

## Ideal Gas Law

$$n/V = P/(R*T) \quad n = (P*V)/(R*T)$$

$$\mathbf{R \text{ for } P} = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}, \mathbf{R \text{ for atm}} = 82.05 \times 10^{-6} \text{ atm m}^3 \text{ mol}^{-1} \text{ K}^{-1}$$

$$1.0 \text{ atm} = 1.01325 \times 10^5 \text{ PA}$$

$$\text{Air: } 8.0 \times 10^{-11} \text{ mol CHCl}_3/\text{mol Air} = 8.0 \times 10^{-2} \text{ ppb, CHCl}_3$$

$$\text{Water: } 42 \mu\text{g/L of something} = 42 \text{ ppb and mg/L} = \text{ppm}$$

Percent concentration of a gas in air is by pressure or moles (multiply  $P_T$  by percentage in IGL to calculate moles)

Percent concentration in water is by mass typically

$$\mathbf{Hardness} = \text{TH} = 2 * [\text{Ca}^{2+}] + 2 * [\text{Mg}^{2+}] + \text{N of other multivalent Cations (answers in eq/L)}$$

$$\mathbf{Carbonate Hardness} = \text{CH} = [\text{HCO}_3^-] + 2 * [\text{CO}_3^{2-}] \text{ up to the TH (answers in eq/L)}$$

$$\mathbf{TDS} = \Sigma \text{ mass concentrations of all ions (answers in mg/L)}$$

$$\mathbf{Alkalinity} = K_w/[\text{H}^+] \text{ or } [\text{OH}^-] + [\text{HCO}_3^-] + 2 * [\text{CO}_3^{2-}] - [\text{H}^+]$$

$$\mathbf{Ionic Strength} = I = 1/2 \Sigma c_i z_i^2 \text{ (molar concentration * the square of the charge for all ions)}$$

$$\mathbf{pH} = -\log [\text{H}^+], 10^{-5} \text{ M of } [\text{H}^+] \text{ has a pH of } 5$$

$$\mathbf{TS} = M_B/V_A \quad \mathbf{TDS} = M_G/V_D \quad \mathbf{SS} = M_E/V_D \quad \mathbf{TVS} = (M_B - M_C)/V_A \quad \mathbf{VSS} = (M_E - M_F)/V_D$$

$$V_A \text{ w/o water} = M_B \text{ which burned} = M_C$$

$$V_D \text{ filtered} = M_E \text{ on paper} + M_G \text{ still in solution, } M_E \text{ burned} = M_F \text{ (for the VSS)}$$

## Turbidity

$$\text{concentration} = \text{particles/cm}^3 \quad \text{surface area concentration} = \mu\text{m}^2/\text{cm}^3$$

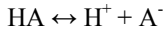
$$\text{Volume of a sphere} = 4/3\pi r^3 \quad \text{Cross sectional area of a sphere} = \pi r^2$$

$$\text{Volume of particles} = \text{density} \times \text{mass} \quad \text{total mass/mass of one particle} = \# \text{ of particles OR number per gram}$$

If this is particles per L, be sure to change to particles per  $\text{cm}^3$  etc.

$$\text{Total cross sectional area} = \text{cross sectional area of one particle} \times \text{number of particles per cm}^3$$

## Acid-Base Reactions & Acid Dissociation & Strong & Weak Acids



$$K_A = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} \quad \text{p}K_A = -\log_{10}(K_A) \quad \text{p}K_A = \text{pH} - \log_{10}[\text{A}^-] + \log_{10}[\text{HA}]$$

$[\text{HCO}_3^-]$  typically balances natural waters for electroneutrality

( $\text{p}K_A$ ) for  $\text{HCO}_3^- \rightarrow \text{CO}_3^{2-} + \text{H}^+$  is 10.33,  $K = 10^{-10.33}$

$$K = \frac{[\text{CO}_3^{2-}][\text{H}^+]}{[\text{HCO}_3^-]}$$

**Relative Humidity** = Vapor Pressure/Saturation Vapor Pressure

$$\mathbf{Kinetics} \quad \mathbf{Rate Law} R = k [\text{A}]^a [\text{B}]^b$$

$$Y_A = 100 \text{ ppb, } Y_B = 50 \text{ ppb, } Y_C = 1 \text{ ppb}$$

$$\mathbf{A + B} \rightarrow \mathbf{C}, k_1 = 2 \times 10^{-4} \text{ ppb}^{-1} \text{ min}^{-1}, R_1 = k_1 [\text{A}][\text{B}]; \mathbf{C} \rightarrow \mathbf{A + B}, k_2 = 0.2 \text{ min}^{-1}, R_2 = -k_2 [\text{C}] \text{ Therefore } dY_C/dt = k_1 [\text{A}][\text{B}] - k_2 [\text{C}]$$

$$\mathbf{A + B} \rightarrow \mathbf{C} \ \& \ \mathbf{C} \rightarrow \mathbf{A + B} \quad \tau = (C)/((k_1 * A * B) - (k_2 * C));$$

$$\mathbf{A + A} \rightarrow \mathbf{Products} \quad \tau = A_0/(2k A_0^2); \mathbf{A} \rightarrow \mathbf{products} \quad \tau = A_0/(k_1 A_0); \mathbf{A} \rightarrow \mathbf{Products} \quad \tau = A_0/(k_0)$$

$$\text{Rate Law } R = -1/a (d[\text{A}]/dt) = -1/b (d[\text{B}]/dt) = 1/c (d[\text{C}]/dt) \text{ where } \mathbf{A + B} \rightarrow \mathbf{C}$$

$$dx/dt = \text{production}(x) - \text{consumption}(x) \text{ @ steady state } dY_x/dt = 0 = k_1 Y_A Y_B - k_2 Y_C \quad \text{solve for } Y_C$$

$$\mathbf{Henry's Law} \quad C_W = K_{H,g} P_g \quad P_g = H_g C_W \quad K_{H,g} \text{ is M/atm} \quad H_g \text{ is atm/M}$$

$$C_W \text{ is the species concentration in aqueous phase (M)}$$

$$P_g \text{ is the partial pressure of the gaseous species (atm)}$$

$$\mathbf{Material Balance} \quad C_X * V_W + (P_X * V_a)/(R * T) = \text{moles}$$

**Solubility Product & Solid Precipitation** (solid must be present)

$$A_x B_y \rightarrow xA + yB \quad [A]^x * [B]^y = K_{sp} (T) \quad \text{e.g. } [\text{Ca}^{2+}][\text{F}^-]^2 = 3 \times 10^{-11} \text{ M}^3 \text{ for CaF}_2$$

## Adsorption

$$\text{Linear: } q_e = K_{ads} C_e \quad \text{Langmuir: } q_e = q_{max} (b C_e)/(1 + b C_e)$$

$$\text{Freundlich: } q_e = K_f C_e^{1/n}$$

$q_e$  = mass of sorbed contaminant (moles or mg per g of sorbent)  $C_e$  = concentration in fluid at equ. (moles or mg per liter)

$$q_{max} = \text{max sorbtion} \quad K_{ads} \ \& \ b \text{ are L/g or moles}$$

$$\text{Freundlich linearized: } \log q_e = 1/n \log C_e + \log K_f \quad \text{Langmuir linearized: } C_e/q_e = C_e/q_{max} + 1/(b * q_{max}) \text{ [plot } C_e/q_e \text{ on Y and } C_e \text{ on X]}$$

Uptake = contaminant on AC (mol or mmol)/grams AC =  $q$ ; then plug in values of  $q$  to graph

Often, sorbed moles +  $C_t$  + gaseous moles = some total number of moles