

NAME: \_\_\_\_\_

**GENERAL CHEMISTRY  
CHEM. 111 SEC. 001  
FINAL EXAM**

***These files are in Adobe Acrobat format, if you are using Netscape Navigator or Internet Explorer and have Adobe Acrobat Reader installed (If you do not; Acrobat Reader can be down loaded for free from Adobe) these files should open directly in your browser.***

**Spring, 2003**

Answer all the questions. DO NOT write on this examination paper; use the blank sheets at the end of the exam for your answers. Credit will not be given for numerical questions unless all relevant calculations are shown. Please give answers to numerical questions to three (3) significant figures.

1. (a) Arrange the following types of intermolecular forces in order of increasing strength.
- Ion-dipole
  - Dipole-Dipole
  - Hydrogen Bonding
  - London Dispersion
- 4 points
- (b) When trying to explain the relative order of boiling points and freezing points of materials, what are two factors that we consider?
- 2 points
- (c)
- i) Arrange the following compounds in the order you would think that their boiling points would be. (lowest first)
- $C_{10}H_{22}$
  - $C_2H_6$
  - $C_8H_{18}$
  - $C_4H_{10}$
- 2 points
- ii) Explain your order.
- 5 points
- (d)
- i) Arrange the following compounds in the order that you think their boiling points would be. (lowest first)
- $C_2H_5OH$
  - $C_3H_8$
  - $CH_3Cl$
  - $LiCl$
- 2 points

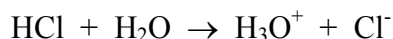
- ii) Explain your order. 5 points
- (e) Explain the source of the intermolecular force in: 5 points
- i) London Dispersion Interactions
- ii) Dipole – Dipole Interactions 5 points
2. (a) 40.71g of potassium sulfate are dissolved in water to produce 100mL of solution:
- i) Calculate the molarity of the solution
- ii) Calculate the molarity of the potassium ions 5 points
- (b) If the density of the solution is 1.216g.mL<sup>-1</sup>:
- i) Calculate the molality of the solution
- ii) Calculate the molality of the sulfate ions 5 points
- (c) Calculate the mole fraction of all species present in the solution. 5 points
3. (a) Ammonium Chloride when dissolved in water is an endothermic process.
- i) Will the solubility of ammonium chloride in water increase or decrease with temperature? 2 points
- ii) Explain your answer. 5 points
- (b) Write the base dissociation constant (equilibrium constant),  $k_b$ , for the following weak base.
- $$(\text{CH}_3)_3\text{N} + \text{H}_2\text{O} \leftrightarrow (\text{CH}_3)_3\text{NH}^+ + \text{OH}^-$$
- 2 Points
- (c) For the weak base in (b) above indicate:
- The acid
  - The base
  - The conjugate acid
  - The conjugate base
- 4 points
- based on the Brønsted-Lowry acid base concept 4 points

(d) Using the data provided at the end of the exam plus your general knowledge arrange the following acids in order of increasing strength.

- Benzoic acid (C<sub>6</sub>H<sub>5</sub>COOH)
- Formic acid (HCOOH)
- Hypochlorous acid (HOCl)
- Nitric acid (HNO<sub>3</sub>)

4 points

(e) For a solution of 0.0376M hydrochloric acid:



- Calculate the solution pH
- Calculate the solution pOH

5 points

(f) Calculate the concentration of hydronium and hydroxide ions in a solution of pOH = 10.4.

5 points

(g) Draw the pH scale.

2 points

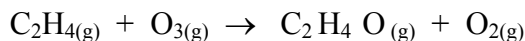
4. (a) The following represents the equilibrium reaction between nitrogen monoxide, oxygen and nitrogen dioxide:



A container is filled initially with NO and O<sub>2</sub>, each at a pressure of 1 atmosphere and allowed to come to equilibrium. If at equilibrium the pressure of O<sub>2</sub> is 0.506 atmospheres, calculate  $k_p$  for the reaction.

5 points

(b) The following data was obtained for the reaction:



<u>Time(s)</u>	<u>[O<sub>3</sub>](moles.L<sup>-1</sup>)</u>
0.0	3.20 x 10 <sup>-5</sup>
20.0	1.95 x 10 <sup>-5</sup>
40.0	1.40 x 10 <sup>-5</sup>
60.0	1.10 x 10 <sup>-5</sup>

- i) Calculate the average rate of reaction over the time period 20.0 – 40.0 seconds.  
5 points
- ii) Calculate the rate of reaction at exactly 30 seconds.  
5 points
- iii) If the reaction is first order, calculate the rate constant.  
5 points
- (c) At 27°C the enthalpy for a reaction is 55.0 kJ mole<sup>-1</sup> and the entropy is 20.55 J.mole<sup>-1</sup>.k<sup>-1</sup>. Is the reaction spontaneous or not?  
3 points
- (d) For the reaction:
- $$\text{KI}_{(s)} \rightarrow \text{K}^+ (\text{aq}) + \text{I}^- (\text{aq})$$
- i) Calculate  $\Delta H^\circ$  for the reaction  
ii) Calculate  $\Delta G^\circ$  for the reaction  
iii) Calculate  $\Delta S^\circ$  for the reaction  
5 points
- (e) 2.01g of a compound is dissolved in water to make 100mL of solution at 30°C. The osmotic pressure of the solution is 5.0 atmospheres. Calculate the molecular weight of the compound.  
3 points

## USEFUL INFORMATION

### Henry's Law

$$C = k.P$$

C = concentration

k = Henry's Law constant

P = Partial pressure of the gas

### Raoult's Law

$$P_{\text{soln}} = \chi_{\text{solv.}} \times P_{\text{solv.}}^{\circ}$$

$P_{\text{soln}}$  = Vapor pressure of solution

$\chi_{\text{solv.}}$  = Mole fraction of solvent

$P_{\text{solv.}}^{\circ}$  = Vapor pressure of pure solvent

### Osmotic Pressure

$$\Pi = MRT$$

$\Pi$  = Pressure

M = Molarity

R = 0.08206 L .atm. K.<sup>-1</sup> mole<sup>-1</sup>

T = Temperature K

### Freezing Point Depression

$$\Delta T = k_f m$$

### Activation Energy

$$k = Ae^{-\frac{E_a}{RT}} \text{ or } \log k = \log A - \frac{E_a}{2.303RT}$$

R = 8.314 J.mole<sup>-1</sup>.K<sup>-1</sup>

### pH

14 = pOH + pH

### Thermodynamics

$$\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$$

## ANSWERS

1. a) London dispersion, Dipole-Dipole, hydrogen bonding, Ion-dipole.  
b) Molecular weight and type of intermolecular forces.  
c)
    - i)  $C_2H_6$ ,  $C_4H_{18}$ ,  $C_{10}H_{22}$
    - ii) As the intermolecular forces in all the compounds are the same (London Dispersion) the boiling point will just depend on the molecular weight. Increasing molecular weight increasing boiling point.
  - d)
    - i)  $C_3H_8$ ,  $CH_3Cl$ ,  $C_2H_5OH$ ,  $LiCl$
    - ii) As these compounds have approximately the same molecular weight their boiling points will depend on the strength of these intermolecular forces.  $C_3H_8$  (London Dispersion),  $CH_3Cl$  (Dipole – Dipole),  $C_2H_5OH$  (hydrogen bonding).  $LiCl$  (ion – dipole).
  - e)
    - i) London Dispersion forces arise because of the distortion in the molecular orbital of a compound when two molecules approach one another. This causes a small induced dipole in the molecules which gives rise to a very small electrostatic attraction between the molecules.
    - ii) This arises in molecules that possess a dipole. The negative end of one molecule attracts the positive end of another molecule resulting in an electrostatic attraction.
2. a)
    - i) 2.34M
    - ii) 4.67M
  - b)
    - i) 1.92m
    - ii) 1.92m
  - c)  $\chi_{K^+} = 0.063$   
 $\chi_{SO_4^{2-}} = 0.031$   
 $\chi_{H_2O} = 0.906$
3. a)
    - i) Solubility will increase
    - ii) LeChatelier's principle is at play here. As the temperature rises, the system will try to oppose this temperature rise. If more ammonium chloride dissolves, this will tend to lower the temperature as this process is endothermic.
  - b)

$$k_b = \frac{[(\text{CH}_3)_3\text{NH}^+][\text{OH}^-]}{[(\text{CH}_3)_3\text{N}]}$$

c)

H<sub>2</sub>O – acid

(CH<sub>3</sub>)<sub>3</sub>N – base

(CH<sub>3</sub>)<sub>3</sub>NH<sup>+</sup> - conjugate acid

OH<sup>-</sup> - conjugate base

d) hydrochloric acid, benzoic acid, formic acid, nitric acid

e)

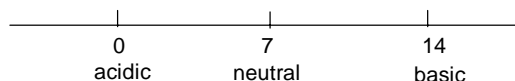
i) pH = 0.43

ii) pOH = 13.57

f) [H<sub>3</sub>O<sup>+</sup>] = 2.51 × 10<sup>-4</sup> M

[OH<sup>-</sup>] = 3.98 × 10<sup>-11</sup> M

g)



4. a)  $k_p = 3.4 \times 10^3$

b)

i)  $2.75 \times 10^{-7} \text{ moles} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$

ii)  $2.75 \times 10^{-7} \text{ moles} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$

iii)  $2.07 \times 10^{-2} \text{ sec}^{-1}$

c)  $\Delta G^\circ = 48.8 \text{ kJ} \cdot \text{mole}^{-1}$  as  $\Delta G^\circ$  is positive the reaction is non-spontaneous

d) i)  $20.55 \text{ kJ} \cdot \text{mole}^{-1}$

ii)  $-11.66 \text{ kJ} \cdot \text{mole}^{-1}$

iii)  $107.52 \text{ J} \cdot \text{K}^{-1} \cdot \text{mole}^{-1}$

e)  $100.5 \text{ g} \cdot \text{mole}^{-1}$