

# CHE 102 Final Reference Sheet - Sean Yang

## Temperature Conversion Factors

$$\frac{1\text{K}}{1.8^\circ\text{R}}, \frac{1\text{K}}{1.8^\circ\text{F}}, \frac{1^\circ\text{C}}{1.8^\circ\text{F}}, \frac{1^\circ\text{C}}{1.8^\circ\text{R}}, \frac{1^\circ\text{C}}{1\text{K}}, \frac{1^\circ\text{F}}{1^\circ\text{R}}$$

(Relative differences only)

## Density

$$\rho = \frac{m}{v}$$

## Average Atomic Mass

$$M = \sum_i x_i M_i$$

## Mole Fraction and Percentage

$$x_A = \frac{n_A}{n_T} = \frac{n_A}{\sum_i n_i}$$

$$\% = x_A \times 100\%$$

## Mass Fraction and Percentage

$$w_A = \frac{m_A}{m_T} = \frac{m_A}{\sum_i m_i}$$

$$\% = w_A \times 100\%$$

## Average Molar Mass

$$M = \sum_i x_i M_i$$

## Concentration

$$\text{molarity} = \frac{n}{V}$$

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

$$\text{volume \%} = \frac{V_{\text{solute}}}{V_{\text{solution}}} \times 100\%$$

$$\text{weight-to-volume \%} = \frac{m_{\text{solute}}}{V_{\text{solution}}} \times 100\%$$

$$\text{molality} = \frac{n_{\text{solute}}}{m_{\text{solvent}}}$$

$$\text{ppm} = \frac{m_{\text{solute}}}{m_{\text{solution}}} \times 10^6$$

$$\text{ppb} = \frac{m_{\text{solute}}}{m_{\text{solution}}} \times 10^9$$

## Percentage Yield and Excess

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

$$\% \text{ excess} = \frac{\text{amount provided} - \text{amount required}}{\text{amount required}} \times 100\%$$

## Boyle's Law (Constant n, T)

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

$$P_1 V_1 = P_2 V_2$$

## Charles' Law (Constant n, P)

$$V \propto T$$

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

Temperature in K

## Avogadro's Law (Constant T, P)

$$V \propto n$$

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

At 0°C and 1 atm: 1 mol gas = 22.414 L

At 25°C and 1 atm: 1 mol gas = 24.465 L

## Ideal Gas Law

$$PV = nRT$$

or  $PV_m = RT$ , where  $V_m = \frac{V}{n}$

Temperature in K

## Ideal Gas Assumptions:

- No intermolecular forces between molecules
- Gas molecules have no volume

Approximation valid at high  $T$ , low  $P$

## Gas Density

$$\rho = \frac{PM}{RT}$$

at 25°C and 1 atm:  $\rho = \frac{M}{24.465 L \cdot \text{mol}^{-1}}$

## Gas Concentration

$$C = \frac{P}{RT}$$

at 25°C:  $C = \frac{P}{24.465 L \cdot \text{atm} \cdot \text{mol}^{-1}}$ , where  $P$  is in atm

## Dalton's Law of Partial Pressures

$$P = P_A + P_B$$

Assuming  $V = V_A = V_B$

## Dalton's Law of Partial Volumes

$$V = V_A + V_B$$

Assuming  $P = P_A = P_B$

## Dalton's Law (Mole Fraction)

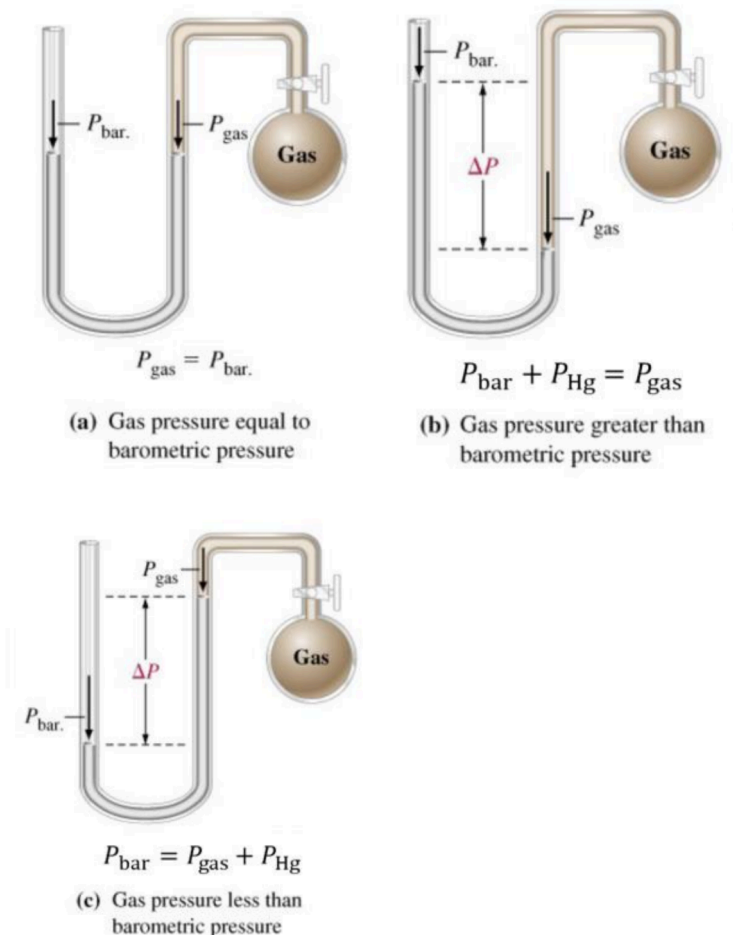
$$y_A = \frac{n_A}{n} = \frac{P_A}{P} = \frac{V_A}{V}$$

$$n_A = y_A n$$

$$P_A = y_A P$$

$$V_A = y_A V$$

## Measuring Pressure with an Open-End Manometer



$$\Delta P_{\text{mmHg}} = \Delta h_{\text{Hg}}$$

## Kinetic Molecular Theory Postulates

- Gas particles are in constant, random motion
- Collisions between gas particles and container walls are elastic
- The average kinetic energy of gas particles is proportional to temperature in K
- Gas particles exert no forces on each other (no attraction or repulsion)

## Reaction Rate Constant Units

Note:  $Q_p$  and  $K_p$  should be calculated using bar units for pressure (1 bar =  $10^5$  Pa = 750 mmHg)

Order	Units of k
0	$\text{mol} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$
1	$\text{s}^{-1}$
2	$\text{L} \cdot \text{mol}^{-1} \cdot \text{s}^{-1}$
n	$\text{L}^{n-1} \cdot \text{mol}^{1-n} \cdot \text{s}^{-1}$

## Kinetic Plots

Order	Plot of	Slope
0	$[A]$ vs. $t$	$-k$
1	$\ln[A]$ vs. $t$	$-k$
2	$\frac{1}{[A]}$ vs. $t$	$k$

## Integrated Rate Laws

Note: Pressure can be used in place of concentration for gases since concentration is proportional to pressure.

Order	Rate Law	Integrated Rate Law	Half-Life
0	rate = $k$	$[A] = [A]_0 - kt$	$t_{\frac{1}{2}} = \frac{[A]_0}{2k}$
1	rate = $k[A]$	$\ln[A] = \ln[A]_0 - kt$	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$
2	rate = $k[A]^2$	$\frac{1}{[A]} = \frac{1}{[A]_0} + kt$	$t_{\frac{1}{2}} = \frac{1}{k[A]_0}$

## Henry's Law and Raoult's Law Units

$C_A$  = concentration of gas in solution ( $\frac{\text{mol}}{\text{L}}$ )

$k_A$  = Henry's law constant ( $\text{mol} \cdot \text{L}^{-1} \cdot \text{atm}^{-1}$ )

$H_A$  = Henry's law constant (atm)

$P_A$  = partial pressure of gas above solution (atm)

$x_A$  = mole fraction of solvent in solution

## Nernst Equation at 25°C

$$E = E^\circ - \left( \frac{0.0592}{n} \right) \log Q$$

Where  $n$  = number of moles of electrons transferred

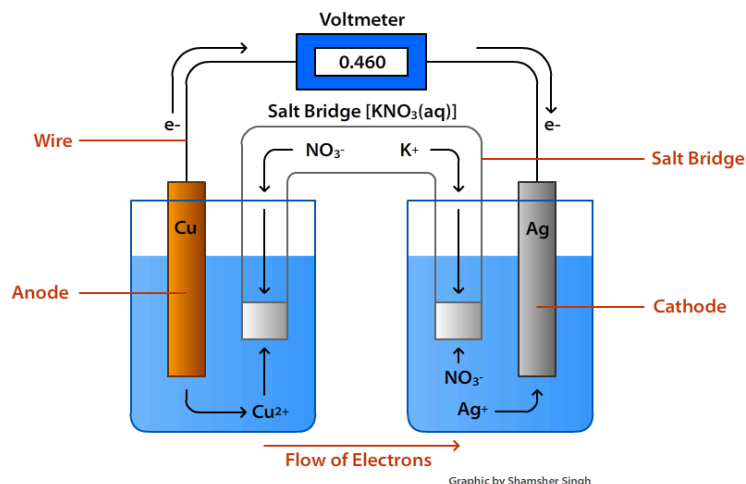
$E^\circ$  = standard cell potential (V)

$Q$  = reaction quotient

## Concentration Cells at 25°C

$$E = \left( \frac{0.0592}{n} \right) \log \left( \frac{C_{\text{low}}}{C_{\text{high}}} \right)$$

## Galvanic cell



Anode (oxidation): left side

Cathode (reduction): right side