Common Equations Used in Chemistry

Equation for density: $d = \dfrac{m}{v}$

Converting °F to °C: $°C = (°F - 32) \times \dfrac{5}{9}$

Converting °C to °F: $°F = °C \times \dfrac{9}{5} + 32$

Converting °C to K: $K = (°C + 273.15)$

Percent composition of an element $= \dfrac{n \text{ x molar mass of element}}{\text{molar mass of compound}} \times 100\%$
    - where n = the number of moles of the element in one mole of the compound

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

molarity (M) $= \dfrac{\text{moles of solute}}{\text{liters of solution}}$

Dilution of Solution: $M_i V_i = M_f V_f$

Boyle's law - Constant T and n: $PV = k$

Boyle's law - For calculating changes in pressure or volume: $P_1 V_1 = P_2 V_2$

Charles' law - Constant P and n: $\dfrac{V}{T} = k$

Charles' law - For calculating temperature or volume changes: $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$

Avogadro's law - Constant P and T: $V = kn$

Ideal Gas equation: $PV = nRT$

Calculation of changes in pressure, temperature, or volume of gas when n is constant:
$$\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$$

Calculation of density or molar mass of gas: $d = \dfrac{PM}{RT}$

Dalton's law of partial pressures - for calculating partial pressures: $P_i = X_i P_T$

Root-mean-square speed of gas molecules: $u_{rms} = (\dfrac{3RT}{M})^{0.5}$

Van der waals equation; for calculating the pressure of a nonideal gas:

$$(P + \dfrac{an^2}{V^2}) \, (V - nb) = nRT$$

Definition of heat capacity, where s is specific heat: $C = ms$

Calculation of heat change in terms of specific heat : $q = ms \, \Delta t$

Calculation of heat change in terms of heat capacity: $q = C \, \Delta t$

Electrical force: $F_{el} = k\dfrac{q_1 q_2}{r^2}$

Potential energy: $V = k\dfrac{q_1 q_2}{r}$

Calculation of standard enthalpy of reaction:
$\Delta H^\circ_{rxn} = \sum n \Delta H^\circ_f \text{(products)} - \sum m \Delta H^\circ_f \text{(reactants)}$ [where n and m are coefficients   in equation]

Mathematical statement of the first law of thermodynamics: $\Delta E = q + w$

Work done in gas expansion or compression: $w = - P \Delta V$

Definition of enthalpy: $H = E + PV$

Enthalpy (or energy) change for a constant-pressure process: $\Delta H = \Delta E + P \Delta V$

Enthalpy (or energy) change for a constant-pressure process: $\Delta E = \Delta H - RT \Delta n$, where Δn is   the change in the number of moles of gas.

Relationship of wavelength and frequency: $u = \lambda \nu$

Energy of a photon: $E = h \nu$

Energy of an electron in the nth state in a hydrogen atom: $E_n = -R_H(\dfrac{1}{n^2})$,

where R_H = Rydberg constant = 2.18×10^{-18} J

Energy of a photon emitted as the electron undergoes a transition from the n_i

level to the n_f level: $E = h\nu = R_H(\dfrac{1}{n_i^2} - \dfrac{1}{n_f^2})$, where R_H = Rydberg

constant = 2.18×10^{-18} J

DeBroglie Relationship of wavelength of a particle to its mass m and velocity

v: $\lambda = \dfrac{h}{mv}$

Uncertainty in the position (Δx) or in the momentum (Δp) of a particle: $\Delta x \, \Delta p \geq \dfrac{h}{4\pi}$

Formal charge on an atom in a Lewis structure = total number of valence electrons in the free atom - total number of nonbonding electrons - $\dfrac{1}{2}$(total number of bonding electrons)

Enthalpy change of a reaction from bond energies:
$\Delta H° = \sum BE \text{ (reactants)} - \sum BE \text{ (products)}$

Dipole moment in terms of charge (Q) and distance of separation (r) between charges: $\mu = Q \times r$

Bond order =
Error!

Bragg equation for calculating the distance between planes of atoms in a crystal lattice:
$2d \sin\theta = \lambda$

Clasius-Clapeyron equation for determining ΔH_{vap} of a liquid:
$$\ln P = -\dfrac{\Delta H_{vap}}{RT} + C$$

Calculation of ΔH_{vap}, vapor pressure, or boiling point of a liquid:
$$\ln \dfrac{P_1}{P_2} = \dfrac{\Delta H_{vap}}{R}\left(\dfrac{T_1 - T_2}{T_1 T_2}\right)$$

Entropy change of heat flow at constant temperature: $S = \dfrac{q}{T}$

Calculating the molality of a solution: molality (m) $= \dfrac{\text{moles of solute}}{1000 \text{ g solvent}}$

Henry's law for calculating solubility (c) of gases: $c = kP$

Raoult's law relating the vapor pressure of a liquid to its vapor pressure in a solution:
   $P_1 = X_1 P^{\circ}_1$

Vapor pressure lowering in terms of the concentration of solution: $P = X_2 P^{\circ}_1$

Boiling point elevation: $T_b = K_b m$

Freezing point depression: $T_f = K_f m$

Osmotic pressure of a solution: $= MRT$

The van't Hoff factor for an electrolyte solution:
   $i = \dfrac{\text{actual number of particles in soln after dissociation}}{\text{number of formula units initially dissoved in soln}}$

Rate law expression. The sum (x+ y) gives the overall order of the reaction:
   $\text{rate} = k[A]^x[B]^y$

Relationship between concentration and time for a first-order reaction: $\ln \dfrac{[A]_0}{[A]} = kt$

Equation for the graphical determination of k for a first-order reaction:
   $\ln [A] = -kt + \ln [A]_0$

Half-life for a first-order reaction: $t_{1/2} = \dfrac{\ln 2}{k} = \dfrac{0.693}{k}$

Relationship between concentration and time for a second-order reaction: $\dfrac{1}{[A]} = \dfrac{1}{[A]_0} + kt$

The Arrhenius equation expressing the dependence of the rate constant on activation energy and temperature: $k = Ae^{-E_a/RT}$

Equation for the graphical determination of activation energy: $\ln k = (-\frac{E_a}{R})(\frac{1}{T}) + \ln A$

Relationships of rate constants at two different temperatures: $\ln \frac{k_1}{k_2} = \frac{E_a}{R}(\frac{T_1 - T_2}{T_1 T_2})$

Law of Mass Action - General expression of equilibrium constant: $K = \frac{[C]^c [D]^d}{[A]^a [B]^b}$

Relationship between K_p and K_c: $K_p = K_c (0.0821*T)^{\Delta n}$

The equilibrium constant for the overall reaction is given by the product of the equilibrium constants for the individual reactions: $K_c = K'_c K''_c$

Ion-product constant of water: $K_W = [H^+][OH^-]$

Definition of pH of a solution: $pH = -\log [H^+]$

Definition of pOH of a solution: $pOH = -\log [OH^-]$

Another form of ion-product constant of water: $pH + pOH = 14.00$

Percent ionization $= \dfrac{\text{ionized acid concentration at equilibrium}}{\text{initial concentration of acid}} \times 100\%$

Relationship between the acid and base ionization constants of a conjugate acid-base pair: $K_a K_b = K_w$

Henderson-Hasselbach equation: $pH = pK_a + \log \dfrac{[\text{conjugate base}]}{[\text{acid}]}$

The second law of thermodynamics (spontaneous process): $\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr} > 0$

The second law of thermodynamics (equilibrium process): $\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr} = 0$

Standard entropy change of a reaction: $\Delta S^\circ_{rxn} = nS^\circ(\text{products}) - mS^\circ(\text{reactants})$, where n and m are coeffecients in the equation

Free-energy change at constant temperature: $\Delta G = \Delta H - T\Delta S$

Standard free-energy change of a reaction:
$\Delta G^\circ_{rxn} = n\Delta G^\circ_f(\text{products}) - m\Delta G^\circ_f(\text{reactants})$, where n and m are coefficients in the equation

Relationship between free-energy change and standard free-energy change and reaction quotient: $\Delta G = \Delta G^\circ + RT \ln Q$

Relationship between standard free-energy change and the equilibrium constant: $\Delta G^\circ = -RT \ln K$

Standard emf of an electrochemical cell: $E^\circ_{cell} = E^\circ_{ox} - E^\circ_{red} = E^\circ_{cathode} - E^\circ_{anode}$

Standard free energy change: $\Delta G^\circ = -nFE^\circ_{cell}$, where F is the Faraday constant

Relationship of the standard emf of the cell to the equilibrium constant:
$$E^\circ_{cell} = \frac{RT}{nF} \ln K$$

The Nernst equation - For calculating the emf of a cell under non-standard conditions:
$$E = E^\circ - \frac{RT}{nF} \ln Q$$

Relationship between mass defect and energy released: $E = (\Delta m)c^2$