



THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

A. M. E. C. E. A

MAIN EXAMINATION

MAY – JULY 2015 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

CHEM 102: PHYSICAL CHEMISTRY I

SCHOOL FOCUSED PROGRAMME

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Date: JULY 2015

Duration: 2 Hours

INSTRUCTIONS: Answer Question ONE and ANY OTHER TWO Questions

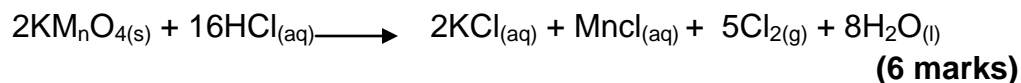
Useful information

$R = 0.0821, \text{ L atm mol}^{-1} \text{ or } 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

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

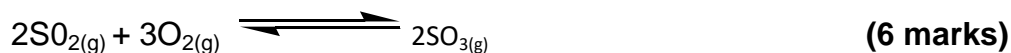
$1 \text{ atm} = 760 \text{ mmHg}$

- Q1. a) State the Boyle's and Charles law of gases and use them to derive the ideal gas equation. **(6 marks)**
- b) State FOUR basic assumptions of the kinetic theory of gases. **(4 marks)**
- c) How many litres of chlorine gas, Cl_2 can be obtained at 40°C and 787 mmHg from 9.41g of hydrogen chloride HCl, according to the following equation.



- d) 100ml of oxygen at 1.75 atm and 200 ml nitrogen at 0.6 atm are passed into a vessel whose capacity is 500ml. Calculate the total pressure in the vessel at the same temperature. **(4 marks)**

- e) 0.250 mol SO₂ and 0.300 mol O_{2(g)} react at 500K in a 2.0l vessel to form 0.08M SO_{3(g)} at equilibrium. Determine K_c at 500 K for the reaction.



- f) State the Graham's law of diffusion and give a relation between the times (t₁ and t₂) of diffusion of two gases of masses M₁ and M₂ respectively to diffuse through a hole of a given temperature. **(4 marks)**

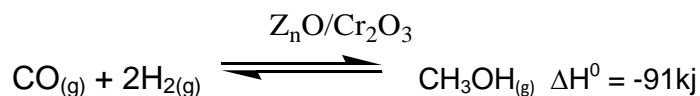
- Q2. a) i Differentiate between real gases and ideal gases. **(2 marks)**
- ii Briefly explain the pressure and volume with regard to modification of ideal gas reaction. **(6 marks)**
- b) i Using ideal gas equation (PV = nRT) derive the real gas equation. **(6 marks)**
- ii Determine the difference between ideal pressure and real pressure of a sample of 1.00 mol ethane, C₂H₆ that has a volume of 22.4l at 0^oc given that the van der waals constants a and b for C₂H₆ are 5.570l² atm (mol⁻¹)² and 0.0650 l mol⁻¹ respectively. **(6 marks)**

- Q3. a) i Define chemical equilibrium **(2 marks)**
- ii Define Le Chatelier's principle. **(2 marks)**
- b) Using examples, explain THREE factors that affect a chemical equilibrium. **(9 marks)**
- c) The following equilibrium process has been studied at 230^oc
- $$2\text{NO}_{(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{2(g)}$$
- in one experiment the concentrations of the reacting species at equilibrium, are found to be [NO] = 0.0542M [O₂] = 0.127M and [NO₂] = 15.5M. Calculate the equilibrium constant (K_c) of the reaction at 230^oc. **(3 marks)**
- d) For the equilibrium $2\text{SO}_{3(g)} \rightleftharpoons 2\text{SO}_{2(g)} + \text{O}_{2(g)}$ at 1000K temperature K_c has the value of 4.07 x 10⁻³. Calculate the value of K_p. **(4 marks)**

- Q4. a) i Define a buffer. **(2 marks)**

- ii List TWO importance of a buffered solution. **(2 marks)**
- iii Calculate the pH of a buffer made from 0.24M NH_3 and 0.20M NH_4Cl $K_b = 1.8 \times 10^{-5}$ **(5 marks)**
- iv Suppose 0.001 mol NaOH is added to 1.0L of the solution in (ii) above what will be the pH of the resulting solution? **(5 marks)**
- b) i Differentiate between a strong base and a weak base. **(2 marks)**
- ii Calculate pH of 0.01M $\text{Ba}(\text{OH})_2$ ($\text{Ba}(\text{OH})_2$ is a strong base). **(4 marks)**

- Q5. a) Consider the reaction for the manufacture of methanol (CH_3OH) by reaction of carbon monoxide with hydrogen in presence of $\text{ZnO}/\text{Cr}_2\text{O}_3$ catalyst as shown below:



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

- i Temperature is increased **(2 marks)**
- ii Volume is decreased for CH_3OH **(2 marks)**
- iii Helium is added **(2 marks)**
- iv CO is added. **(2 marks)**
- v Catalyst is removed. **(2 marks)**
- b) i Write the equilibrium constant expression the equation in (a) above. **(2 marks)**
- ii Briefly explain the common ion effect. **(2 marks)**
- iii Given that K_{sp} for AgCl is $2.8 \times 10^{-10} \text{ M}^2$ determine the solubility of $\text{AgCl}_{(s)}$ in 0.1M AgNO_3 **(3 marks)**
- c) The solubility of CuBr_2 is $2.0 \times 10^{-4} \text{ M}$ at 25°C . Calculate the K_{sp} value of CuBr_2 **(3 marks)**

END