

## Key Equations for General Chemistry:

These are the key equation that you should know for your first semester of general chemistry. Of course every professor is different in what they expect. Some want you to memorize every equation while other give it to you.

Temperature Scale Conversions:

$$T (K) = T^{\circ}C + 273.15$$

$$T (F) = T^{\circ}C \times (9^{\circ}F/5^{\circ}C) + 32^{\circ}F$$

$$T (C) = \frac{(T^{\circ}F - 32)}{1.8}$$

In science, we use Celsius and Kelvin. This will be useful for all kind of work that you will do for your homework and for lab as well. This will be also important for the gasses chapter with gas laws and temperature needs to be converted to Kelvin.

Density:

$$Density = \frac{Mass (g)}{Volume (mL \text{ or } cm^3)}$$

Percent Error:

$$Percent \ Error = \frac{Experimental \ value - Accepted \ value}{Accepted \ value} \times 100\%$$

Relationship between Mass Number (A), Number of Protons (p), and Number of Neutrons (n):

A = number of protons (p) + number of neutrons

Atomic Mass:

$$Atomic \ Mass = \sum_n (fraction \ of \ isotope) \times (mass \ of \ isotope)$$

Specific to the beginning chapters.

Avogadro's Number:

$$1 \ mole = 6.0221421 \times 10^{23} \ particles$$

This is used whenever you want to convert to particles of a substance.

Coulomb's Law:

$$E = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 \times q_2}{r}$$

$$(\epsilon_0 = 8.85 \times 10^{-12} C^2 / J \cdot m)$$

You may not need to use this to solve things but you need to understand it conceptually.

Formula Mass:

$$\left( \begin{array}{l} \text{No. of atoms of 1}^{st} \\ \text{element in chemical} \\ \text{formula} \end{array} \times \begin{array}{l} \text{atomic mass} \\ \text{of 1}^{st} \text{ element} \end{array} \right) + \left( \begin{array}{l} \text{No. of atoms of 2}^{nd} \\ \text{element in chemical} \\ \text{formula} \end{array} \times \begin{array}{l} \text{atomic mass} \\ \text{of 2}^{nd} \text{ element} \end{array} \right) + \dots$$

Mass Percent from the Chemical Formula:

$$\text{Mass \% of element X (in a mol of compound)} = \frac{\text{moles of X in formula} \times \text{mass of X (g/mol)}}{\text{mass (g) of 1 mol of compound}} \times 100$$

Empirical Formula Molar Mass:

$$\text{Molecular Formula} = n \times (\text{empirical formula})$$

$$n = \frac{\text{molar mass}}{\text{empirical formula molar mass}}$$

Percent Yield:

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Molarity:

$$M = \frac{\text{amount of solute (in mol)}}{\text{volume of solution (in L)}}$$

Solution Dilution:

$$M_1 \cdot V_1 = M_2 \cdot V_2$$

Relationship between Pressure (P), Force (F), and Area (A)

$$P = \frac{F}{A}$$

Boyle's Law: Relationship between Pressure and Volume:

$$V \propto \frac{1}{P}$$

$$P_1V_1 = P_2V_2$$

Charles's Law: Relationship Between Volume and Temperature:

$$V \propto T \text{ (in K)}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Avogadro's Law: Relationship between Volume and Amount in Moles (n):

$$V \propto n$$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Ideal Gas Law: Relationship Between Volume, Pressure, Temperature, and Amount:

$$PV = nRT$$

Dalton's law: Relationship Between Partial Pressures  $P_n$  in Mixture of gasses and Total Pressure:

$$P_{total} = P_a + P_b + P_c + \dots$$

$$P_a = \frac{n_aRT}{V} \quad P_b = \frac{n_bRT}{V} \quad P_c = \frac{n_cRT}{V}$$

Mole Fraction:

$$X_a = \frac{n_a}{n_{total}}$$

$$P_a = X_a P_{total}$$

Average Kinetic Energy:

$$KE_{avg} = \frac{3}{2}RT$$

Relationship between Root Mean Square Velocity and Temperature:

$$U_{rms} = \sqrt{\frac{3RT}{M}}$$

Relationship of Effusion Rates of two Different Gasses

$$\frac{\text{rate } A}{\text{rate } B} = \sqrt{\frac{M_B}{M_A}}$$

Van Der Waals Equation The Effects of Volume and Intermolecular Forces on Non ideal gas Behavior:

$$\left[ P + a \left( \frac{n}{V} \right)^2 \right] \times (V - nb) = nRT$$

Kinetic Energy:

$$KE = \frac{1}{2}mv^2$$

Change in Internal Energy (deltaE) of a Chemical System:

$$\Delta E = E_{products} - E_{reactions}$$

Energy Flow between System and Surroundings:

$$\Delta E_{system} = -\Delta E_{surroundings}$$

Relationship Between Internal Energy, Heat, and Work:

$$\Delta E = q + w$$

Relationship Between Heat, Temperature, and Heat Capacity:

$$q = C \times \Delta T$$

Relationship Between Heat, Mass, Temperature, and Specific Heat Capacity of a Substance:

$$q = m \times C_s \times \Delta T$$

Relationship Between Work, Force, and Distance:

$$w = F \times D$$

Relationship Between Work, Pressure, and Change in Volume:

$$W = -P_{ext} \Delta V$$

Change in Internal Energy of System at Constant Volume:

$$\Delta E = q_v$$

Heat of a Bomb Calorimeter:

$$q_{cal} = C_{cal} \times \Delta T$$

Heat Exchange between a Calorimeter and a Reaction:

$$q_{cal} = -q_{rxn}$$

Relationship Between Enthalpy, Internal Energy, Pressure, and Volume:

$$\Delta H = \Delta E + P\Delta V$$

$$\Delta H = q_p$$

Relationship between Enthalpy of a reaction and the Heats of Formation:

$$\Delta H_{rxn}^0 = \sum n_p \Delta H_F^{\circ}(\text{products}) - \sum n_r \Delta H_F^{\circ}(\text{reactants})$$

Relationship between Frequency, Wavelength, and the Speed of Light:

$$\nu = \frac{c}{\lambda}$$

Relationship Between Energy, Frequency, Wavelength, and Plank Constant:

$$E = h\nu$$

$$E = \frac{hc}{\lambda}$$

De Broglie Relation: Relationship Between Wavelength, Mass, and Velocity of a Particle:

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

Heisenberg Uncertainty Principle: Relationship Between a Particle's Uncertainty in Position and Uncertainty in Velocity:

$$\Delta x \times m\Delta v \geq \frac{h}{4\pi}$$

Energy of an Electron in an Orbital with Quantum Number n in a Hydrogen Atom:

$$E_n = -2.18 \times 10^{-18} J \left( \frac{1}{n^2} \right) \quad (n = 1, 2, 3, \dots)$$

Change in Energy That Occurs in an Atom When It Undergoes a Transition Between Levels:

$$\Delta E = -2.18 \times 10^{-18} J \left( \frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

Dipole Moment: Separation of Two Particles of Equal but Opposite Charge of Magnitude  $q$  by a Distance  $r$ :

$$\mu = qr$$

Percent Ionic Character:

$$\text{Percent ionic character} = \frac{\text{measured dipole moment of bond}}{\text{dipole moment if electron were completely transferred}} \times 100\%$$

Formal Charge:

$$\text{Formal charge} = \# \text{ of valence electrons} - (\# \text{ of nonbonding electrons} + \frac{1}{2} \# \text{ of shared electrons})$$

Enthalpy Change of a Reaction: Relationship of Bond Energies:

$$\Delta H_{rxn} = \sum (\Delta H' \text{ s bonds broken}) + \sum (\Delta H' \text{ s bonds formed})$$

Bond Order of a Diatomic Molecule:

$$\text{Bond order} = \frac{(\# \text{ of electrons in bonding MOs}) - (\# \text{ of electrons in antibonding MOs})}{2}$$

Clausius-Clapeyron Equation: Relationship Between Vapor Pressure, the Heat of Vaporization, and Temperature:

$$\ln P_{vap} = \frac{-\Delta H_{vap}}{RT} + \ln \beta (\beta \text{ is a constant})$$

$$\ln \frac{p_2}{p_1} = \frac{-\Delta H_{vap}}{R} \left( \frac{1}{T_2} - \frac{1}{T_1} \right)$$

Bragg's Law: Relationship between Light Wavelength, Angle of Reflection, and Distance: between Atomic layers:

$$n\lambda = 2d \sin \theta \quad (n = \text{integer})$$

Henry's Law: Solubility of gasses with Increasing Pressure:

$$S_{gas} = k_H P_{gas} \quad (k_H \text{ is Henry's law constant})$$

Molality:

$$m = \frac{\text{amount solvent (in mol)}}{\text{mass solvent (in kg)}}$$

Make Sure not to confuse this with Molarity.

Concentration of a Solution in Part by Mass and Parts by Volume:

$$\text{Percent by mass} = \frac{\text{mass solute} \times 100\%}{\text{mass solution}}$$

Parts Per million (ppm):

$$\text{Parts per million (ppm)} = \frac{\text{mass solute} \times 10^6}{\text{mass solution}}$$



Parts per billion (ppb):

$$\text{Parts per billion (ppb)} = \frac{\text{mass solute} \times 10^9}{\text{mass solution}}$$

Parts by volume:

$$\text{Parts by volume} = \frac{\text{volume solute} \times \text{multiplication factor}}{\text{volume solution}}$$

Concentration of a Solution in Mole Fraction (X) and Mole Percent:

$$X_{\text{solute}} = \frac{n_{\text{solute}}}{n_{\text{solute}} + n_{\text{solvent}}}$$

$$\text{Mol } \% = X \times 100\%$$

Raoult's Law: relationship Between the Vapor Pressure of a Solution, the Mole Fraction of the Solvent: and the Vapor Pressure of the Pure Solvent:

$$P_{\text{solution}} = X_{\text{solvent}} P_{\text{solvent}}^0$$

The Vapor Pressure of a Solution Containing Two Volatile Components:

$$P_A = x_A P_A^0$$

$$P_B = x_B P_B^0$$

$$p_{\text{tot}} = P_A + P_B$$

Relationship Between Freezing Point Depression, Molality, and Freezing Point Depression Constant:

$$\Delta T_f = m \times K_f$$

Relationship Between Boiling Point Elevation, Molality, and Boiling Point Elevation Constant:

$$\Delta T_b = m \times K_b$$

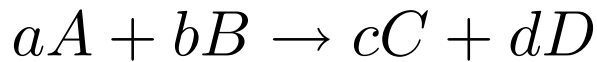
Relationship between Osmotic Pressure ( $\Pi$ ), Molarity, the Ideal Gas Constant, and Temperature:

$$\Pi = MRT (R = 0.08206 \text{ L atm/mol} \cdot K)$$

van't Hoof Factor ( $i$ ): Ratio of Moles of Particles in Solution to Moles of Formula Units Dissolved:

$$i = \frac{\text{moles of particles in solution}}{\text{moles of formula units dissolved}}$$

The Rate of the Reaction:



$$\text{Rate} = -\frac{1}{a} \frac{\Delta(A)}{\Delta t} = -\frac{1}{b} \frac{\Delta[B]}{\Delta t} = +\frac{1}{c} \frac{\Delta[C]}{\Delta t} + \frac{1}{d} \frac{\Delta[D]}{\Delta t}$$

The Rate Law:

$$\text{Rate} = k[A]^n \text{ (single reactant)}$$

$$\text{Rate} = k[A]^m[B]^n \text{ (multiple reactants)}$$

Integrated Rate Laws and Half Life:

Reaction Order, Integrated Rate Law, Units of  $k$ , Half Life Expressions:

$$0, [A]_t = -kt + [A]_0, M \cdot s^{-1}, t_{(1/2)} = \frac{[A]_0}{2k}$$

$$1, \ln [A]_t = -kt + \ln [A]_0, s^{-1}, t_{(1/2)} = \frac{0.693}{k}$$

$$2, \frac{1}{[A]_t} = kt + \frac{1}{[A]_0}, M^{-1} \cdot s^{-1}, t_{(1/2)} = \frac{1}{k[A]_0}$$

Rate Laws are constally duscussed in Ochem and Biochem as well.

The First Order and Half-Life equtions are used in nucelar chemistry section as well.

Arrhenius Equation:

$$K = Ae^{-E_a/RT}$$

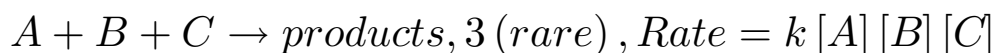
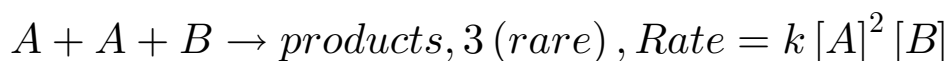
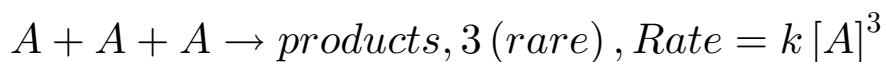
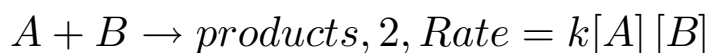
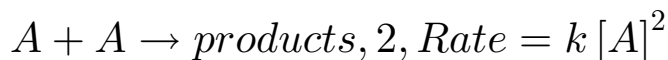
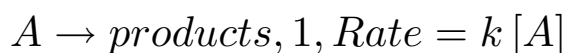
$$\ln K = -\frac{E_a}{R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right) \text{ (linearized form)}$$

$$\ln \left( \frac{k_2}{k_1} \right) = \frac{E_a}{R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right) \text{ (two - point form)}$$

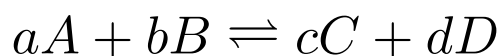
$$k = pze^{-E_a/RT} \text{ (collision theory)}$$

Rate Laws for Elementary Steps:

Elementary Step, Molecularity, Rate Law:



Expression for the Equilibrium Constant K:

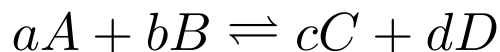


$$K = \frac{[C]^c [D]^d}{[A]^a [B]^b} \text{ (equilibrium concentrations only)}$$

Relationship between the Equilibrium Constant and the the Chemical Equation:

1. If you reverse the equation, invert the equilibrium constant.
2. If you multiply the coefficient in the equation by a factor, raise the equilibrium constant to the same factor.
3. If you add two or more individual chemical equations to obtain an overall equation, multiply the corresponding equilibrium constants by each other to obtain the overall equilibrium constant.

Expression for the Equilibrium Constant,  $K_p$ :

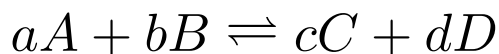


$$K_p = \frac{P_C^c P_D^d}{P_A^a P_B^b} \text{ (equilibrium partial pressures only)}$$

Relationship Between The Equilibrium Constants:

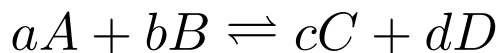
$$K_p = K_c (RT)^{\Delta n}$$

The Reaction Quotient  $Q_c$ :



$$Q_c = \frac{[C]^c [D]^d}{[A]^a [B]^b} \text{ (concentrations at any point in the reaction)}$$

The Reaction Quotient  $Q_p$ :



$$Q_p = \frac{P_C^c P_D^d}{P_A^a P_B^b} \text{ (partial pressures at any point in the reaction)}$$

Relationship of  $Q$  to the Direction of the Reaction:

- $Q < K$  Reaction goes to the right.
- $Q > K$  Reaction goes to the left.
- $Q = K$  Reaction is at equilibrium.

*Note* : In all of these equations  $[H^+]$  is interchangeable with  $[H_3O^+]$ .

Expression for the Acid Ionization Constant  $K_a$ :

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

The Ion Product Constant for Water  $K_w$ :

$$K_w = [H_3O^+] [OH^-] = 1.0 \times 10^{-14} \text{ (at } 25^\circ\text{C)}$$

Expression for the pH Scale:

$$pH = -\log [H_3O^+]$$

Expression for the pOH Scale:

$$pOH = -\log [OH^-]$$

Relationship between pH and pOH:

$$pH + pOH = 14.00$$

Expression for the pKa Scale:

$$pK_a = -\log K_a$$

Useful in organic and biochemistry. Used as a scale for the acidity of a compound. The lower the number the more acidic. The higher the number the less acidic.

Expression for Percent Ionization:

$$\begin{aligned} \text{Percent ionization} &= \frac{\text{concentration of ionized acid}}{\text{initial concentration of acid}} \times 100\% \\ &= \frac{[H_3O^+]_{\text{equil}}}{[HA]_{\text{init}}} \times 100\% \end{aligned}$$

Relationship Between  $K_a$ ,  $K_b$ , and  $K_w$ :

$$K_a \times K_b = K_w$$

The Henderson-Hasselbalch Equation:

$$pH = pK_a + \log \frac{[Base]}{[Acid]}$$

Effective Buffer Range:

$$pH \text{ range} = pK_a \pm 1$$

The Relation between  $Q$  and  $K_{sp}$ :

- If  $Q < K_{sp}$ , the solution is unsaturated < more of the solid ionic compound can be dissolved in the solution.
- If  $Q = K_{sp}$ , the solution is saturated. The solution is holding the equilibrium amount of dissolved ionic, and additional solid will not dissolve in the solution.
- If  $Q > K_{sp}$ , the solution is supersaturated. Under most circumstances, the solid will precipitate out of a supersaturated solution.

The Definition of Entropy:

$$S = k \ln W, k = 1.38 \times 10^{-23} \text{ J/K}$$

Change in Entropy:

$$\Delta S = S_{final} - S_{initial}$$

$$\Delta S = q_{rev}/T \text{ (Isothermal, reversible process)}$$

Change in the Entropy of the Universe:

$$\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$$

Change in the Entropy of the Surroundings:

$$\Delta S_{surr} = \frac{-\Delta H_{sys}}{T} \text{ (constant } T, P)$$

Change in Gibbs Free Energy:

$$\Delta G = \Delta H - T\Delta S$$

The Relationship between Spontaneity, Delta H, Delta S, and Temperature:

$\Delta H$	$\Delta S$	Low Temp.	High Temp	
-	+	<i>Spontaneous</i> ( $\Delta G < 0$ )	<i>Spontaneous</i> ( $\Delta G < 0$ )	always spontaneous
+	-	<i>Nonspontaneous</i> ( $\Delta G > 0$ )	<i>Nonspontaneous</i> ( $\Delta G > 0$ )	never spontaneous
-	-	<i>Spontaneous</i> ( $\Delta G < 0$ )	<i>Nonspontaneous</i> ( $\Delta G > 0$ )	spontaneous @low temp.
+	+	<i>Nonspontaneous</i> ( $\Delta G > 0$ )	<i>Spontaneous</i> ( $\Delta G < 0$ )	spontaneous @high temp.

Standard Change in Entropy:

$$\Delta S_{rxn}^0 = \sum n_p S^0(\text{products}) - \sum n_r S^0(\text{reactants})$$

Methods for Calculating the Free Energy of Formation:

$$1 \cdot \Delta G_{rxn}^0 = \Delta H_{rxn}^0 - T\Delta S_{rxn}^0$$

$$2 \cdot \Delta G_{rxn}^0 = \sum n_p \Delta G_f^0(\text{products}) - \sum n_r \Delta G_f^0(\text{reactants})$$

$$3 \cdot \Delta G_{rxn}^0(\text{overall}) = \Delta G_{rxn}^0(\text{step 1}) + \Delta G_{rxn}^0(\text{step 2}) + \Delta G_{rxn}^0(\text{step 3}) + \dots$$

The Relationship Between  $\Delta G_{rxn}^0$  and  $\Delta G_{rxn}$ :

$$\Delta G_{rxn} = \Delta G_{rxn}^0 + RT \ln Q, R = 8.314 \text{ J/mol} \cdot \text{K}$$

The Relationship Between  $\Delta G_{rxn}^0$  and  $k$ :

$$\Delta G_{rxn}^0 = -RT \ln k$$

## The Temperature Dependence of the Equilibrium Constant:

$$\ln K = \frac{\Delta H_{rxn}^0}{R} \left( \frac{1}{T} \right) + \frac{\Delta S_{rxn}^0}{R}$$

$$\ln \left( \frac{K_2}{K_1} \right) = \frac{\Delta H_{rxn}^0}{R} \left( \frac{1}{T_2} - \frac{1}{T_1} \right)$$

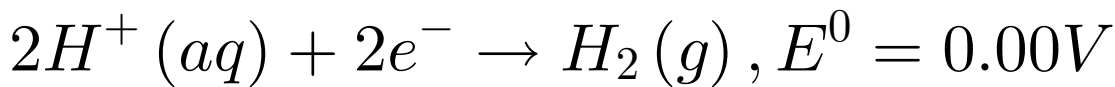
## Definition of an Ampere:

$$1 \text{ A} = 1 \text{ C/s}$$

## Definition of a Volt:

$$1 \text{ V} = 1 \text{ J/s}$$

## Standard Hydrogen Electrode:



## Equation for Cell Potential:

$$E_{cell}^{\circ} = E_{cathode}^{\circ} - E_{anode}^{\circ}$$

## Relating $E_{cell}^{\circ}$ and $K$

$$E_{cell}^{\circ} = \frac{0.0592V}{n} \log K \text{ (at } 25^{\circ}C)$$

## The Nernst Equation:

$$E_{cell} = E_{cell}^{\circ} - \frac{0.0592V}{n} \log Q \text{ (at } 25^{\circ}C)$$

## The Integrated Rate Law:

$$\ln \frac{N_t}{N_0} = -kt$$

$N_t$  = number of radioactive nuclei at time  $t$ .

$N_0$  = initial number of radioactive nuclei.

## Einstein's Energy-Mass Equation

$$E = mc^2$$

These equations are used in the electrochemistry section.

Used in Nuclear Chemistry.



Lever Rule:

In a two-phase region on a phase diagram, two different crystal structures coexist in equilibrium. Whichever phase has a composition closer to the overall composition of the alloy is the phase present in the larger relative amount.

If there is anything that I have missed let me know at [cosmeticsyourwaysblog@gmail.com](mailto:cosmeticsyourwaysblog@gmail.com). I hope this helps in your chemistry endeavors.