Technical University of Mombasa

Faculty of Applied and Health Sciences

DEPARTMENT OF **PURE AND APPLIED SCIENCES**

DIPLOMA IN ANALYTICAL CHEMISTRY
(DAC 12S)

ACH 2103: INTRODUCTION TO PHYSICAL CHEMISTRY

SPECIAL/SUPPLEMENTARY: EXAMINATIONS

SERIES: February 2013

TIME: 2 HOURS

INSTRUCTIONS:

You should have the following for this paper

- *Answer booklet*

This paper consists of ***FIVE*** questions.
Answer Question **ONE (compulsory)** and any other **TWO** questions
*This paper consists of **4 PRINTED** pages*

Question ONE

(i) Briefly discuss each of the following

a) Real gas
b) Mole fraction
c) Solution
d) Solubility product
e) Buffer solution

(2marks each, total 10 marks)

(ii) From first principles, show that

a) $PV = nRT$ **(5marks)**

b) $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

(3marks)

(iii) a) State Daltons Law of partial pressures **(2marks)**

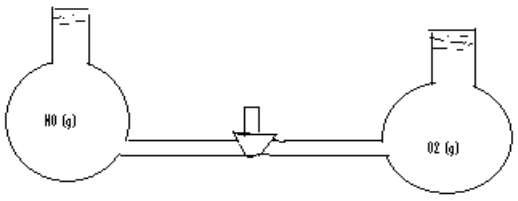
b) Halomethane ($F_3C - CHBrCl$) is a commonly used surgical anaesthetic delivered by inhalation. What is the partial pressure of each gas if 15.0grams halomethane gas is mixed with 22.6g oxygen gas and the total pressure is 862mmHg? (Molar mass of halomethane is 197.4glmol and oxygen = 32g/mol). **(5marks)**

c) The reaction between nitrogen monoxide, NO and oxygen gas , O_2, to form NO_2 is environmentally important. The reaction is

$2NO + O_2 \longrightarrow 2NO_2$

(g) (g) (g)

Suppose that the two reactant gases are kept in separate containers as shown below:



V = 4.0L
P = 360mmHg

V = 2.0L
P = 0.996atm

Then suppose that the valve is opened and the reaction proceeds to completion at a constant temperature of 25˚C

i) What gas remain at the end of the reaction **(2marks)**

ii) What are their partial pressures, and what is the total pressure in the system?

(3marks)

Question TWO

a) i) Explain why gases at low temperature and high pressure do not obey the ideal gas equation **(2marks)**

ii) The van der Waals equation can be written as follows

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Explain the meaning of each term. **(3marks)**

iii) What is the pressure of 5.0mol CH_4(methane) in 2.00litre container at 273K when calculated using the van der Waals equation? A = 2.25 l^2.atm/mol^2 and b= 0.0428l/mol. **(5marks)**

b) A sample of nitrogyl bromide (NOBr) is heated to 100˚C in a 1.0 litre container to decompose it partially according to the equation:

$$2NOBr_{(g)} \rightleftharpoons 2NO_{(g)} + Br_{2(g)}$$

The container is found to contain 6.44g NOBr, 3.15g NO and 8.38g Br_2 at equilibrium (N=14, 0 =16 and Br = 80)

i) Find the value of K_C at 100˚C **(4marks)**

ii) Find the total pressure exerted by the mixture of gases **(4marks)**

iii) Express Kp for this reaction at 100˚C. **(2marks)**

Question THREE

a) Write the equailibrium constant expression KC for

i) $CO_{(g)} + 3H_{2(g)} \rightleftharpoons CH_{4(g)} + H_2O_{(g)}$ **(3marks)**

ii) $CH_{4(g)} + H_2O_{(l)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$ **(3marks)**

iii) $\frac{1}{2} N_{2(g)} + 3/2H_{2(g)} \rightleftharpoons NH_{3(g)}$ **(4marks)**

b) (i) Ethylene glycol (EG) is a common automobile antifreeze. It is water soluble and fairly non – volatile (197˚C boiling point). Calculate the freezing point depression of a solution containing 651g of ethylene glycol in 2505g of water. (Molar mass of ethylene glycol = 62.07glmol) (Kf of ethylene glycol = 1.86˚C/m) **(6marks)**

(ii) The average osmotic pressure of sea – water is about 30.0 atm at 25˚C. Calculate the molar concentration of an aqueous solution of sucrose that is isotonic with sea water. **(4marks)**

Question FOUR

a) Oxygen gas is generated in the decomposition of potassium chlorate and collected over water at 20˚C. The volume of the gas collected at atmospheric pressure of 755 mmHg is 370ml. Calculate the mass of oxygen gas obtained. The vapour pressure of water at 20˚C is 17.5mmHg at 20˚C. (O = 16)

$$2KClO_3 \longrightarrow KCl + 3O_2$$
(s) (s) (g)

(8marks)

b) A mixtures of gases whose composition is as follows: 0.3 moles A, 0.25 moles to and 0.3moles C have a total pressure of 2 atm. Calculate the partial pressure of the gases. **(4marks)**

c) Ethanol (C_2H_5OH) burns in air as given by the following equation:

$$C_2H_5OH + O_2 \longrightarrow CO_2 + H_2O$$
(l) (g) (g) (l)

i) Balance the equation **(2marks)**

ii) Determine the volume of air in litres at 30C and 800mmHg required to burn 230g of ethanol. Assume air to be 21.0% O2 by volume. (C = 12, H = 1 and O = 16) **(6marks)**

Question FIVE

a) Distinguish between

(i) Real gas and ideal gas **(4marks)**

(ii) Diffusion and effusion **(4marks)**

b) Part of the contact process for the manufacture of sulphuric acid involves the reversible reaction:

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 \qquad \Delta H = -198KJ/mol$$
(g) (g) (g)

i) State Le-Chatelier's principle **(2marks)**

ii) For the above equilibrium, state and explain the effect on the equilibrium position of

a. Increasing the pressure at constant temperature **(2marks)**

b. Increasing the temperature, at constant pressure. **(2marks)**

iii) Write an expression for the equilibrium constant, K_c, for the above equilibrium **(2marks)**

iv) State and explain the effect on Kc of

a) increasing the pressure, at constant temperature. **(2marks)**

b) increasing the temperature, at constant pressure. **(2marks)**