UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, MAY 2019

COURSE NO: MN/GL/PE/ES 154 **COURSE NAME**: Physical and Analytical Chemistry

CLASS: **MN/GL/PE/ES I** **TIME: 3 HOURS**

Name**:** _____Index Number: _____

Answer Question 1 and Any Other Four

Question 1

a. Define the following terms;

i. Sample
ii. Precipitant
iii. Mother liquor
iv. Supernatant liquid
v. Aliquot
vi. Analyte
vii. Absorbance
viii. Transmittance **4 marks**

b. What are the characteristics of a sample? **1 mark**

c. A solution containing 4.5 M of a coloured species has an absorbance of 0.3 in a 2 cm cell. Calculate its molar absorptivity. **3 marks**

d. 0.2000 g sample of a metal alloy is dissolved and the tin is reduced to tin (II). Titration of tin (II) requires 22.30 mL of 0.1000 M $K_2Cr_2O_7$. Calculate the percentage of tin in the alloy [Sn = 59.35] $K_2Cr_2O_7 + Sn^{2+} \rightarrow SnCr_2O_7 + 2K^+$ **3 marks**

e. A 2.50 g sample of a fertilizer was dissolved in water. Barium sulphate was precipitated by adding barium chloride solution. The relevant equation is

$$Ba^{2+}\,(aq) + SO_4^{2+}\,(aq) \rightarrow BaSO_4\,(s)$$

The precipitate was filtered, washed, dried and had a mass of 0.566 g.

i. Calculate the number of moles of barium sulphate precipitated
ii. Calculate the mass of sulphate in the sample of fertilizer
iii. What is the percentage of sulphate in the fertilizer? **6 marks**

f. List 3 types of impurities in precipitation. **3 marks**

Question 2

a. List the four types of quantum numbers and comment on the significance of each.

2 marks

b. Provide the possible values for the following quantum numbers for electrons in n= 3

i. ℓ

ii. m_s

iii. m_l **3 marks**

c. A σ bond is said to be symmetric with respect to the inter-nuclear axis. Is the same true of a π bond? Justify your answer. **2 marks**

d. Consider an ionic compound MX_2 where M is a metal that forms a cation of +2 charge, and X is a non-metal that forms an anion of –1 charge. Use the following energy values tocalculate the lattice energy (in kJ/mol) for MX_2.

ΔH^o_{sub}= 296 kJ/mol;	ΔH^o_f = -421 kJ/mol;
1^{st} ionization energy = 378 kJ/mol;	2^{nd} ionization energy = 555 kJ/mol;
bond dissociation enthalpy = 310 kJ/mol;	electron affinity = -427 kJ/mol.

3 marks

Question 3

a. Identify 3 factors that affect the solubility of a liquid. **1.5 marks**

b. Differentiate between the following terms;

i. Cohesive force and adhesive force

ii. Surface tension and capillary action

iii. Absolute viscosity and kinematic viscosity

iv. Wetting liquid and non-wetting liquid **2 marks**

c. State and explain the three types of wetting **1.5 marks**

d. A particular balloon is designed by its manufacturer to be inflated to a volume of no more than 2.5 L. If the balloon is filled with 2.0 L of helium at sea level, is released, and rises to

an altitude at which the atmospheric pressure is only 500 mmHg, will the balloon burst? (Assume temperature is constant.) **2 marks**

e. Consider the following chemical equation.

$$2NO_2(g) \rightarrow N_2O_4(g)$$

If 25.0 mL of NO_2 gas is completely converted to N_2O_4 gas under the same conditions, what volume will the N_2O_4 occupy? **1 mark**

f. One litre of solution was prepared containing 0.00408 mole of $Pb(NO_3)_2$. To this solution was added 0.0105 mole of NH_4Cl. Given that K_{sp} for $PbCl_2$ is equal to 2.4×10^{-4}, determine whether or not $PbCl_2$ will precipitate from the solution. **2 marks**

Question 4

a. Define the following and give an example each

i. Open system
ii. Closed system
iii. Isolated system **0.5 mark for each**

b. Differentiate between Enthalpy and entropy **1 mark**

c. The combination of hydrogen gas and oxygen gas to give water vapour can be expressed by $2H_{2(g)} + O_{2(g)} \leftrightarrow 2H_2O_{(g)}$ $\Delta H = -484$ kJ

Predict the effect of each of the following changes to the system on the direction of equilibrium.

i. H_2O is removed as it is being generated
ii. The system is cooled **1 mark**

d. When solid potassium hydroxide pellets are added to water, the following reaction takes place: $NaOH_{(s)} \rightarrow NaOH_{(aq)}$

For this reaction at constant pressure, $\Delta H = -43$ kJ/mol. Answer the following questions regarding the addition of 14 g of NaOH to water:

i. Does the beaker get warmer or colder?
ii. Is the reaction exo- or endothermic?

iii. What is the enthalpy change for the dissolution? **1.5 marks**

e. Consider the reaction $2POCl_3(g) \rightarrow 2PCl_3(g) + O_2(g)$

i. Calculate $\Delta G°$ for this reaction. The $\Delta G°_f$ values for $POCl_3(g)$ and $PCl_3(g)$ are -502 kJ mol^{-1} and -270 kJ mol^{-1}, respectively.
ii. Is this reaction feasible under standard conditions at 298 K?
iii. The value of $\Delta S°$ for this reaction is 179 J K^{-1} mol^{-1}. At what temperatures is this reaction spontaneous at standard conditions? Assume that $\Delta H°$ and $\Delta S°$ do not depend on temperature. **3 marks**

f. Given the following reactions and ΔH values,

a. $B_2O_{3(s)} + 3H_2O_{(g)} \rightarrow B_2H_{6(g)} + 3O_{2(g)}$ $\Delta H = +2035$ kJ

b. $2H_2O_{(l)} \rightarrow 2H_2O_{(g)}$ $\Delta H = +88$ kJ

c. $H_{2(g)} + ½O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H = -286$ kJ

d. $2B_{(s)} + 3H2(g) \rightarrow B_2H_{6(g)}$ $\Delta H = +36$ kJ

Calculate ΔH for $2B_{(s)} + 3/2O2_{(g)} \rightarrow B_2O_{3(s)}$ **2 marks**

Question 5

a. Define the following;

i. mole fraction
ii. molarity
iii. molality **0.5 mark each**

b. A patient has a cholesterol count of 986 mg/dL. What is the molarity of cholesterol in this patient's blood if the molecular mass of cholesterol is 386.64 g/mol? (1 L = 10 dL)

1.5 marks

c. A solution of density 0.903 g/mL contains 0.255 mol of an organic compound (solute) (Molar mass of organic compound = 165 g/mL) in 298 g of benzene (solvent). Calculate:

i. molarity
ii. molality **2 marks**

d. How would you prepare 200 mL of 6 M H_2SO_4 solution from a stock solution that is 36% and has a specific gravity of 3.14? **2 marks**

e. A solution of density 0.903 g/mL contains 0.255 mol of an organic compound (solute) (Molar mass of organic compound = 165 g/mol) in 298 g of benzene (solvent). Calculate its molarity and its molality. **3 marks**

Question 6

a. What is solubility? **0.5 mark**

b. State the factors that affect solubility? **1.5 marks**

c. What is solubility product? **0.5 mark**

d. What is ion activity product? **0.5 mark**

e. What is the relationship between solubility and ion activity product? **1 mark**

f. What is the difference between activity and fugacity? **2 marks**

g. The solubility product of anhydrite ($CaSO_4$) is 4.2×10^{-5} mol^2 L^{-2} and the of fluorite (CaF2) is 3.89×10^{-11} mol^3 L^{-3}. What is the solubility for each compound in water? **4 marks**

Question 7

a. What is kinetics? **(0.5 mark)**

b. What factors affect the rate of reaction? **(2 marks)**

c. What is the order of a reaction? **(0.5 mark)**

d. What is integrated rate of equation? **(0.5 mark)**

e. What is the relationship between equilibrium constant and rate constant? **(1 mark)**

f. State the relationship between half-life and order of reaction for 1^{st} order and 2^{nd} order reactions. **(2 marks)**

g. Derive the integrated rate equation for 1^{st} and 2^{nd} order reactions. **(2 marks)**

h. What is activation energy? **(0.5 mark)**

i. What is a catalyst and how does it affect the rate of a reaction? **(1 mark)**