MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SPECIAL /SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRIC AND ELECTRONICS ENGINEERING)

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECU 102: CHEMISTRY FOR ENGINEERS II

DATE: 17/3/2022 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.

Required data

- Gas constant, R = 8.314 $JK^{-1}mol^{-1}$ = 0.08206 L atm K^{-1} mol^{-1}
- 1 atm = 760 mmHg = 101325 Nm^{-2}

SECTION A - COMPULSORY.

QUESTION ONE (30 MARKS)

a) i) What is a buffer solution? (1 mark)

ii) What is the pH of a solution containing 0.15 M of NH_4Cl and 1.5 M NH_3, given that K_b of NH_3 1.8 x 10^{-5} . (3 marks)

b) i) State the two conditions under which a real gas behaves more like an ideal gas (2 marks)

ii) A sample of a gas at 27^o C has a mass of 14.5 g. Calculate the molar mass of this gas which is confined in a 3 L tank at a pressure 650mm Hg? (3 marks)

c) i) State Dalton's Law of partial pressures (1 mark)

ii) A metal can of volume 2000.0 cm^3 contains 2.0 g of nitrogen gas and 6.0 g of hydrogen gas at exactly 200 ^{o}C. What is the total pressure of gas in the can? Given Ram N=14 and H=1 (4 marks)

d) Calculate the vapour pressure a solution **containing** 11.7 g benzene (MW=78) and 4.6 g toluene (MW =92) at 50 ^{o}C, if the vapour pressure of the pure components at this temperature are 3.6 x 10^4 Nm^{-2} and 1.12 x 10^4 Nm^{-2} respectively**.**

(4 marks)

e) The following table lists kinetics data for the reaction of nitric oxide with hydrogen at 1280 °C: $2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$: From the following data, determine the rate law and rate constant. (4 marks)

Run	$[NO]_o$ (M)	$[H_2]_o$ (M)	Initial Rate (M/min)
1	0.0100	0.0100	0.00600
2	0.0200	0.0300	0.144
3	0.0100	0.0200	0.0120

f) i) State the Le Chateliers principle (1 mark)

ii) In which of the following reactions will the amount of product at equilibrium increase if the total gas pressure is raised from 1 atm to 10 atm? Explain. (3 marks)

(**a**) $SO_{2(g)} + Cl_{2(g)} \leftrightarrow SO_2Cl_{2(g)}$

(**b**) $N_{2(g)} + O_{2(g)} \leftrightarrow 2NO_{(g)}$

(**c**) $SO_{2(g)} + ½\ O_{2(g)} \leftrightarrow SO_{3(g)}$

g) The molar solubility of $Ca(OH)_2$ is 6.875×10^{-3} mol/ L. Calculate the K_{sp} value for for $Ca(OH)_2$ (4 marks)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) Determine K_c at 298 K for the reaction $2\ CH_{4(g)} \leftrightarrow C_2H_{2(g)} + 3\ H_{2(g)}$, given the following data at 298 K. (5 marks)

$CH_{4(g)} + H_2O_{(g)} \leftrightarrow CO_{(g)} + 3\ H_{2(g)}$ $K_p = 1.2\times10^{-25}$

$2\ C_2H_{2(g)} + 3\ O_{2(g)} \leftrightarrow 4\ CO_{(g)} + 2\ H_2O_{(g)}$ $K_p = 1.1\times10^{2}$

$H_{2(g)} + ½\ O_{2(g)} \leftrightarrow H_2O_{(g)}$ $K_p = 1.1\times10^{40}$

(*Hint:* How are K_c and K_p for the reaction related?)

b) Isoprene is a liquid compound that can be polymerized to form synthetic rubber. It is composed of 88.17 % C and 11.83 % H. Its molar mass is 68.11 g/mol. What are its empirical and molecular formula? (4 marks)

c) Define the following terms;

i) Rate of reaction

ii) Half -life

iii) First order reaction (3 marks)

d) An Astronaut balloon has a volume of 31,150 L. If the temperature at ground level is 86°F (30°C) and the atmospheric pressure is 745 mmHg, how many moles of hydrogen gas are needed to fill the balloon? (3 marks)

e) Using the integrated form of the rate law, determine the rate constant K of a zero order if the initial concentration of A is 6.0 M and after 4 min the concentration is 1.5 M. Determine the half-life of this reaction. (5 marks)

QUESTION THREE (20 MARKS)

a) i) State the Graham's law of effusion? (1 mark)

ii) Two porous containers are filled with hydrogen and neon, respectively. Under identical conditions, 2/3 of the hydrogen escapes in 6 hours. How long will it take for half the neon to escape? (3 marks)

b) Define the following terms;

i) E.M.F.
ii) Standard reduction potential (2 marks)

c) Given the following electrochemical cell: Ag / Ag^+(1.5 M) // Li^+(1.5 M) / Li and the following cell potentials, consider the redox reaction:

$Ag^+_{(aq)} + e^- \rightarrow Ag$ $\quad E^o = 0.80$ V
$Li^+_{(aq)} + e^- \rightarrow Li$ $\quad E^o = -3.05$ V

i) Write the half reactions at the anode, cathode and the overall reaction (3 marks)

ii) Determine the E.M.F. of the cell at 25 °C. (3 marks)

iii) Is the cell galvanic? (1 mark)

d) Given the following data

Reduction Half-Reaction	Reduction potential
$Cu^{2+} + 2\ e^- \rightarrow Cu$	0.3419V
$Zn^{2+} + 2\ e^- \rightarrow Zn$	-0.7618V

Draw a schematic diagram of a spontaneous cell using separate beakers for each half cell.

Label the anode, cathode and the other components of the cell. Indicate the flow of the electrons (3 marks)

e) Balance the following redox reaction in acidic conditions. (4 marks)

f) $Cr_2O_2^{-7}{}_{(aq)} + HNO_{2\ (aq)} \rightarrow Cr^{3+}{}_{(aq)} + NO^{-3}{}_{(aq)}$

QUESTION FOUR (20 MARKS)

a) The following data was obtained for the decomposition of a certain compound

Time (min)	[A] (M)
0	0.36
15	0.30
30	0.25
48	0.19
75	0.13

i) Determine if the above data support a first order reaction. (3 marks)

ii) Calculate the rate constant for the reaction. (2 marks)

b) i) State Raoult's Law (1 mark)

ii) List any two properties of an ideal solution. (2 marks)

c) Suppose you had a solution of 6.84 g of sugar (sucrose, $C_{12}H_{22}O_{11}$) in 90.0 g of water. At 100 °C, the saturated vapour pressure of water at its boiling point is 101325 Pa. Calculate the vapour pressure of the solution at that temperature. Given (H=1; C=12; O=16)

(4 marks)

d) An aqueous solution contains 0.97g/L of an organic compound. The osmotic pressure of the solution is 62.9 torr at 25.0 °C. Calculate the molar mass of the compound. (4 marks)

e) Suppose that in the reaction $PBr_{5\,(g)} \leftrightarrow PBr_{3\,(g)} + Br_{2\,(g)}$, the fraction of PBr_5 that dissociate to reach equilibrium is Y and the total gas pressure at equilibrium is **P**. Show that

$$K_p = \frac{Y^2 P}{1 - Y^2}$$

(4 marks)

QUESTION FIVE (20 MARKS)

a) What is the pH of a 0.4M NH_4Cl solution if the K_b of NH_3 is 1.8×10^{-5} (4 marks)

Given the equation: $NH_4^+{}_{(aq)} + H_2O_{(l)} \leftrightarrow NH_{3(aq)} + H_3O^+{}_{(aq)}$

b) i) State Henry's Law (1 mark)

ii) Estimate the freezing point of a mixture made up by combining one mole of ethylene glycol (MW = 62, density 1.11 g/cm^3) with two volumes of water. Given $KF = -1.86$ K L^{-1} mol. (4 marks)

c) i) Define colligative properties (1 mark)

ii) Give three condition for applicability of Henry's law (3 marks)

d) Sketch the following graphs:

e) i) Pressure against volume based on Boyle's law (2 marks)

ii) Volume against temperature based on Charles's law (2 marks)

e) Given an equation below for an ideal gas

$$P = \frac{mN\overline{u}^2}{3V}$$

Show that the kinetic energy E_k for one mole of a gas is dependent on temperature

(3 marks)