



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

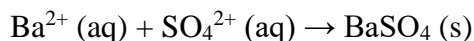
TIME: 3 HOURS

Name: _____ Index Number: _____

Answer Question 1 and Any Other Four

Question 1

- a. Define the following terms;
- Sample
 - Precipitant
 - Mother liquor
 - Supernatant liquid
 - Aliquot
 - Analyte
 - Absorbance
 - Transmittance
- 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



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

- Calculate the number of moles of barium sulphate precipitated
- Calculate the mass of sulphate in the sample of fertilizer
- 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 to calculate the lattice energy (in kJ/mol) for MX_2 .

$$\Delta H_{\text{sub}}^{\circ} = 296 \text{ kJ/mol};$$

$$1^{\text{st}} \text{ ionization energy} = 378 \text{ kJ/mol};$$

$$\text{bond dissociation enthalpy} = 310 \text{ kJ/mol};$$

$$\Delta H_{\text{f}}^{\circ} = -421 \text{ kJ/mol};$$

$$2^{\text{nd}} \text{ ionization energy} = 555 \text{ kJ/mol};$$

$$\text{electron affinity} = -427 \text{ kJ/mol}.$$

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

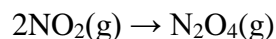
- c. State and explain the three types of wetting

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.



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 $\text{Pb}(\text{NO}_3)_2$. 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

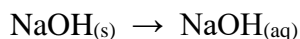
c. The combination of hydrogen gas and oxygen gas to give water vapour can be expressed by $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \leftrightarrow 2\text{H}_2\text{O}(\text{g})$ $\Delta\text{H} = -484 \text{ kJ}$

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:



For this reaction at constant pressure, $\Delta\text{H} = -43 \text{ kJ/mol}$. 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?

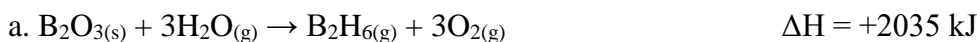
1.5 marks

e. Consider the reaction $2\text{POCl}_3(\text{g}) \rightarrow 2\text{PCl}_3(\text{g}) + \text{O}_2(\text{g})$

- i. Calculate ΔG° for this reaction. The ΔG°_f values for $\text{POCl}_3(\text{g})$ and $\text{PCl}_3(\text{g})$ 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 ΔS° for this reaction is $179 \text{ J K}^{-1} \text{ mol}^{-1}$. At what temperatures is this reaction spontaneous at standard conditions? Assume that ΔH° and ΔS° do not depend on temperature.

3 marks

f. Given the following reactions and ΔH values,



Calculate ΔH for $2\text{B}(\text{s}) + \frac{3}{2}\text{O}_2(\text{g}) \rightarrow \text{B}_2\text{O}_3(\text{s})$

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/mol) 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 $4.2 \times 10^{-5} \text{ mol}^2 \text{ L}^{-2}$ and the of fluorite (CaF_2) is $3.89 \times 10^{-11} \text{ mol}^3 \text{ L}^{-3}$. 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 1st order and 2nd order reactions. **(2 marks)**
- g. Derive the integrated rate equation for 1st and 2nd 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)