

Common Equations Used in Chemistry

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

Converting °F to °C: $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$

Converting °C to °F: $^{\circ}\text{F} = ^{\circ}\text{C} \times \frac{9}{5} + 32$

Converting °C to K: $\text{K} = (^{\circ}\text{C} + 273.15)$

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

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

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

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: $\frac{V}{T} = k$

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

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:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

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

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

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

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

$$\left(P + \frac{an^2}{V^2}\right) (V - nb) = nRT$$

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

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

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

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

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

Calculation of standard enthalpy of reaction:

$H^\circ_{rxn} = n H^\circ_f(\text{products}) - m H^\circ_f(\text{reactants})$ [where n and m are coefficients in equation]

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

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: $\Delta H = \Delta E + RT \ \Delta n$, where n is the change in the number of moles of gas.

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

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

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

where $R_H = \text{Rydberg constant} = 2.18 \times 10^{-18} \text{ J}$

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

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

constant = $2.18 \times 10^{-18} \text{ J}$

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

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

Uncertainty in the position (x) or in the momentum (p) of a particle: $\Delta x \Delta p$

$$\geq \frac{h}{4}$$

Formal charge on an atom in a Lewis structure = total number of valence electrons in the free atom - total number of nonbonding electrons -

$$\frac{1}{2}(\text{total number of bonding electrons})$$

Enthalpy change of a reaction from bond energies:

$$\Delta H^\circ = \text{BE (reactants)} - \text{BE (products)}$$

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:

$$2d \sin \theta = n\lambda$$

Clausius-Clapeyron equation for determining H_{vap} of a liquid:

$$\ln P = -\frac{H_{\text{vap}}}{RT} + C$$

Calculation of H_{vap} , vapor pressure, or boiling point of a liquid:

$$\ln \frac{P_1}{P_2} = \frac{H_{\text{vap}}}{R} \left(\frac{T_1 - T_2}{T_1 T_2}\right)$$

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

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

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: $\pi = MRT$

The van't Hoff factor for an electrolyte solution:

$$i = \frac{\text{actual number of particles in soln after dissociation}}{\text{number of formula units initially dissolved in soln}}$$

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

$$\frac{[A]_0}{[A]} = kt$$

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: $t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$

Relationship between concentration and time for a second-order reaction: $\frac{1}{[A]}$

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

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: $\ln k = \left(-\frac{E_a}{R}\right) \left(\frac{1}{T}\right) + \ln A$

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

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 : $K_p = K_c(0.0821 \cdot T)^n$

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

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

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

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

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

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

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

Standard free-energy change of a reaction:

$\Delta G^\circ_{\text{rxn}} = n \Delta G^\circ_f(\text{products}) - m \Delta G^\circ_f(\text{reactants})$, 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: $E^\circ_{\text{cell}} = E^\circ_{\text{ox}} - E^\circ_{\text{red}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$

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

Relationship of the standard emf of the cell to the equilibrium constant:

$$E^\circ_{\text{cell}} = \frac{RT}{nF} \ln K$$

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: $E = (\Delta m)c^2$