

## CHE 111/112– Equations Sheet

### Chapter 5 – Gases

Pressure:  

$$P = \frac{F}{A} = \frac{m \times a}{A}$$

Gas Constant:  

$$R = \frac{8.314 \text{ J}}{\text{K} \cdot \text{mol}} = 0.08205 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

Dalton's Law:  

$$P_{\text{total}} = \sum P_i = P_1 + P_2 + P_3 \dots$$

$$P_1 = X_1 \cdot P_{\text{total}}$$

Graham's Law:  

$$\frac{\text{Rate}_1}{\text{Rate}_2} = \frac{\sqrt{m_2}}{\sqrt{m_1}} = \sqrt{\frac{m_2}{m_1}}$$

van der Waals Equation:  

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

Ideal Gas Law:  

$$PV = nRT$$

STP  
 (Standard Temperature and Pressure)  
 0°C and 1 atm

Kinetic-Molecular Theory:  

$$E_K = \frac{3RT}{2N_A} = \frac{1}{2}mu^2$$

Effusion:  

$$\frac{u_1}{u_2} = \frac{\sqrt{m_2}}{\sqrt{m_1}} = \sqrt{\frac{m_2}{m_1}}$$

Pascal Units:  

$$1 \text{ Pa} = \frac{\text{N}}{\text{m}^2} = \frac{\text{kg}}{\text{m} \cdot \text{s}^2}$$

Mole Fraction (X):  

$$\frac{\text{moles of component}}{\text{Total mols in mixture}}$$

Kinetic-Molecular Theory:  

$$u = \sqrt{\frac{3RT}{mN_A}} = \sqrt{\frac{3RT}{M}}$$

van der Waals Equation:  

$$P = \frac{nRT}{(v-nb)} - \frac{an^2}{v^2}$$

### Chapter 6 - Thermochemistry

Kinetic Energy  

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

Work (PV)  

$$w = -P\Delta V$$

Energy Transfer  

$$q_v = \Delta E \quad (\Delta V = 0)$$

$$q_p = \Delta E + P\Delta V = \Delta H \text{ (Constant P)}$$

Heating Curves  

$$q = ms\Delta T$$

Average Bond Dissociation Energies (D) (kJ/mol)												
H-H	436		C-H	410		N-H	390		O-H	460	F-F	159
H-C	410		C-C	350		N-C	300		O-C	350	Cl-Cl	243
H-F	570		C-F	450		N-F	270		O-F	180	Br-Br	193
H-Cl	432		C-Cl	330		N-Cl	200		O-Cl	200	I-I	151
H-Br	366		C-Br	270		N-Br	240		O-Br	210	S-F	310
H-I	298		C-I	240		N-I	-		O-I	220	S-Cl	250
H-N	390		C-N	300		N-N	240		O-N	200	S-Br	210
H-O	460		C-O	350		N-O	200		O-O	180	S-S	225
H-S	340		C-S	260		N-S	-		O-S	-		
<b>Multiple Covalent Bonds:</b>												
C=C	611		C≡C	835		C=O	732		O=O	498	N≡N	945

Speed of a Wave  

$$u = \lambda\nu$$

Balmer-Rydberg Equation II  

$$\nu = R \cdot c \left(\frac{1}{m^2} - \frac{1}{n^2}\right) \text{ with } n > m$$

Planck's Constant  

$$h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$$

### Chapter 7

Energy of a Wave  

$$E = h\nu$$

Rydberg Constant  

$$R = 1.097 \times 10^7 \text{ nm}^{-1}$$

De Broglie Equation  

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

Effective Nuclear Charge

Balmer-Rydberg Equation I  

$$\frac{1}{\lambda} = R \left(\frac{1}{m^2} - \frac{1}{n^2}\right) \text{ with } n > m$$

Speed of Light  

$$c = 3.00 \times 10^8 \text{ m/s}$$

Heisenberg Uncertainty Principle  

$$(\Delta x)(\Delta mv) \geq \frac{h}{4\pi}$$

$$Z_{eff} = Z_{actual} - \text{Electron Shielding}$$

**Chapter 8**

**Ionization Energy (kJ/mol)**

**Ionization Energy**  
( $E_{IE}$ )

	Na	Mg	Al	Si	P	S	Cl	Ar
1	496	738	578	787	1,012	1,000	1,251	1,520
2	4,562	1,451	1,817	1,577	1,903	2,251	2,297	2,665
3	6,912	7,733	2,745	3,231	2,912	3,361	3,822	3,931
4	9,543	10,510	11,575	4,356	4,956	4,564	5,158	5,770
5	13,353	13,630	14,380	16,091	6,273	7,013	6,540	7,238
6	16,610	17,995	18,376	19,784	22,233	8,495	9,458	8,781
7	20,114	21,703	23,293	23,783	25,397	27,106	11,020	11,995

**Lattice Energies (kJ/mol)**

Cation	Anion				
	F <sup>-</sup>	Cl <sup>-</sup>	Br <sup>-</sup>	O <sup>-</sup>	O <sup>-2</sup>
Li <sup>+</sup>	1,036	853	807	757	2,925
Na <sup>+</sup>	923	787	747	704	2,695
K <sup>+</sup>	821	715	682	649	2,360
Be <sup>+2</sup>	3,505	3,020	2,914	2,800	4,443
Mg <sup>+2</sup>	2,957	2,524	2,440	2,327	3,791
Ca <sup>+2</sup>	2,630	2,258	2,176	2,074	3,401
Al <sup>+3</sup>	2,515	5,492	5,361	5,218	1,5916

**Electron Affinity (kJ/mol)**

	Anion				
	F <sup>-</sup>	Cl <sup>-</sup>	Br <sup>-</sup>	O <sup>-</sup>	O <sup>-2</sup>
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**Chapter 11**

Clausius-Clapeyron Equation I

$$\ln P_{vap} = \left( -\frac{\Delta H_{vap}}{R} \right) \frac{1}{T} + C$$

Clausius-Clapeyron Equation II

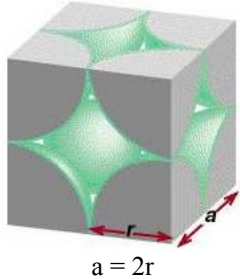
$$\ln P_2 = \ln P_1 + \left( \frac{\Delta H_{vap}}{R} \right) \left( \frac{1}{T_1} - \frac{1}{T_2} \right)$$

Calorimetry

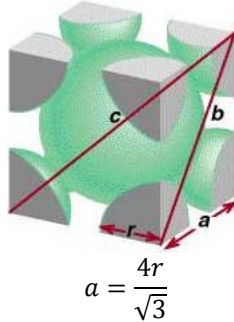
$$q = ms\Delta T$$

$$q = m\Delta H$$

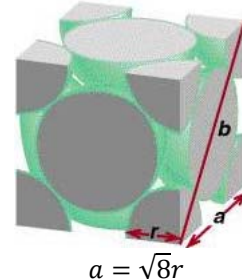
Simple Cubic Cell (SCC)



Body Cubic Cell (BCC)



Face Cubic Cell (FCC)



Bragg Equation

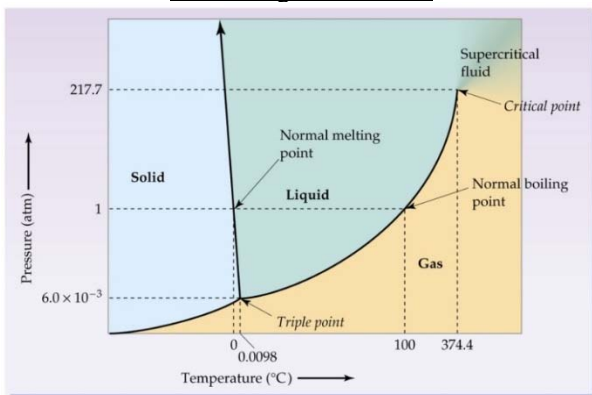
$$d = \frac{n\lambda}{2 \sin \theta}$$

Dipole Moments

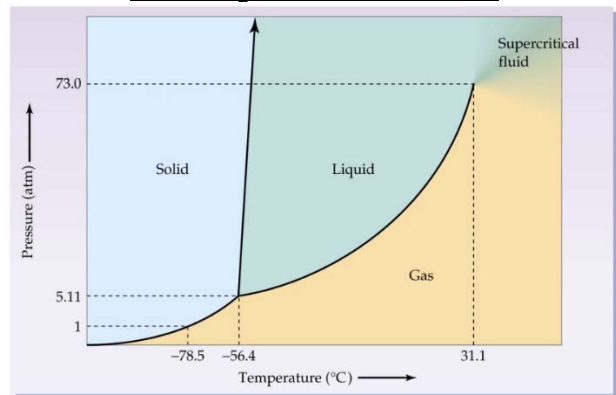
$$\mu = Q \times r$$

$$1 \text{ D} = 3.36 \times 10^{30} \text{ C} \cdot \text{m}$$

Phase Diagram of Water



Phase Diagram of Carbon Dioxide



## Chapter 12

Molarity (M):  
$$\frac{\text{mol solute}}{\text{L solution}}$$

Mass Percent (m/m):  
$$\frac{\text{Mass of component}}{\text{Total mass of solution}}$$

Henry's Law:  
$$\text{Solubility} = k \cdot P$$

Volatile Solute:  
$$P_{\text{Total}} = P_A + P_B$$
$$P_{\text{Total}} = (P_A^\circ \cdot X_A) + (P_B^\circ \cdot X_B)$$

Osmotic Pressure:  
$$\Pi = iMRT$$

Molality (m):  
$$\frac{\text{mols solute}}{\text{kg solvent}}$$

Part per million (ppm):  
$$\frac{\text{Mass of component}}{\text{Total mass of solution}} \times 10^6$$

Raoult's Law:  
$$P_{\text{soln}} = P_{\text{solvent}} \times X_{\text{solvent}}$$
$$\Delta P_{\text{soln}} = P_{\text{solvent}} \times X_{\text{solute}}$$

Boiling Point Elevation:  
$$\Delta T_B = imK_B$$

Mole Fraction(X):  
$$\frac{\text{moles solute}}{\text{moles solute} + \text{moles solvent}} = \frac{\text{mols solute}}{\text{mols solution}}$$

Part per billion (ppb):  
$$\frac{\text{Mass of component}}{\text{Total mass of solution}} \times 10^9$$

van't Hoff Factor:  
$$i = \frac{\text{mols of particle}}{\text{mols of solute dissolved}}$$

Freezing Point Depression:  
$$\Delta T_F = imK_F$$

## Chapter 13 and 14

0<sup>th</sup> Order Reaction  
$$[A]_t = -kt + [A]_0$$

Arrhenius Equation  
$$k = Ae^{-E_a/RT}$$
$$\ln k = \left(\frac{-E_a}{R}\right) \left(\frac{1}{T}\right) + \ln A$$
$$\ln\left(\frac{k_2}{k_1}\right) = \left(\frac{-E_a}{R}\right) \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

### 1<sup>st</sup> Order Reaction

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

Relationship  $k_p$  and  $k_c$   
$$k_p = k_c(RT)^{\Delta n}$$

### 2<sup>nd</sup> Order Reaction

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$$
$$t_{1/2} = \frac{1}{k[A]_0}$$

Quadratic Equation  
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

## Chapter 15 and 16

### Log Relationships

$$\text{pH} = -\log[\text{H}^+]$$
$$[\text{H}^+] = 10^{-\text{pH}}$$

### Dissociation of Water

$$\text{pH} + \text{pOH} = 14$$
$$[\text{H}^+][\text{OH}^-] = 1 \times 10^{-14}$$

### Henderson-Hasselbalch Equation

$$\text{pH} = \text{pK}_a + \log \frac{[\text{Base}]}{[\text{Acid}]}$$

## Chapter 17 - Thermodynamics

### Boltzmann Equation:

$$S = k \ln(W)$$
$$k = \frac{R}{N_a} = 1.38 \times 10^{-23} \text{ J/K}$$

### Entropy:

$$\Delta S_{Total}^{\circ} = \Delta S_{System}^{\circ} + \Delta S_{Surr}^{\circ}$$
$$\Delta S_{Surr}^{\circ} = \frac{-\Delta H^{\circ}}{T}$$

### Standard Change:

$$\Delta S^{\circ} = S_{\text{Prod}}^{\circ} - S_{\text{React}}^{\circ}$$
$$\Delta H^{\circ} = H_{\text{Prod}}^{\circ} - H_{\text{React}}^{\circ}$$
$$\Delta G^{\circ} = G_{\text{Prod}}^{\circ} - G_{\text{React}}^{\circ}$$

### Entropy and Expansion I:

$$\Delta S = n R \ln\left(\frac{V_f}{V_i}\right)$$

### Entropy and Expansion II:

$$\Delta S = n R \ln\left(\frac{P_i}{P_f}\right)$$

### Free Energy and Equilibrium

$$\Delta G^{\circ} = -RT \ln K_{eq}$$
$$K_{eq} = e^{-\frac{\Delta G^{\circ}}{RT}}$$

### Gibbs Free Energy:

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

### Equilibrium Temperature:

$$T = \frac{\Delta H}{\Delta S}$$

### Free Energy and Non-Equilibrium

$$\Delta G = \Delta G^{\circ} + RT \ln Q$$

## Chapter 18 - Electrochemistry

### Electromotive Force (EMF)

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

### Gibbs Free Energy and EMF

$$\Delta G = -nFE$$

### Conversion Factors:

$$1 \text{ Faraday (F)} = \frac{96,500 \text{ C}}{\text{mol } e^{-}}$$
$$1 \text{ F} = \frac{C}{A \cdot \text{sec}}$$

### Nernst Equation I (General):

$$E = E_{\text{cell}}^{\circ} - \frac{2.303RT}{nF} \log Q$$

### Units of Energy:

$$1 \text{ V} = \frac{1 \text{ J}}{1 \text{ C}}$$

### Watts:

$$1 \text{ Watt (W)} = \frac{1 \text{ J}}{\text{sec}}$$

### Nernst Equation I (STP):

$$E = E_{\text{cell}}^{\circ} - \frac{0.0592 \text{ V}}{n} \log Q$$

### Coloumbs:

$$C = \text{amp} \cdot \text{sec}$$

## Chapter 19 - Nuclear Chemistry

### Decay

$$\text{Decay Rate} = k \times N$$

$$\ln\left(\frac{N_t}{N_0}\right) = -kt$$

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

### Atomic Masses

$$\text{proton} = 1.00728 \text{ amu}$$

$$\text{neutron} = 1.00866 \text{ amu}$$

$$\text{electron} = 5.486 \times 10^{-4} \text{ amu}$$

### Conversion Factors

$$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$$

$$1 \text{ J} = \frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$$

$$1 \text{ g} = 6.022 \times 10^{23} \text{ amu}$$

### Einstein

$$E = mc^2$$

$$c = 3.00 \times 10^8 \text{ m/s}^2$$

### Units for Measuring Radiation

$$\text{Becquerel:} \quad 1 \text{ Bq} = 1 \text{ dis/s}$$

$$\text{Curie:} \quad 1 \text{ Ci} = 3.7 \times 10^{10} \text{ dis/s}$$

$$\text{Gray:} \quad 1 \text{ Gy} = 1 \text{ J/kg tissue}$$

$$\text{Rad:} \quad 1 \text{ Rad} = 0.01 \text{ Gy}$$

$$\text{Sievert:} \quad 1 \text{ Sv} = 1 \text{ J/kg tissue}$$

$$\text{Rem:} \quad 1 \text{ rem} = 0.01 \text{ Sv}$$