodium Na^+	S	S	S	S	S	S	S	S	S	S
Zinc Zn^{2+}	S	I	S	S	I	S	I	I	S	I
	Bromide	Carbonate	Chloride	Chlorates	Hydroxide	Nitrate	Oxide	Phosphate	Sulfate	Dichromate $Cr_2O_7^{2-}$

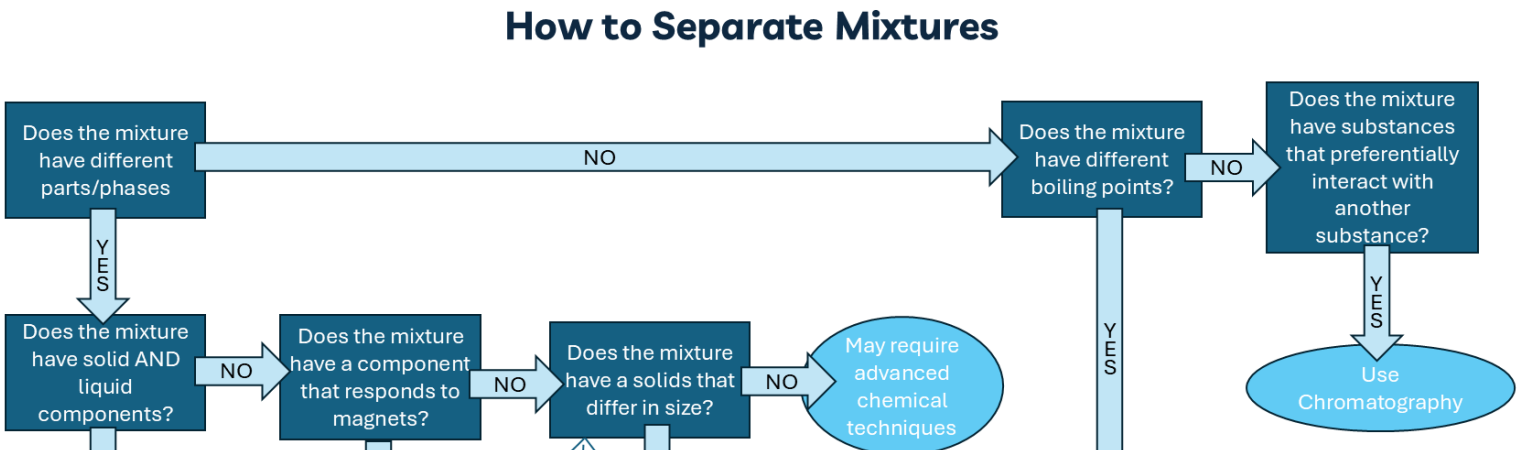
	Proton	Neutron	Electron
Mass (kg)	1.672622×10^{-27}	1.674927×10^{-27}	9.109383×10^{-31}
Charge (C)	1.602189×10^{-19}	0	1.602189×10^{-19}

Electromagnetic Spectrum



How to Classify Matter

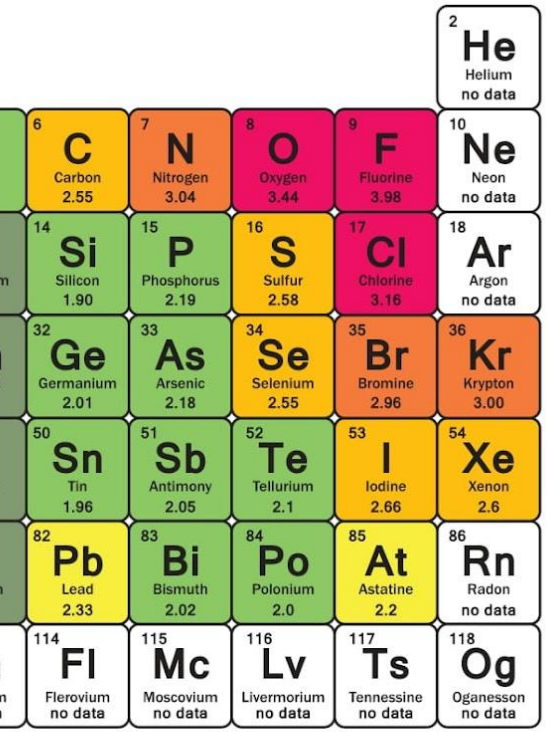


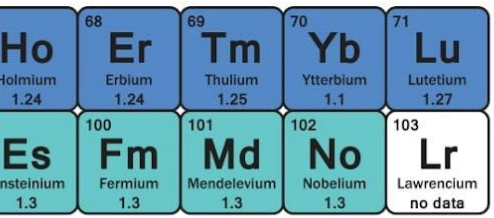

How to Separate Mixtures
Does the mixture have different parts/phases
NO
Does the mixture have different boiling points?
NO
Does the mixture have substances that preferentially interact with another substance?
YES
Use Chromatography
YES
Does the mixture have solid AND liquid components?
NO
Does the mixture have a component that responds to magnets?
NO
Does the mixture have a solids that differ in size?
NO
May require advanced chemical techniques

Pa)

					He −268.9
077 **B** 900	3500 **C** 4827	−210.0 **N** −195.8	−218.8 **O** −183.0	−219.7 **F** −188.1	−248.6 **Ne** −246.0
60.3 **Al** 519	1414 **Si** 3265	44.15 **P** 280.5	115.2 **S** 444.6	−101.5 **Cl** −34.04	−189.3 **Ar** −185.8
9.77 **Ga** 229	938.2 **Ge** 2833	816.8 **As** 613.0	220.8 **Se** 684.8	−7.050 **Br** 58.78	−157.4 **Kr** −153.4
56.6 **In** 027	231.9 **Sn** 2586	630.6 **Sb** 1587	449.5 **Te** 987.8	113.7 **I** 184.4	−111.8 **Xe** −108.1
03.8 **Tl** 473	327.5 **Pb** 1749	271.4 **Bi** 1564	253.8 **Po** 962.0	301.8 **At** 336.8	−71.15 **Rn** −61.85

nts


2
He
Helium
no data
6
C
Carbon
2.55
7
N
Nitrogen
3.04
8
O
Oxygen
3.44
9
F
Fluorine
3.98
10
Ne
Neon
no data
14
Si
Silicon
1.90
15
P
Phosphorus
2.19
16
S
Sulfur
2.58
17
Cl
Chlorine
3.16
18
Ar
Argon
no data
32
Ge
Germanium
2.01
33
As
Arsenic
2.18
34
Se
Selenium
2.55
35
Br
Bromine
2.96
36
Kr
Krypton
3.00
50
Sn
Tin
1.96
51
Sb
Antimony
2.05
52
Te
Tellurium
2.1
53
I
Iodine
2.66
54
Xe
Xenon
2.6
82
Pb
Lead
2.33
83
Bi
Bismuth
2.02
84
Po
Polonium
2.0
85
At
Astatine
2.2
86
Rn
Radon
no data
114
Fl
Flerovium
no data
115
Mc
Moscovium
no data
116
Lv
Livermorium
no data
117
Ts
Tennessine
no data
118
Og
Oganesson
no data


Ho
Holmium
1.24
68
Er
Erbium
1.24
69
Tm
Thulium
1.25
70
Yb
Ytterbium
1.1
71
Lu
Lutetium
1.27
Es
nsteinium
1.3
100
Fm
Fermium
1.3
101
Md
Mendelevium
1.3
102
No
Nobelium
1.3
103
Lr
Lawrencium
no data

Ionization Energy Chart

Values given in kJ/mol

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1 H 1312														
2	3 Li 513	4 Be 899											5 B 801	6 C 1086	7 N 1402
3	11 Na 496	12 Mg 738											13 Al 577	14 Si 786	15 P 1012
4	19 K 419	20 Ca 590	21 Sc 631	22 Ti 658	23 V 650	24 Cr 653	25 Mn 717	26 Fe 759	27 Co 760	28 Ni 737	29 Cu 745	30 Zn 906	31 Ga 589	32 Ge 762	33 As 947
5	37 Rb 403	38 Sr 550	39 Y 616	40 Zr 660	41 Nb 664	42 Mo 685	43 Tc 702	44 Ru 711	45 Rh 720	46 Pd 805	47 Ag 731	48 Cd 868	49 In 558	50 Sn 709	51 Sb 834
6	55 Cs 376	56 Ba 503	57-71 *	72 Hf 642	73 Ta 761	74 W 770	75 Re 760	76 Os 840	77 Ir 880	78 Pt 770	79 Au 890	80 Hg 1007	81 Tl 589	82 Pb 716	83 Bi 703
7	87 Fr 400	88 Ra 509	89-103 **	104 Rf 490	105 Db 640	106 Sg 730	107 Bh 660	108 Hs 750	109 Mt 840	110 Ds Unknown	111 Rg Unknown	112 Cn Unknown	113 Nh Unknown	114 Fl Unknown	115 Mc Unknown

Lanthanide Series*	57 La 538	58 Ce 527	59 Pr 523	60 Nd 530	61 Pm 536	62 Sm 543	63 Eu 547	64 Gd 592	65 Tb 565	66 Dy 572	67 Ho 581	68 Er 589	69 T 5
Actinide Series**	89 Ac 499	90 Th 587	91 Pa 568	92 U 584	93 Np 597	94 Pu 585	95 Am 578	96 Cm 581	97 Bk 601	98 Cf 608	99 Es 619	100 Fm 627	101 M 6

ATOMIC RADIUS
(picometers)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	37 H																	31 He
2	152 Li	111 Be											82 B	77 C	75 N	73 O	71 F	38 Ne
3	186 Na	160 Mg											143 Al	111 Si	106 P	102 S	99 Cl	71 Ar
4	227 K	197 Ca	160 Sc	145 Ti	131 V	125 Cr	137 Mn	124 Fe	125 Co	125 Ni	128 Cu	134 Zn	122 Ga	122 Ge	119 As	116 Se	114 Br	88 Kr
5	248 Rb	215 Sr	178 Y	159 Zr	143 Nb	136 Mo	135 Tc	133 Ru	134 Rh	138 Pd	144 Ag	149 Cd	163 In	140 Sn	145 Sb	135 Te	133 I	108 Xe
6	265 Cs	217 Ba	172 Lu	156 Hf	143 Ta	137 W	137 Re	134 Os	136 Ir	139 Pt	144 Au	150 Hg	170 Tl	175 Pb	154 Bi	167 Po		

Atomic radius tends to decrease in any period as the atomic number increases.

Atomic radius tends to increase in any group as the atomic number increases.

COMPARING ATOMIC AND IONIC RADII

Cations

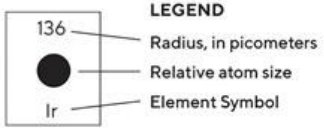
The radius of a cation is less than its atom's radius.

152 Li	76 Li^+	111 Be	45 Be^{2+}
186 Na	102 Na^+	160 Mg	72 Mg^{2+}
227 K	138 K^+	197 Ca	100 Ca^{2+}

Anions

The radius of an anion is greater than its atom's radius.

73 O	140 O^{2-}	71 F	133 F^-
102 S	184 S^{2-}	99 Cl	181 Cl^-
		114 Br	196 Br^-



SOURCES

1. Web Elements, Bond length data
2. Shannon R. D., Ion Radii (6-cordinate), *Revised Effective Ionic Radii and Systematic Studies of Interatomic Distances in Halides and Chalcogenides*, (1976)

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