

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

1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d¹⁰ 4p⁶ 5s² 4d¹⁰ 5p⁶ 6s² 4f¹⁴ 5d¹⁰ 6p⁶ 7s² 5f¹⁴ 6d¹⁰ 7p⁶

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

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

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

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

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

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

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

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

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

$\text{pH}_{\text{sigfig}} = \text{past decimal}$

$K_{\text{eq}} = \frac{[\text{product}]}{[\text{reactant}]}$

$K_{\text{acid}} K_{\text{base}} = K_w = 1.0 \times 10^{-14}$

$i = 1$ (non-electrolyte) Van't Hoff Factor $C^\circ = \frac{9}{5}(F^\circ - 32)$

$\Delta T_f = K_f m_i$

$\Delta T_b = K_b m_i$

$\Pi = iMRT$

$\Delta E = q + w = q - P\Delta V$

$\Delta H = \Delta E + P\Delta V$ $P_{\text{sea}} = 101325 \text{ Pa} = 1 \text{ atm} = 760 \text{ mmHg, torr} = 14.7 \text{ psi}$

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

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

$R_{\text{Ideal Gas}} = 62.4 \frac{\text{L} \cdot \text{mmHg}}{\text{mol} \cdot \text{K}} = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} = 8.314 \frac{\text{L} \cdot \text{kPa}}{\text{mol} \cdot \text{K}}, \frac{\text{J}}{\text{mol} \cdot \text{K}}$
1 lb = 453.6 g
2.54 cm = 1 in
0.946 L = 1 qt
 $F^\circ = \frac{9}{5}C^\circ + 32$
 $h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}, \text{ kg} \cdot \text{m}^2/\text{s}$
 $c = 3.00 \times 10^8 \text{ m/s}$
1 mol = 6.022×10^{23} = 22.4 L_{STP}
 $\rho_{\text{water}} = 1 \text{ g/mL}$
 $P_{\text{sea}} = 101325 \text{ Pa} = 1 \text{ atm} = 760 \text{ mmHg, torr} = 14.7 \text{ psi}$
 $K_{\text{bwater}} = 0.512$ $K_{\text{fwater}} = 1.86$

| Group → | | | | | | | | | | | | | | | | | |
|---------|--------|--|--|--|--|--|--|--|--|--|--|------|------|------|------|------|------|
| 1 | 2 | | | | | | | | | | | 13 | 14 | 15 | 16 | 17 | 18 |
| H | He | | | | | | | | | | | B | C | N | O | F | Ne |
| 1.008 | 4.0026 | | | | | | | | | | | 2.04 | 2.55 | 3.04 | 3.44 | 3.98 | |
| Li | Be | | | | | | | | | | | Al | Si | P | S | Cl | Ar |
| 6.94 | 9.0122 | | | | | | | | | | | 1.61 | 1.90 | 2.19 | 2.58 | 3.16 | |
| Na | Mg | | | | | | | | | | | Ga | Ge | As | Se | Br | Kr |
| 22.990 | 24.305 | | | | | | | | | | | 1.61 | 1.90 | 2.19 | 2.58 | 2.96 | 3.00 |
| K | Ca | | | | | | | | | | | In | Sn | Sb | Te | I | Xe |
| 39.098 | 40.078 | | | | | | | | | | | 1.61 | 1.90 | 2.19 | 2.58 | 2.66 | 2.60 |
| Rb | Sr | | | | | | | | | | | Tl | Pb | Bi | Po | At | Rn |
| 85.468 | 87.62 | | | | | | | | | | | 1.61 | 1.90 | 2.19 | 2.58 | 2.66 | 2.60 |
| Cs | Ba | | | | | | | | | | | Pb | Bi | Po | At | Rn | |
| 132.91 | 137.33 | | | | | | | | | | | 1.61 | 1.90 | 2.19 | 2.58 | 2.66 | 2.60 |
| Fr | Ra | | | | | | | | | | | 1.61 | 1.90 | 2.19 | 2.58 | 2.66 | 2.60 |
| (223) | (226) | | | | | | | | | | | 1.61 | 1.90 | 2.19 | 2.58 | 2.66 | 2.60 |

| | | |
|-----|-----------------------|---------------------|
| IA | 1 | |
| 1 | H ₂ | Hydrogen 1.008 |
| IIA | 2 | |
| 3 | Li | Lithium 6.94 |
| 4 | Be | Beryllium 9.0122 |
| 11 | Na | Sodium 22.990 |
| 12 | Mg | Magnesium 24.305 |
| 19 | K | Potassium 39.098 |
| 20 | Ca | Calcium 40.078 |
| 37 | Rb | Rubidium 85.468 |
| 38 | Sr | Strontium 87.62 |
| 55 | Cs | Caesium 132.91 |
| 56 | Ba | Barium 137.33 |
| 87 | Fr | Francium (223) |
| 88 | Ra | Radium (226) |

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 (145) | 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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CO₂
CO
CH₄
C₂H₆
C₃H₈
C₄H₁₀
NO
NO₂
N₂O
NH₃
SO₃
SO₂
H₂S
HCl

Super 7 Strong Acids

HI
HBr
HCl
HNO₃
H₂SO₄
HClO₃
HClO₄

| Polyatomic Ions | | |
|---------------------------------|--|---|
| 1+ | | 2- |
| ammonium | | |
| 1- | | |
| nitrate | | |
| nitrite | | |
| hydroxide | | (CrO ₄) ⁻² (Cr ₂ O ₇) ⁻² (CO ₃) ⁻² (HPO ₄) ⁻² (MnO ₄) ⁻² (O ₂) ⁻² (S ₂ O ₃) ⁻² (SO ₄) ⁻² (SO ₃) ⁻² (C ₂ O ₄) ⁻² |
| <u>bicarbonate</u> or | | |
| hydrogen carbonate | | |
| acetate | | |
| perchlorate | | |
| chlorate | | chromate dichromate carbonate <u>dibasic phosphate or hydrogen phosphate</u> manganate peroxide thiosulfate sulfate sulfite oxalate |
| chlorite | | |
| hypochlorite | | |
| cyanide | | |
| thiocyanate | | |
| bisulfate or hydrogen sulfate | | 3- |
| permanganate | | |
| dihydrogen phosphate | | |
| periodate | | |
| iodate | | |
| hypoiodite | | (AsO ₄) ⁻³ (AsO ₃) ⁻³ (BO ₃) ⁻³ (C ₆ H ₅ O ₇) ⁻³ (PO ₄) ⁻³ (PO ₃) ⁻³ (SiO ₄) ⁻⁴ |
| amide | | |
| formate | | |
| phosphate or tribasic phosphate | | |
| phosphite | | |
| silicate (ortho) | | |

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

Metal Activity Series / Redox Table

| | | | |
|--|--|---|---|
| <div> <div> Strong Acids</div> <div> HI HBr HCl HNO₃ H₂SO₄ HClO₃ HClO₄ </div> </div> <div> <div> Super Strong Acids</div> <div> </div> </div> | <div> <div> Strong Base Is</div> <div> Group I/II Hydroxides (OH)- </div> </div> | <div> <div> Metal Ion(s) Found in nature</div> <div> Li⁺ K⁺ Ba²⁺ Ca²⁺ Na⁺ Mg²⁺ Al³⁺ Mn²⁺ Zn²⁺ Cr³⁺ Fe³⁺ Co²⁺ Ni⁺ Sn²⁺ Pb²⁺ 2H⁺ Cu²⁺ Ag⁺ Hg²⁺ Pt²⁺ Au³⁺ </div> </div> <div> <div> Metal Obtained</div> <div> Li (s) K (s) Ba(s) Ca (s) Na (s) Mg (s) Al (s) Mn (s) Zn (s) Cr (s) Fe (s) Co (s) Ni (s) Sn(s) Pb (s) H₂ (g) Cu (s) Ag (s) Hg (l) Pt (s) Au (s) </div> </div> | <div> <div> CO₂ CO CH₄ C₂H₆ C₃H₈ C₄H₁₀ NO NO₂ N₂O NH₃ SO₃ SO₂ H₂S HCl </div> </div> |
|--|--|---|---|

| Table 20-1 | Processes Leading to Oxidation and Reduction | |
|------------|---|--|
| | <u>Oxidation</u> | <u>Reduction</u> |
| | 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 |

Solubility Chart

$\text{MO} + \text{H}_2\text{O} \rightarrow \text{M}(\text{OH})$ base
 $\text{N.M.O} + \text{H}_2\text{O} \rightarrow \text{Acid}$
 $\text{MO} + \text{NMO} \rightarrow \text{Salt}$
 $\text{MCO}_3 \rightarrow \text{MO} + \text{CO}_2$
 $\text{M}(\text{OH}) \rightarrow \text{MO} + \text{H}_2\text{O}$
 $\text{MClO}_3 \rightarrow \text{MCl} + \text{O}_2$
 $\text{Acid} \rightarrow \text{NMO} + \text{H}_2\text{O}$
 $\text{Combustion} \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{E}$

| Cations | Soluble with ____ (aq) | Forms Precipitates with ____ (s) |
|--|------------------------|---|
| Na^+, K^+, and NH_4^+ | Most Anions | $(\text{NH}_4)_2\text{C}_2\text{O}_4$ forms a precipitate |
| Bi^{3+} | Nothing | Most anions |
| As^{3+} | I^{1-} | Most anions |
| Sb^{3+} | Cl^{1-} | Most anions |

| Anions | Soluble with ____ (aq) | Forms Precipitates with ____ (s) |
|---|---|---|
| NO_3^{1-} nitrate | Most cations | No common cations |
| ClO_4^{1-} perchlorate | Most cations | No common cations |
| ClO_3^{1-} chlorate | Most cations | No common cations |
| $\text{C}_2\text{H}_3\text{O}_2^{1-}$ acetate | Most cations | Ag^{1+} , Hg_2^{2+} |
| F^{1-} fluoride | Most cations | Cr^{3+} |
| Cl^{1-} chloride | Most cations | Ag^+ , $\text{Pb}^{2+,4+}$, Hg_2^{2+} , Tl^{1+} |
| Br^{1-} bromide | Most cations | Ag^+ , $\text{Pb}^{2+,4+}$, Hg_2^{2+} , Tl^{1+} |
| I^{1-} iodide | Most cations | Ag^+ , $\text{Pb}^{2+,4+}$, Hg_2^{2+} , Tl^{1+} |
| SO_4^{2-} sulfate | Most cations | Ag^+ , Ba^{2+} , Sr^{2+} , $\text{Pb}^{2+,4+}$, Ca^{2+} , Hg_2^{2+} |
| CrO_4^{2-} chromate | Most cations | Ba^{2+} , Sr^{2+} , $\text{Pb}^{2+,4+}$, Ca^{2+} , Hg_2^{2+} |
| S^{2-} sulfide | Na^+ , K^+ , NH_4^+ , Li^+ , Sr^{2+} | Most other cations |
| OH^{1-} hydroxide | Na^+ , K^+ , NH_4^+ , Li^+ , Sr^{2+} , Ba^{2+} , Ca^{2+} | Most other cations |
| CO_3^{2-} carbonate | Na^+ , K^+ , NH_4^+ , Li^+ | Most other cations |
| PO_4^{3-} phosphate | Na^+ , K^+ , NH_4^+ | Most other cations |
| O^{2-} oxide | No common cations | Most cations |