

Name: \_\_\_\_\_

**GENERAL CHEMISTRY  
CHEM. 111 SEC. 020**

**EXAM II**

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**2nd Summer Session, 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 3 significant figures.

1. a) Explain or define the following:

- i) Lattice Site
- ii) Unit Cell
- iii) Allotrope
- iv) Ionic Solid
- v) Molecular Solid

10 points

b) 36.1g of ethanol ( $C_2H_5OH$ ) at  $-117^\circ C$  (its freezing point) is heated to  $50^\circ C$ . Calculate the heat energy required for this process given heat of fusion of ethanol is  $40.5 kJ \cdot mole^{-1}$  and its heat capacity is  $2.465 \cdot g^{-1} \cdot ^\circ C^{-1}$ .

5 points

2. a) 67.21g of Iron(II) Sulfate are dissolved in 250g of water. Calculate:

- i) The molality of the solution.
- ii) The molality of Iron ions in solution.
- iii) The molality of Sulfate ions in solution.

10 points

b) 38.3g of methanol ( $CH_3OH$ ) are dissolved in 76.0g of water. Calculate the mole fraction of all components present in the solution.

10 points

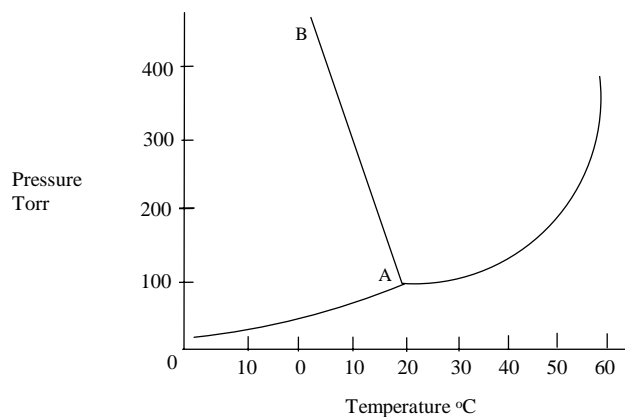
c) 105.1g of Calcium Chloride are dissolved in water to produce 270mL of solution. The density of the solution is  $1.231 g \cdot mL^{-1}$ . Calculate:

- i) The weight % of the solution.
- ii) The weight % of calcium ions in solution.
- iii) The weight % of chloride ions in solution.

10 points

3. a)
- i) Would you expect water and ethanol ( $C_2H_5OH$ ) to be miscible?  
1 point
  - ii) Explain your answer in (i) above.  
2 points
  - iii) Would you expect octane ( $C_8H_{18}$ ) and pentane ( $C_5H_{12}$ ) to be miscible?  
1 point
  - iv) Explain your answer in (iii) above.  
2 points
  - v) Would you expect water and nonanol ( $C_9H_{19}OH$ ) to be miscible?  
1 point
  - vi) Explain your answer in (v) above.  
3 points
  - vii) Would you expect potassium chloride to be miscible in water?  
1 point
  - viii) Explain your answer in (vii) above.  
2 points
- b) What is the difference between the terms liquid and solution?  
2 points
4. a) Calculate the vapor pressure at  $50^\circ C$  of a solution formed by dissolving 20.0mL of glycerol ( $C_3H_8O_3$ ) in 500.0 mL of water. Given the vapor pressure of water at  $50^\circ C$  is 92.5 Torr and the density of water and glycerol at  $50^\circ C$  are  $0.988g \cdot mL^{-1}$  and  $1.26g \cdot mL^{-1}$  respectively.  
10 points
- b) 0.2688g of a compound are dissolved in 100mLs of water (density  $1.00g \cdot mL^{-1}$ ) to produce a solution. The resultant solution freezes at  $-0.150^\circ C$ . Calculate the molecular weight of the compound given  $K_f$  for water is  $1.86^\circ C \cdot m^{-1}$ .  
10 points
- c) 14.71g of magnesium nitrate are dissolved in water to produce 150mL of solution. Calculate the osmotic pressure of the solution.  
10 points

5. The following is the phase diagram for a compound:



- i) At what temperature and pressure will the compound exist as a gas/liquid/solid equilibrium? 2 points
- ii) At an external pressure of 300 Torr, at what temperature will the compound boil? 2 points
- iii) At pressure of 200 Torr at what temperature will the compound freeze? 2 points
- iv) In what phase will the compound exist at a temperature of 60°C and a pressure of 100 Torr? 2 points
- v) What does the line AB represent? 2 points

### **EXTRA CREDIT**

In question 4b, if the compound was one of the following. Determine which compound and explain your choice for credit.

5 points

- i) Potassium Permanganate
- ii) Ethanol ( $C_2H_5OH$ )
- iii) Aluminium Chloride
- iv) Calcium nitrate

## USEFUL INFORMATION

### Dipole Movement

$$\mu = Qr$$

$\mu$  = dipole moment

Q = charge on the atoms

r = distance between charges on atoms (bond length)

absolute charge on e =  $1.60218 \times 10^{-19}$  C (Coulombs)

1 Debye =  $3.34 \times 10^{-30}$  C.m.

### Raoult's Law

$$P_{\text{solution}} = P_{\text{solvent}}^{\circ} \times X_{\text{solvent}}$$

### Freezing Point Depression

$$\Delta T = K_f m$$

$K_f$  water =  $1.86^{\circ}\text{C}\cdot\text{m}^{-1}$

### Osmotic Pressure

$$\Pi = M R T$$

$\Pi$  = Osmotic Pressure

R = Gas Constant =  $0.0821\text{.ats.L.mole}^{-1}\cdot\text{k}^{-1}$

T = Temperature K

M = Molarity

## ANSWERS

1. a)
  - i) This is the location in a crystalline structure that is occupied by an ion, atom or molecule.
  - ii) This is the basic three dimensional unit which is repeated throughout the crystal structure to produce the crystalline solid.
  - iii) These are different crystalline structures that have identical chemical compositions.
  - iv) These are crystalline materials in which the lattice sites are occupied by ions.
  - v) These are crystalline materials in which the lattice sites are occupied by molecules.
- b) 46.6kJ
2. a)
  - i) 1.77m
  - ii)  $[\text{Fe}^{2+}] = 1.77\text{m}$
  - iii)  $[\text{SO}_4^{2-}] = 1.77\text{m}$
- b)  $X_{\text{CH}_3\text{OH}} = 0.220$   
 $X_{\text{H}_2\text{O}} = 0.780$
- c)
  - i) 31.6%
  - ii) 11.4%
  - iii) 20.2%
3. a)
  - i) Miscible
  - ii) Water and ethanol have similar forces of interaction – hydrogen bonding.
  - iii) Miscible
  - iv) Octane and pentane have similar forces of interaction London Dispersion Forces
  - v) Immiscible
  - vi) While at first glance both appear to have similar forces of interaction – hydrogen bonding this is not the whole story. In nonanol the hydrogen bonding is very weak and the bulk of the molecule consists of  $\text{C}_9\text{H}_{19}$  in which the only forces of interaction are London Dispersion. It is this part of the molecule that is important in determining miscibility. Clearly water and nonanol do not really have similar forces of interactions and structure
  - vii) Miscible

viii) Potassium chloride is ionic and dissolves in water as we have ion-dipole interactions between water and ions.

b) A liquid generally refers to a pure material a solution is a mixture of two or more materials.

4. a) 91.6 Torr

b)  $33.3 \text{ g} \cdot \text{mole}^{-1}$

c) 48.3 ats

5.

i) ~100 Torr and  $18^\circ\text{C}$

ii)  $\sim 57^\circ\text{C}$

iii)  $\sim 13^\circ\text{C}$

iv) Gas

v) Equilibrium conditions for the solid/liquid phase

### EXTRA CREDIT

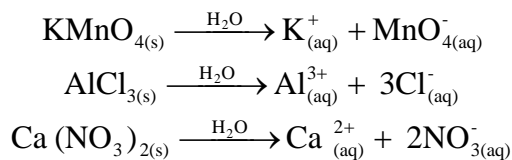
$$\text{KMnO}_4 \text{ mol. wt.} = 158.0 \text{g.mole}^{-1}$$

$$\text{C}_2\text{H}_5\text{OH mol. wt.} = 46.07 \text{g.mole}^{-1}$$

$$\text{AlCl}_3 \text{ mol. wt.} = 133.3 \text{g.mole}^{-1}$$

$$\text{Ca}(\text{NO}_3)_2 \text{ mol. wt.} = 164.1 \text{g.mole}^{-1}$$

Looking at the molecular weight none seem to match. However, three of the compounds are ionic and will dissolve in solution.



This means the effective ‘molecular weight ‘ will be for:

$$\text{kMnO}_4 \frac{158}{2} = 79$$

$$\text{AlCl}_3 \frac{133.3}{4} = 33.3$$

$$\text{Ca}(\text{NO}_3)_2 \frac{164.1}{3} = 54.7$$

Therefore compound in  $\text{AlCl}_3$