

$\Delta H_{\text{vap}} = -\Delta H_{\text{cond}} = 40.67 \text{ kJ/mol}$   
 $C_{\text{water}} = 4.184 \text{ J/(g} \cdot \text{K)}$   
 $C_{\text{steam}} = 1.865 \text{ J/(g} \cdot \text{K)}$   
 $C_{\text{ice}} = 2.11 \text{ J/(g} \cdot \text{K)}$   
 $\Delta H_{\text{fus}} = -\Delta H_{\text{solid}} = 6.01 \text{ J/(g} \cdot \text{K)}$

1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>6</sup> 4s<sup>2</sup> 3d<sup>10</sup> 4p<sup>6</sup> 5s<sup>2</sup> 4d<sup>10</sup> 5p<sup>6</sup> 6s<sup>2</sup> 4f<sup>14</sup> 5d<sup>10</sup> 6p<sup>6</sup> 7s<sup>2</sup> 5f<sup>14</sup> 6d<sup>10</sup> 7p<sup>6</sup>

# PERIODIC TABLE OF ELEMENTS

$P \propto V^{-1}$  and  $V \propto T$   
 $\left[ P + \frac{an^2}{V^2} \right] [V - nb] = nRT$

(Ideal Gas Law)  $PV = nRT$

Combined Gas)  $\frac{PV}{T} = k$  (for constant amount)

(Molarity)  $M = \frac{\text{moles solute}}{\text{L solution}}$

(Molality)  $m = \frac{\text{moles solute}}{\text{kg solvent}}$

(Mole Fraction)  $x = \frac{\text{moles component}}{\text{moles total}}$

(Graham)  $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

$\text{pH} = -\log_{10}[H^+]$

$\text{pH} + \text{pOH} = 14$

$E_{\text{photon}} = hf = hc/\lambda$

$E_n = -\frac{R_H}{n^2}$

$R_H = 2.18 \times 10^{-18} \text{ J (Rydberg)}$

$\Delta E = R_H \left( \frac{1}{n_i^2} - \frac{1}{n_f^2} \right)$

$\lambda = \frac{h}{p}$

$R_{\text{Ideal Gas}} = 62.4 \frac{\text{L} \cdot \text{mmHg}}{\text{mol} \cdot \text{K}} = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} = 8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}$

$f = Ae^{-E_a/RT}$  (Boltzmann)  
 $\ln k = -E_a \left( \frac{1}{RT} \right) + \ln A$

2.54 cm = 1 in  
0.946 L = 1 qt

$[A] = \frac{1}{akt + \frac{1}{[A]_0}}$

$F^\circ = \frac{9}{5} C^\circ + 32$

$C^\circ = \frac{5}{9} (F^\circ - 32)$

$h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$ ,  $\text{kg} \cdot \text{m}^2/\text{s}$

$c = 3.00 \times 10^8 \text{ m/s}$

1 mol =  $6.022 \times 10^{23}$  = 22.4 L<sub>STP</sub>

$\rho_{\text{water}} = 1 \text{ g/mL}$

$P_{\text{sea}} = 101325 \text{ Pa} = 1 \text{ atm} = 760 \text{ mmHg}$ ,  $\text{torr} = 14.7 \text{ psi}$

$K_{\text{bwater}} = 0.512$

$K_{\text{fwater}} = 1.86$

Group →

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H	He																
Li	Be	B	C	N	O	F	Ne										
Na	Mg	Al	Si	P	S	Cl	Ar										
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	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	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

2	He	Helium	4.0026
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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	H <sub>2</sub>																
2	Li	Be															
3	Na	Mg															
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I
6	Cs	Ba	57-71	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At
7	Fr	Ra	89-103	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Lanthanum	Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium
138.91	140.12	140.91	144.24	(145)	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.05	174.97
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium
(227)	232.04	231.04	238.03	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(266)

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CO<sub>2</sub>  
CO  
CH<sub>4</sub>  
C<sub>2</sub>H<sub>6</sub>  
C<sub>3</sub>H<sub>8</sub>  
C<sub>4</sub>H<sub>10</sub>  
NO  
NO<sub>2</sub>  
N<sub>2</sub>O  
NH<sub>3</sub>  
SO<sub>3</sub>  
SO<sub>2</sub>  
H<sub>2</sub>S  
HCl

Super 7 Strong Acids

HI  
HBr  
HCl  
HNO<sub>3</sub>  
H<sub>2</sub>SO<sub>4</sub>  
HClO<sub>3</sub>  
HClO<sub>4</sub>

# Solubility Chart

Cations	Soluble with ____ (aq)	Forms Precipitates with ____ (s)
$\text{Na}^+$ , $\text{K}^+$ , and $\text{NH}_4^+$	Most Anions	$(\text{NH}_4)_2\text{C}_2\text{O}_4$ forms a precipitate
$\text{Bi}^{3+}$	Nothing	Most anions
$\text{As}^{3+}$	$\text{I}^{1-}$	Most anions
$\text{Sb}^{3+}$	$\text{Cl}^{1-}$	Most anions

Anions	Soluble with ____ (aq)	Forms Precipitates with ____ (s)
$\text{NO}_3^{1-}$ nitrate	Most cations	No common cations
$\text{ClO}_4^{1-}$ perchlorate	Most cations	No common cations
$\text{ClO}_3^{1-}$ chlorate	Most cations	No common cations
$\text{C}_2\text{H}_3\text{O}_2^{1-}$ acetate	Most cations	$\text{Ag}^{1+}$ , $\text{Hg}_2^{2+}$
$\text{F}^{1-}$ fluoride	Most cations	$\text{Cr}^{3+}$
$\text{Cl}^{1-}$ chloride	Most cations	$\text{Ag}^+$ , $\text{Pb}^{2+,4+}$ , $\text{Hg}_2^{2+}$ , $\text{Tl}^{1+}$
$\text{Br}^{1-}$ bromide	Most cations	$\text{Ag}^+$ , $\text{Pb}^{2+,4+}$ , $\text{Hg}_2^{2+}$ , $\text{Tl}^{1+}$
$\text{I}^{1-}$ iodide	Most cations	$\text{Ag}^+$ , $\text{Pb}^{2+,4+}$ , $\text{Hg}_2^{2+}$ , $\text{Tl}^{1+}$
$\text{SO}_4^{2-}$ sulfate	Most cations	$\text{Ag}^+$ , $\text{Ba}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Pb}^{2+,4+}$ , $\text{Ca}^{2+}$ , $\text{Hg}_2^{2+}$
$\text{CrO}_4^{2-}$ chromate	Most cations	$\text{Ba}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Pb}^{2+,4+}$ , $\text{Ca}^{2+}$ , $\text{Hg}_2^{2+}$
$\text{S}^{2-}$ sulfide	$\text{Na}^+$ , $\text{K}^+$ , $\text{NH}_4^+$ , $\text{Li}^+$ , $\text{Sr}^{2+}$	Most other cations
$\text{OH}^{1-}$ hydroxide	$\text{Na}^+$ , $\text{K}^+$ , $\text{NH}_4^+$ , $\text{Li}^+$ , $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$ , $\text{Ca}^{2+}$	Most other cations
$\text{CO}_3^{2-}$ carbonate	$\text{Na}^+$ , $\text{K}^+$ , $\text{NH}_4^+$ , $\text{Li}^+$	Most other cations
$\text{PO}_4^{3-}$ phosphate	$\text{Na}^+$ , $\text{K}^+$ , $\text{NH}_4^+$	Most other cations
$\text{O}^{2-}$ oxide	No common cations	Most cations

Polyatomic Ions			
1+		2-	
(NH <sub>4</sub> ) <sup>+1</sup>	ammonium	(CrO <sub>4</sub> ) <sup>-2</sup>	chromate
1-		(Cr <sub>2</sub> O <sub>7</sub> ) <sup>-2</sup>	dichromate
(NO <sub>3</sub> ) <sup>-1</sup>	nitrate	(CO <sub>3</sub> ) <sup>-2</sup>	carbonate
(NO <sub>2</sub> ) <sup>-1</sup>	nitrite	(HPO <sub>4</sub> ) <sup>-2</sup>	dibasic phosphate or <u>hydrogen phosphate</u>
(OH) <sup>-1</sup>	hydroxide		
(HCO <sub>3</sub> ) <sup>-1</sup>	<u>bicarbonate</u> or hydrogen carbonate	(MnO <sub>4</sub> ) <sup>-2</sup>	manganate
(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sup>-1</sup>	acetate	(O <sub>2</sub> ) <sup>-2</sup>	peroxide
		(S <sub>2</sub> O <sub>3</sub> ) <sup>-2</sup>	thiosulfate
(ClO <sub>4</sub> ) <sup>-1</sup>	perchlorate	(SO <sub>4</sub> ) <sup>-2</sup>	sulfate
(ClO <sub>3</sub> ) <sup>-1</sup>	chlorate	(SO <sub>3</sub> ) <sup>-2</sup>	sulfite
(ClO <sub>2</sub> ) <sup>-1</sup>	chlorite	(C <sub>2</sub> O <sub>4</sub> ) <sup>-2</sup>	oxalate
(ClO) <sup>-1</sup>	hypochlorite		
		3-	
(CN) <sup>-1</sup>	cyanide	(AsO <sub>4</sub> ) <sup>-3</sup>	arsenate
(SCN) <sup>-1</sup>	thiocyanate	(AsO <sub>3</sub> ) <sup>-3</sup>	arsenite
(HSO <sub>4</sub> ) <sup>-1</sup>	bisulfate or hydrogen sulfate	(BO <sub>3</sub> ) <sup>-3</sup>	borate
(MnO <sub>4</sub> ) <sup>-1</sup>	permanganate		
(H <sub>2</sub> PO <sub>4</sub> ) <sup>-1</sup>	dihydrogen phosphate	(C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sup>-3</sup>	citrate
		(PO <sub>4</sub> ) <sup>-3</sup>	phosphate or tribasic phosphate
(IO <sub>4</sub> ) <sup>-1</sup>	periodate	(PO <sub>3</sub> ) <sup>-3</sup>	phosphite
(IO <sub>3</sub> ) <sup>-1</sup>	iodate		
(IO) <sup>-1</sup>	hypoiodite		
		4-	
(NH <sub>2</sub> ) <sup>-1</sup>	amide	(SiO <sub>4</sub> ) <sup>-4</sup>	silicate (ortho)
(CHO <sub>2</sub> ) <sup>-1</sup>	formate		

Atomic Ions			
+1		-1	
Li <sup>+1</sup>	Lithium	F <sup>-1</sup>	Fluoride
Na <sup>+1</sup>	Sodium	Br <sup>-1</sup>	Bromide
K <sup>+1</sup>	Potassium	Cl <sup>-1</sup>	Chloride
Ag <sup>+1</sup>	Silver	I <sup>-1</sup>	iodide
Cu <sup>+1</sup>	Copper (I) or Cuprous	H <sup>-1</sup>	hydride
Cs <sup>+1</sup>	Cesium		
H <sup>+1</sup>	Hydrogen		
+2		-2	
Mg <sup>+2</sup>	Magnesium	O <sup>-2</sup>	Oxide
Ca <sup>+2</sup>	Calcium	O <sub>2</sub> <sup>-2</sup>	Peroxide
Ba <sup>+2</sup>	Barium	S <sup>-2</sup>	Sulfide
Zn <sup>+2</sup>	Zinc		
Cd <sup>+2</sup>	Cadmium (II)		
Cr <sup>+2</sup>	Chromium (II) or Chromous	+2 (cont)	
Co <sup>+2</sup>	Cobalt (II) or Cobaltous	Cu <sup>+2</sup>	Copper (II) or Cupric
Hg <sup>+2</sup>	Mercury (II) or Mercuric	Pb <sup>+2</sup>	Lead (II) or Plumbous
Hg <sub>2</sub> <sup>+2</sup>	Mercury (I) or Mercurous	Fe <sup>+2</sup>	Iron (II) or Ferrous
Mn <sup>+2</sup>	Manganese (II) or manganous	Ni <sup>+2</sup>	Nickel (II)
		Sn <sup>+2</sup>	Tin (II) or Stannous
		Sr <sup>+2</sup>	Strontium
+3		-3	
Al <sup>+3</sup>	Aluminum	N <sup>-3</sup> P <sup>-3</sup>	Nitride Phosphide
Fe <sup>+3</sup>	Iron (III) or Ferric		
Ni <sup>+3</sup>	Nickel (III)		
Cr <sup>+3</sup>	Chromium (III) or Chromic		
+4			
Pb <sup>+4</sup>	Lead (IV)		
Si <sup>+4</sup>	Silicon (IV)		
Sn <sup>+4</sup>	Tin (IV) or Stannic		
Mn <sup>+4</sup>	Manganese (IV)		

## **Metal Activity Series / Redox Table**

<b>Element</b>	<b>Metal Ion(s) Found in nature</b>	<b>Metal Obtained</b>
Lithium	$\text{Li}^+$	$\text{Li}_{(s)}$
Potassium	$\text{K}^+$	$\text{K}_{(s)}$
Barium	$\text{Ba}^{2+}$	$\text{Ba}_{(s)}$
Calcium	$\text{Ca}^{2+}$	$\text{Ca}_{(s)}$
Sodium	$\text{Na}^+$	$\text{Na}_{(s)}$
Magnesium	$\text{Mg}^{2+}$	$\text{Mg}_{(s)}$
Aluminum	$\text{Al}^{3+}$	$\text{Al}_{(s)}$
Manganese	$\text{Mn}^{2+}$	$\text{Mn}_{(s)}$
Zinc	$\text{Zn}^{2+}$	$\text{Zn}_{(s)}$
Chromium	$\text{Cr}^{3+}, \text{Cr}^{2+}$	$\text{Cr}_{(s)}$
Iron	$\text{Fe}^{3+}, \text{Fe}^{2+}$	$\text{Fe}_{(s)}$
Cobalt	$\text{Co}^{2+}$	$\text{Co}_{(s)}$
Nickel	$\text{Ni}^+$	$\text{Ni}_{(s)}$
Tin	$\text{Sn}^{2+}$	$\text{Sn}_{(s)}$
Lead	$\text{Pb}^{2+}$	$\text{Pb}_{(s)}$
Hydrogen	$2\text{H}^+$	$\text{H}_{2(g)}$
Copper	$\text{Cu}^{2+}, \text{Cu}^+$	$\text{Cu}_{(s)}$
Silver	$\text{Ag}^+$	$\text{Ag}_{(s)}$
Mercury	$\text{Hg}^{2+}$	$\text{Hg}_{(l)}$
Platinum	$\text{Pt}^{2+}$	$\text{Pt}_{(s)}$
Gold	$\text{Au}^{3+}, \text{Au}^+$	$\text{Au}_{(s)}$

<b>Table 20-1      Processes Leading to Oxidation and Reduction</b>	
<b><u>Oxidation</u></b>	<b><u>Reduction</u></b>
Complete loss of electrons (ionic reactions)	Complete gain of electrons (ionic reactions)
Shift of electrons away from an atom in a covalent bond	Shift of electrons toward an atom in a covalent bond
Gain of oxygen	Loss of oxygen
Loss of hydrogen by a covalent compound	Gain of hydrogen by a covalent compound
An increase in oxidation number	A decrease in oxidation number