Krug Updated 2019

Chemistry Formula Sheet

Data Analysis

Absolute error = |Experimental Value − Accepted Value| * Absolute error is always positive.

$$\% \textbf{ Error} = \frac{|\text{Experimental Value} - \text{Accepted Value}|}{\text{Accepted Value}} \times \mathbf{100} \qquad \textbf{\textit{in other words}} \qquad \frac{\text{Big \#} - \text{Small \#}}{\text{True \#}} \times 100$$

$$\frac{Density\ (g/ml)}{1} = \frac{mass\ (g)}{volume\ (ml)}$$

Density has units of **g/ml** or **g/cm^3** or **kg/m^3**   **1 ml = 1 cm^3**

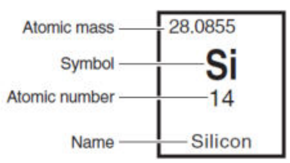
Sig Fig Rules:

Zeros in the FRONT are NEVER significant. **0.002 = 1 sig figs**
Zeros in the MIDDLE are ALAWAYS. **2005 = 4 sig figs**
Zeros at the END – ONLY IF A DECIMAL **5000 = 1 sig fig   5.000 = 4 sig figs**

Base Metric Units: Length (meters) Volume (liters) Mass (grams) Energy (Joules)

1 kilogram = 1000 grams **1 Liter = 1000 milliliters** **1 meter = 100 cm**

Atomic Structure



Atomic Mass on the periodic table has a decimal because it is based on the average mass of all known **isotopes**. Each isotope has a different number of **neutrons** but the same number of **protons**. Some isotopes are rare and others are very abundant. Abundancy can be given as a **percent** (% Abundance) or as a **decimal** (Relative Abundance). The average mass is based on the weighted abundance of each isotope.

$$\text{Average Atomic Mass} = \frac{\textbf{(Mass} \times \textbf{\% Abundance)+(Mass} \times \textbf{\% Abundance)}}{\mathbf{100}} \quad \textbf{\textit{or}} \quad = \frac{\textbf{(Mass} \times \textbf{Relative Abundance)+(Mass} \times \textbf{Relative Abundance)}}{\mathbf{100}}$$

Atomic number = equals the number of protons for given element

Mass # = protons + neutrons for a given isotope

Proton # = atomic number

Neutron # = mass # - atomic number

Electron # = Proton # for neutral elements

$^{48}_{22}$Ti
Mass # = 48
Atomic # = 22
Protons = 22
Neutrons = 48 - 22 = 26

Oxidation # = charge on atom based on # of electrons (**LEO** + goes **GER -**)

Metals lose electrons to become **positive**.

Nonmetals gain electrons to become **negative**.

Electron configuration pattern: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$

Aufbau Principal – start with lowest orbital

Pauli Principal – only two electrons per orbital

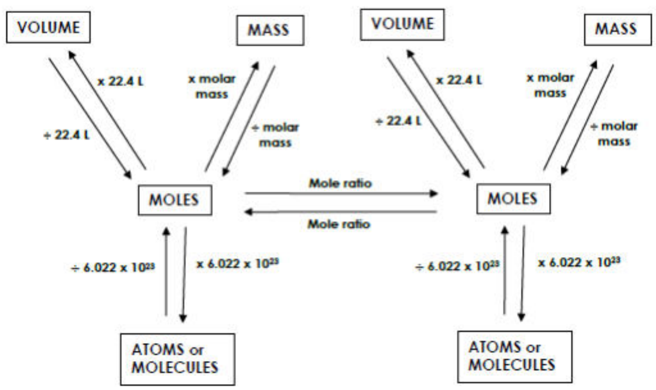
Hund's Rule – fill all up arrows before adding down arrows

Abbreviated Configuration – starts from previous noble gas
ex. Strontium = [Kr] 5s^2

			1s	2s	2px	2py	2pz
Lithium,	Li	$1s^2 2s^1$	↑↓	↑			
Beryllium,	Be	$1s^2 2s^2$	↑↓	↑↓			
Boron,	B	$1s^2 2s^2 2p^1$	↑↓	↑↓	↑		
Carbon,	C	$1s^2 2s^2 2p^2$	↑↓	↑↓	↑	↑	
Nitrogen,	N	$1s^2 2s^2 2p^3$	↑↓	↑↓	↑	↑	↑
Oxygen,	O	$1s^2 2s^2 2p^4$	↑↓	↑↓	↑↓	↑	↑
Fluorine,	F	$1s^2 2s^2 2p^5$	↑↓	↑↓	↑↓	↑↓	↑
Neon,	Ne	$1s^2 2s^2 2p^6$	↑↓	↑↓	↑↓	↑↓	↑↓

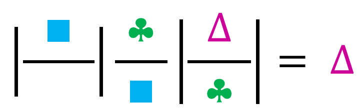
Stoichiometry

The Roadmap to Stoichiometry



If you only have 1 chemical, then all conversions are compared to 1 mole. Multiply when you are given moles and want to covert to liters, grams, atoms, or molecules. Divide if you are starting with liters, grams, atoms, or molecules and need to calculate the number of moles.

$$\frac{\boldsymbol{Moles}}{\mathbf{1}} = \frac{\boldsymbol{grams}}{\boldsymbol{molar\ mass}}$$



Limiting Reactant is the reactant that will run out first.
Excess Reactant is abundant and will be left over after the reaction is complete.

$$\%\ \textbf{Yield} = \frac{\text{Actual (made in lab)}}{\text{Theoretical (calcualted by math)}} \text{ x } 100$$

Stoichiometry proves the **Law of Mass Conservation** because the total mass of the reactants equals the total mass of the products.

Kelvin (K) = °C + 273 **Celsius °C** = K – 273

Absolute Zero = 0 K or - 273°C
Freezing Point of Water = 0°C or + 273 K
Boiling Point of Water = 100°C or 373 K

Standard Temperature & Pressure (STP)
- Pressure = 1atm = 760 mmHg = 101.3kPa
- Temperature = 0°C = 273K

Boyle's Law $P_1V_1 = P_2V_2$

Guy Lussac's Law $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Charles' Law $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Avogadro's Law $\frac{V_1}{n_1} = \frac{V_2}{n_2}$

Ideal Law $PV = nRT$

Combined Law $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Dalton's Laws: $P_1 + P_2 + P_3 = P_{total}$

$n_1 + n_2 + n_3 = n_{total}$

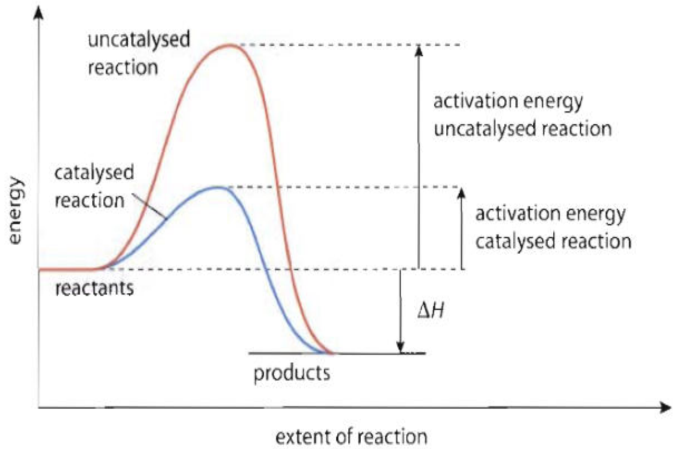
$\frac{P_1}{P_{total}} = \frac{n_1}{n_{total}}$

Graham's Law: $\frac{\text{fast rate}}{\text{slow rate}} = \sqrt{\frac{\text{slow molar mass}}{\text{fast molar mass}}}$

<u>Behavior of Gases</u>

Gases move in rapid, random, constant motion.
Gases move in straight line paths.
Gases have negligible volume (basically zero) compared to their containers.
Gases have elastic collisions in which they do not lose kinetic energy when colliding.
Gases prefer high temperature an low pressure.
The average kinetic energy of the molecules is proportional to the temperature.
Gases exert pressure on walls of container and on nearby molecules.
Gases have low intermolecular forces (nonpolar) and are not attracted unless induced.

Causes of Change



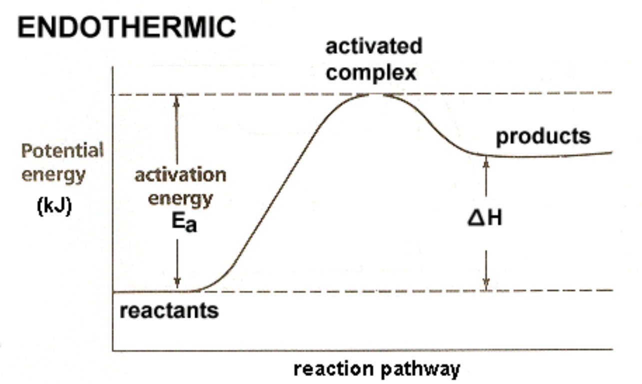
A **catalyst** lowers the activation energy and speeds up the reaction.

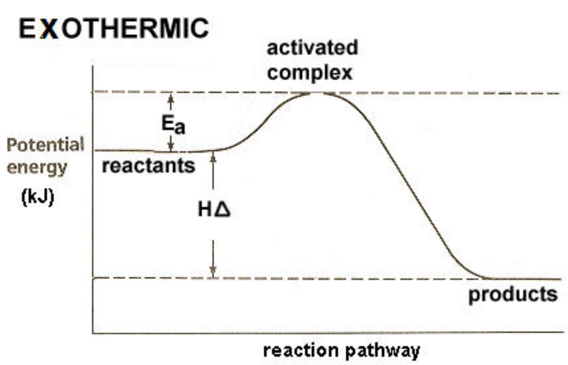
Activation energy is the energy required to break bonds.

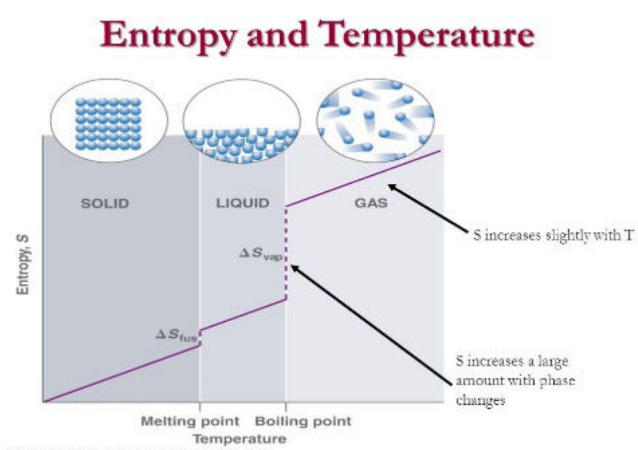
Enthalpy (ΔH) is the energy absorbed or released in a chemical reaction; equals products minus reactants.

Endothermic reactions occur when products are higher than the reactants because the reaction absorbed energy during the reaction; **(+ΔH)**

Exothermic reactions occur when products are lower than the reactants because the reaction has released energy during the reaction**; (– ΔH)**







Entropy (ΔS) is a measure of randomness.

Gases (g) and **aqueous ions (aq)** have the most

$$aA + bB \rightleftharpoons cC + dD$$

$$K_{eq} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

Temperature, Pressure, and Concentration can effect Keq.

Keq >1 favors products; forward rxn

Keq = 1 @ equilibrium

Keq < 1 favors reactants; reverse rxn

*Solids and Liquids are NOT included in Keq equation.

$$\mathbf{Q = mass \cdot specific\ heat \cdot (T_{final} - T_{initial})}$$

$$\Delta G = \Delta H - \left(T \times \frac{\Delta S}{1000}\right)$$

$$\mathbf{\Delta H = Products - Reactants}$$

Solute, Solvents, and Solutions

$$\frac{\text{Moles}}{1} = \frac{\text{grams}}{\text{molar mass}} \qquad \frac{\text{Liters}}{1} = \frac{\text{milliliters}}{1000} \qquad \frac{\text{Molarity}}{1} = \frac{\text{moles}}{\text{liters}}$$

Preparing dilutions: $M_1 V_1 = M_2 V_2$ **Stock = more concentrated solution**

A **solute** is dissolved by the **solvent** in order to make a **solution.**

Homogeneous – looks the same (Examples: air, bronze, salt water)

Heterogeneous – looks different (Examples: lava lamp; oil and water; ice water, cement)

Acids & Bases

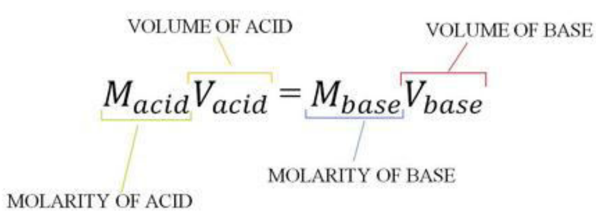
Arrhenius Theory – acids produce H^+ and bases have OH^-

Bronsted – Lowry – acids are **proton donors** and bases are **proton acceptors**

$pH = -\log [H^+]$ $10^{-pH} = [H^+]$ $pOH = -\log [OH^-]$ $10^{-pOH} = [OH^-]$

An acid-base titration is a lab technique that allows you to determine the concentration of an unknown solution. (There are other types of titrations, but this is the most common.) Some terms you need to know:

- **Titrant**: a solution of known concentration (usually); usually the solution in the buret
- **Analyte**: the solution you are trying to determine the concentration of; usually the solution in the beaker or flask
- **Equivalence point:** the volume of titrant added to give **equal moles of acid and base** (in an acid/base titration)
- **End point:** the volume of titrant added to make the color of the indicator change **hopefully, the equivalence point and the end point happen at the same time!
- **Indicator:** a solution that changes color in varying pH ranges



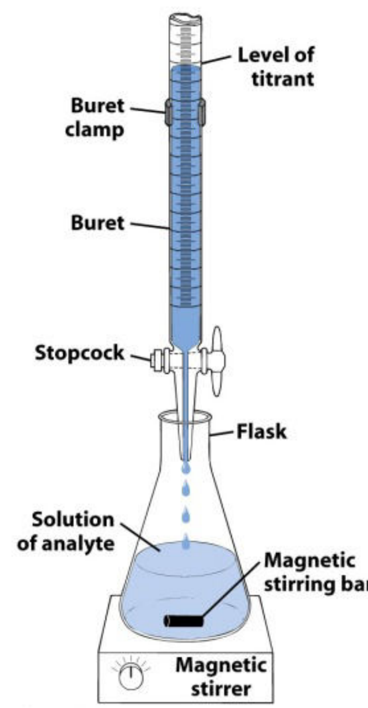


Figure 7-1
Quantitative Chemical Analysis, Seventh Edition
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Note: If you are using a diprotic or triprotic acid, then you need to add coefficients to the equation above. (C_a = coefficient of acid; C_b = coefficient of base. Coefficients are based on the # of moles required for a balanced chemical equation.)

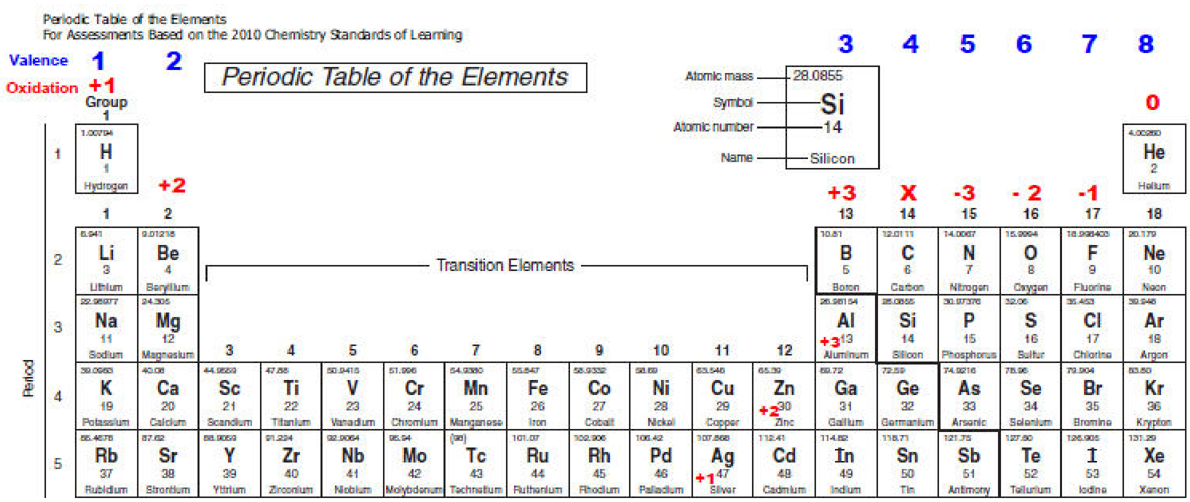
$$M_a C_b V_a = M_b C_a V_b$$

DIATOMIC Molecules

Elements that never exist alone (are always found in pairs) – Start with 7 and make a 7 then top your hat; **N_2, O_2, F_2, Cl_2, Br_2, I_2, H_2**; or Have No Fear Of Ice Cold Beer **H_2, N_2, F_2, O_2, I_2, Cl_2, Br_2**

Polyatomic Ions

Ion Name	Ion Formula	Example
Hydroxide	OH^{-1}	Sodium Hydroxide $NaOH$
Nitrate	NO_3^{-1}	Sodium Nitrate $NaNO_3$
Carbonate	CO_3^{-2}	Potassium Carbonate K_2CO_3
Sulfate	SO_4^{-2}	Magnesium Sulfate $MgSO_4$
Phosphate	PO_4^{-3}	Calcium Phosphate $Ca_3(PO_4)_2$
Ammonium	NH_4^{+1}	Ammonium Hydroxide NH_4OH



Roman numerals are only used for the transition elements in columns 3 – 12, and 14.
Silver (Ag+1) and Zinc (Zn+2) do not change so they do not need Roman numerals.

Greek prefixes (mono, di, tri, tetra) are only used with nonmetal covalent bonds.