

NAME: _____

**GENERAL CHEMISTRY
CHEM. 111 SEC. 003
FINAL EXAM**

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Spring Semester 2004

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 problems unless all relevant calculations are shown. Please give answers to numerical questions to three (3) significant figures.

1. a) Explain, define or describe as appropriate the following terms:

- i) pH
- ii) Activation energy
- iii) Lattice site
- iv) Dynamic equilibrium
- v) Le Châtelier's principle
- vi) Weak acid/base
- vii) Temperature
- viii) Allotrope
- ix) Miscible
- x) Solubility

20 points

2. a) 0.1293g of magnesium sulfate are dissolved in water to produce 200mLs of solution. Calculate:

- i) the concentration of magnesium ions in solution in ppm (parts per million).
- ii) the concentration of sulfate ions in solution in ppm (parts per million).

6 points

b) 2.192g of barium nitrate are dissolved in water to produce 150mLs of solution. Calculate:

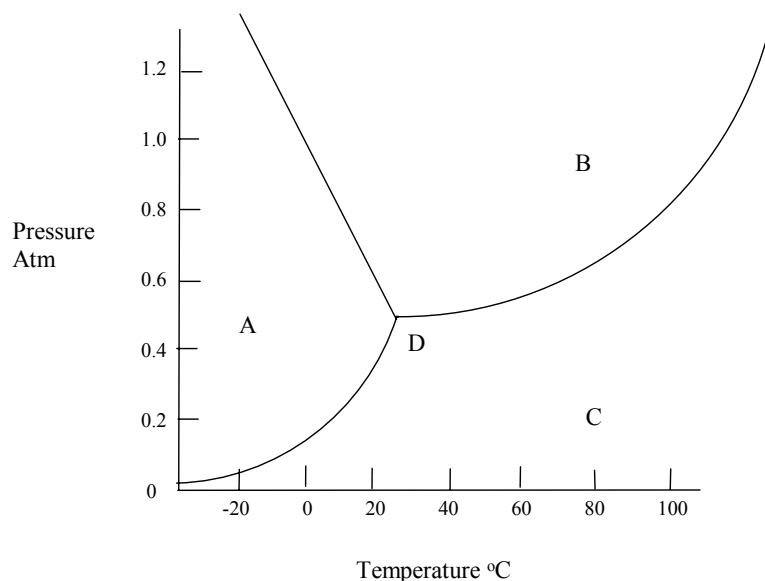
- i) the molarity of the solution.
- ii) the molarity of the barium ions in solution.
- iii) the molarity of the nitrate ions in solution.

8 points

c) 15.613g of copper(II) bromide are dissolved in water to produce 100mLs of solution. If the density of the solution is 1.056g.mL^{-1} . Calculate the mole fraction of all species present in solution.

6 points

3. a) For the following phase diagram of a compound X:



- i) What phases are present at A, B, C and D? 4 points
- ii) At a pressure of 0.8atm, at what temperature will X boil? 1 point
- iii) If I keep the temperature constant at 0°C and increase the pressure from 0.20atm to 1.2atm, at what pressure will X sublime and at what temperature will X melt? 2 points
- b) 1.27g of an unknown compound are dissolved in 200g of water to form a solution. The resulting solution freezes at -0.05°C and pure water freezes at 0°C. Given the freezing point depression constant (K_f) of water is 1.80 °C.m⁻¹. Calculate the molecular weight of the unknown compound. 6 points
- c) If the real molecular weight of the unknown compound in 3(b) is 118g.mole⁻¹, explain your answer obtained in 3(b). 2 points
4. a) 3.71g of nitric acid (HNO₃) are dissolved in water to produce 250mLs of solution. Calculate:
- i) the pH of the solution. 5 points
- ii) the pOH of the solution. 1 point

b) The pH of a solution is 3.7. Calculate:

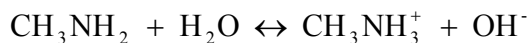
i) the hydronium ion concentration of the solution.

2 points

ii) the hydroxide ion concentration of the solution.

2 points

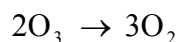
c) For the following reaction, what is the Brønsted-Lowery?



- i) Acid ii) Base
iii) Conjugate acid iv) Conjugate base

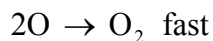
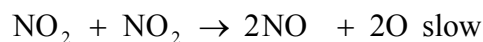
4 points

5. a) If the following reaction is first order, write the rate expression for the reaction:



2 points

b) The mechanism for a reaction is:



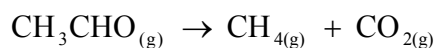
i) Write the rate expression of the reaction.

2 points

ii) What is the order of this reaction?

1 point

c) The following data were obtained for the reaction:



<u>Rate Constant (k)</u>	<u>T (C°)</u>
0.011	427
0.035	457
0.105	487
0.343	517
0.789	537

Calculate the activation energy of the reaction.

5 points

6. a) Explain the following:

i) London dispersion forces

2 points

ii) Dipole – Dipole forces

2 points

iii) Hydrogen bonding

2 points

iv) Ion – Dipole interaction

2 points

b) Explain the melting points of the following compounds:

<u>Compound</u>	<u>Melting Point (°C)</u>
Ne	-248
H ₂ O	0
NaCl	801
HCl	-115

5 points

7. a) Calculate how much heat energy is required to convert 100g of ice at 0°C to steam (gas) at 100°C. Given the heat of fusion of water is 6.01kJ.mole⁻¹, heat of vaporizing water at 100°C is 40.79kJ.mole⁻¹ and the heat capacity of water is 4.18J.g⁻¹.°C⁻¹.

4 points

b) Lead(II) chloride is a sparingly soluble material. Calculate the equilibrium concentration of lead ions and chloride ions in water.

4 points

USEFUL INFORMATION

Henry's Law

$$C_{(g)} = k_H P_{(g)}$$

Roault's Law

$$P_{\text{soln}} = X_{\text{soln}} P^{\circ}_{\text{solvent}}$$

Depression of Freezing Point

$$\Delta T = k_f m$$

Elevation of Boiling Point

$$\Delta T = k_b m$$

Osmotic Pressure

$$\Pi = MRT$$

Π = Pressure

M = Molarity

R = 0.08206 L .atm. K.⁻¹ mole⁻¹

T = Temperature K

Activation Energy

$$\log k = \log A - \frac{E_a}{2.303RT}$$

ANSWERS

1. a)
- i) $\text{pH} = -\log [\text{H}_3\text{O}^+]$
 - ii) Activation energy is the energy barrier that reactants have to overcome to form a transition state before going to products.
 - iii) Lattice site is the position in a crystal occupied by a molecule, atoms, or ion.
 - iv) A dynamic equilibrium is a system in which on the macro scale appears static but on the molecular scale is undergoing constant change.
 - v) Le Châtelier's principle states that any system in dynamic equilibrium will move in a direction to oppose any constraint placed on it.
 - vi) Weak acid/base is any acid or base that does not totally dissociate in solution.
 - vii) Temperature is a measure of the average kinetic energy of atoms or molecules.
 - viii) These are materials that are chemically identical but have different crystal structures.
 - ix) Miscible is when a material will completely dissolve in another material.
 - x) Solubility is a measure of how much solute will dissolve in a given amount of solvent.
2. a) $[\text{Mg}^{2+}] = 130 \text{ ppm}$
 $[\text{SO}_4^{2-}] = 516 \text{ ppm}$
- b)
- i) 0.0559M
 - ii) $[\text{Ba}^{2+}] = 0.0559\text{M}$
 - iii) $[\text{NO}_3^-] = 0.112\text{M}$
- c) $\chi_{\text{Ca}^{2+}} = 0.0134$
 $\chi_{\text{Br}^-} = 0.0269$
 $\chi_{\text{H}_2\text{O}} = 0.960$

3. a)
- i) A Solid
 - B Liquid
 - C Gas
 - D Solid – Liquid – Gas
- ii) $\sim 95^{\circ}\text{C}$
- iii) $\sim 0.15\text{atm}$
- b) Mol. Wt. = 229
- c) Compound must be partially dissociated.
4. a) pH = 0.630
pOH = 13.4
- b)
- i) $[\text{H}_3\text{O}^+] = 1.99 \times 10^{-4}$
 - ii) $[\text{OH}^-] = 5.01 \times 10^{-11}$
- c)
- i) H_2O
 - ii) CH_3NH_2
 - iii) CH_3NH_3^+
 - iv) OH^-
5. a) Rate = $k [\text{O}_3]$
- b)
- i) Rate = $k [\text{NO}_2]^2$
 - ii) 2
- c) $182.\text{kJ.mole}^{-1}$
6. a)
- i) London Dispersion forces arise because of the small induced dipole that occurs when two atoms or molecules come very close together and their respective electron clouds are distorted. This occurs in all atoms and molecules and is electrostatic in nature.
 - ii) Dipole – Dipole interactions occur in polar molecules. The permanent dipole in the molecule causes an attraction between the molecules and is electrostatic in nature.
 - iii) Hydrogen bonding occurs in molecules when hydrogen is bonded to a small very electronegative atom like N, O, F.

iv) This type of interaction occurs between a polar molecule and an ion and is electrostatic in nature.

b)	<u>Compound</u>	<u>Mol. Wt.</u>	<u>Melting Point °C</u>
	Ne	20.18	-248
	H ₂ O	18.02	0
	NaCl	58.44	801
	HCl	36.46	-115

Neon has London dispersion forces and has the lowest melting point as London dispersion forces are the weakest forces. Water and neon have ~ same molecular weight but water has hydrogen bonding which is a quite strong force of interaction and therefore has a much higher melting point than neon. Sodium chloride has the highest molecular weight and has very strong ion-ion interactions which give it a very high melting point. Hydrogen chloride has a higher molecular weight than Neon or Water but only relatively weak dipole-dipole interactions hence its melting point is much higher than Neon but lower than water.

7. a) 301.5kJ

b) $[\text{Pb}^{2+}] = 1.59 \times 10^{-2}\text{M}$

$[\text{Cl}^-] = 3.17 \times 10^{-2}\text{M}$