

# CATHOLIC UNIVERSITY OF EASTERN AFRICA

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**SPECIAL/SUPPLEMENTARY EXAMINATION**

**JANUARY – APRIL 2020 TRIMESTER**

**FACULTY OF SCIENCE**

**DEPARTMENT OF NATURAL SCIENCE (CHEMISTRY)**

**REGULAR PROGRAMME**

**CHEM 102: PHYSICAL CHEMISTRY I**

**Date: APRIL 2020**

**Duration: 2 Hours**

**INSTRUCTIONS: Answer Question ONE and ANY OTHER TWO Questions**

### Data

$$R = 0.0821 \text{ Latm mol}^{-1} \text{ or } 8.314 \text{ Jmol}^{-1} \text{K}^{-1}$$

$$1 \text{ atm} = 760 \text{ mmHg}$$

$$0^\circ\text{C} = 273 \text{ K}$$

- Q1. a) An aqueous solution containing 1.00 g of compound P in 100.0g water was found to have a freezing point of  $-0.102^\circ\text{C}$
- i) Determine the molar mass of P **(8 marks)**
  - ii) Elemental analysis of compound P showed that it consists of 39.55% C, 7.75% H and 52.7% O by mass. Determine the molecular formula of P. **(3 marks)**
- b) i) State five assumptions of the kinetic molecular theory of gases. **(5 marks)**
- ii) Describe how the kinetic molecular theory of gases explains Charles and Boyle's laws. **(4 marks)**
- c) Consider the following general gas phase reaction.



Where c, d, m and n represent the reacting mole ratios of gases C, D, M and N respectively.

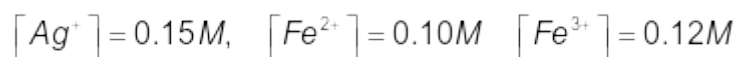
Derive the relationship between the partial pressure equilibrium constant  $K_p$  and the concentration equilibrium constant  $K_c$ . **(4 marks)**

- d) 0.250 mol  $SO_{2(g)}$  and 0.300 mol  $O_{2(g)}$  reacts at 500K in a 2.0L vessel to form 0.160 mol  $SO_{3(g)}$  at equilibrium. Determine  $K_c$  at 500K for the reaction
- $$2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$$
- (6 marks)**

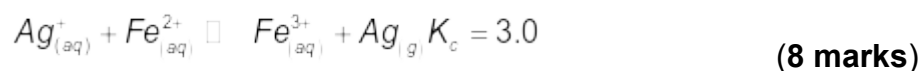
- Q2. a) An ethanol water solution was made by dissolving 25.0 mL of ethanol ( $C_2H_5OH$   $d = 0.789g/mL$ ), in sufficient volume of water to produce 500.0 mL of a solution with a density of 0.982g/mL. **What** is the concentration of ethanol in this solution expressed as:

- Mass percent
- Mole fraction
- Molarity
- Molality ( $C_2H_5OH = 46.07$ ,  $H_2 = 18.02$ ) **(10 marks)**

- b) i) State Le chatelier's principle. **(2 marks)**  
 ii) Solid silver was added to a solution with the following concentrations.



Determine the direction of the reaction and the concentrations of all species at equilibrium.



- Q3. a) i) Define a buffer **(2 marks)**

- ii) Calculate the pH of a buffer made from 0.24M  $\text{NH}_3$  and 0.20M  $\text{NH}_4\text{Cl}$   
 $K_b = 1.8 \times 10^{-5}$  (5 marks)
- iii) Suppose 0.001 mol  $\text{NaOH}$  is added to 1.0 L of the solution in (ii) above, what will be the pH of the resulting solution? (5 marks)
- b) Calculate the molecular mass of a liquid that, when vaporized at  $100^\circ\text{C}$  and 755 torr, yield 185 mL of vapour with a mass of 0.523 g. (4 marks)
- c) Under what conditions do the properties of real gases differ substantially from those of ideal gases? (4 marks)
- Q4. a) A sample of an unknown gas was found to have a density of 5.38g/L at  $15^\circ\text{C}$  and 736 mmHg. Determine its molar mass. (5 marks)
- b) Use a phase diagram to show the difference in freezing and boiling points of sucrose solution and water. In the diagram label all the phases, and triple points. (8 marks)
- c) What is the vapor pressure (in mmHg) of a solution prepared by dissolving 5.00 g of benzoic acid ( $\text{C}_7\text{H}_6\text{O}_2$ ) in 100.0g of ethyl alcohol ( $\text{C}_2\text{H}_6\text{O}$ ) at  $35^\circ\text{C}$ ? The vapor pressure of ethyl alcohol at  $35^\circ\text{C}$  is 100.5 mmHg. (7 marks)
- Q5. a) The total concentration of dissolved particles inside red blood cell is 0.30M, and the membrane surrounding the cells is semi permeable. What would the osmotic pressure (in atm) inside the cells become if the cells were removed from blood plasma and placed in pure water at 298k? (5 marks)
- b) Oxalic acid ( $\text{H}_2\text{C}_2\text{O}_4$ ) is a diprotic acid that occurs in plants such as spinach. Calculate the pH, and the concentration of  $\text{C}_2\text{O}_4^{2-}$  ions in 0.20M  $\text{H}_2\text{C}_2\text{O}_4$  ( $K_{a1} = 5.9 \times 10^{-2}$ ,  $K_{a2} = 6.4 \times 10^{-5}$ ) (10 marks)

- c) Methanol (CH<sub>3</sub>OH) is manufactured by reaction of carbon monoxide with hydrogen in the presence of **Zno**/Cr<sub>2</sub>O<sub>3</sub> catalyst as shown below:



Explain how the changes in the following parameters affects the yield of methanol:

- i) Temperature is increased
- ii) Volume is decreased
- iii) Helium is added
- iv) CO is added
- v) Catalyst is removed.

**(5 marks)**

**\*END\***