MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR DEGREE IN BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING BACHELOR OF SCIENCE IN CIVIL AND BUILDING ENGINEERING BACHELOR OF SCIENCE IN MECHANICAL ENGINERRING

ECU 102: CHEMISTRY FOR ENGINEERS II

DATE: 13/6/2017 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Required Data

- R = 8.314 $JK^{-1}mol^{-1}$ = 0.08206 L atm K^{-1} mol^{-1}
- 1 atm = 760 mmHg

Provided:

Periodic table

SECTION A – COMPULSORY (30 MARKS)

1. a) i) Derive the Van der Waals' equation of state from ideal gas equation. (3 marks)

ii) A sample of 4.37 moles of Cl_2 gas is confined in a volume of 2.45 L at 38 °C. Calculate the pressure of the gas (in atm) using:

I) The ideal gas equation (2 marks)

II) The Van der Waals' equation of state given a = 6.49 atm L^2 mol^2 and b = 0.0562 L mol^{-1}. (3 marks)

b) A compound was found to contain 49.98 g carbon and 10.47 g hydrogen. The molecular mass of the compound is 58.12 g mol^{-1}. Determine the molecular formula (4 marks)

c) i) State the Le Chatelier's principle. (1 mark)

ii) Carbonyl Chloride ($COCl_2$) also called phosgene was used in the World War I as a poisonous gas. The equilibrium concentrations for the reaction between carbon monoxide and molecular chlorine to form carbonyl chloride (equation below)

$$CO_{(g)} + Cl_{2(g)} \leftrightarrow COCl_{2g)}$$

at 74 °C are [CO] = 1.2 x 10^{-2} M, [Cl_2] = 0.054 M and [$COCl_2$] = 0.14 M. Calculate:

I) The equilibrium constant K_c (3 marks)

II) The value of K_p at 500 °C (2 marks)

III) Explain the effect of i) increasing pressure ii) adding a catalyst to the above reversible equation (2 marks)

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

ii) A mixture of gases contain contains 4.46 moles of neon (Ne), 0.74 moles of argon (Ar) and 2.15 moles of Xenon (Xe). Calculate the partial pressures of the gases if the total pressure is 2.00 atm at a certain temperature. (3 marks)

e) Explain **four** factors that affect the rate of a chemical reaction (6 marks)

SECTION B : ANSWER ANY TWO QUESTIONS (20 MARKS EACH

2. a) The reaction of nitric oxide with hydrogen at 100 °C is presented as:

$$2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$$

From the following data collected at 25 °C:

Experiment	[NO] (M)	[H_2] (M)	Initial Rate (M/s)
1	5×10^{-3}	2×10^{-3}	2.5×10^{-5}
2	10×10^{-3}	2×10^{-3}	5×10^{-5}
3	10×10^{-3}	4×10^{-3}	10×10^{-5}

Determine the:

I) Rate law (4 marks)

II) Rate constant (2 marks)

III) The rate of the reaction when [NO] = 1.2×10^{-3} M and [H_2] = 6.0×10^{-3} M (3 marks)

b) Ethyl iodide (C_2H_5I) decomposes at a certain temperature in the gas phase as follows: $C_2H_5I_{(g)} \rightarrow C_2H_{4(g)} + HI_{(g)}$. The following data was obtained.

Time (min)	0	15	30	48	75
[C_2H_5I] (M)	0.36	0.30	0.25	0.19	0.13

i) Determine if the above data support a first order reaction. (4 marks)

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

c) Define a half-life ($t_{1/2}$) of a reaction and show that for a 1st order rate reaction, the half life ($t_{1/2}$) is independent of the initial concentration (5 marks)

3. a) i) Write the balanced net ionic equation for the reaction in an acidic medium by the ion-electron method:

$$MnO_4^- + Fe^{2+} \rightarrow Mn^{2+} + Fe^{3+}$$ (3 marks)

ii) Identify the oxidizing and the reducing agent in the above equation (2 marks)

b) An electrochemical cell is made up of electrodes M and N with the half-cell reactions:

$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ $\quad E^o = 0.34$ V

$Zn^{2+}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$ $\quad E^o = -0.76$ V

i) Determine the half- reaction that occurs at the cathode, anode and the overall cell reaction (3 marks)

ii) If the $[Cu^{2+}]$ = 0.15 M and $[Zn^{2+}]$ = 0.25 M for the above cell, calculate the EMF of the cell at 25 °C. (3 marks)

iii) Draw a conventional schematic diagram of the 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 (5 marks)

iv) Explain **two** applications of electrolytic cells (2 marks)

d) State the Nernst equation and define all the terms (2 marks)

4. a) The concentration of H^+ ions in a bottle of wine was 3.2 x 10^{-4} M right after the cork was removed. Only half of the wine was consumed. The other half, after it had been standing open to the air for a month was found to have a H^+ concentration of 1 x 10^{-3} M.

i) Define the pH of a solution (2 marks)

ii) Calculate the pH of the wine on the two occasions (4 marks)

b) Sodium ethanoate was added to 0.2 mol dm^{-3} ethanoic acid until the concentration of the salt was 0.05 mol dm^{-3}. Given that the K_a for ethanoic acid is 1.74 x 10^{-5} mol dm^{-3}, Calculate the pH of the solution formed. (4 marks)

c) Derive the Henderson – Hasselbalch equation (4 marks)

d) Urea can be synthesised in the laboratory by the combination of ammonia and carbon dioxide according the equation:

$$NH_{3(g)} + CO_{2(g)} \rightarrow (NH_2)_2CO_{(aq)} + H_2O_{(l)}$$

i) Calculate the amount of urea that will be produced by the complete reaction of 5.25 moles of ammonia (3 marks)

ii) Determine the stoichiometric amount of carbon dioxide required to react with 5.25 moles of ammonia (3 marks)

5. a) i) Define colligative properties (1 mark)

ii) State four examples of colligative properties (2 marks)

b) i) State Raoult's law (include the mathematical expression) (2 marks)

ii) Vapour pressure of chloroform ($CHCl_3$) and dichloromethane (CH_2Cl_2) at 298 K are 200 mm Hg and 415 mm Hg respectively. A solution was prepared by mixing 25.5 g of $CHCl_3$ and 40 g of CH_2Cl_2 at 298 K. (RMM of C = 12, H = 1, Cl = 35.5).

Calculate;

i) The number of moles of CH_2Cl_2 (1 mark)

ii) The number of moles of $CHCl_3$ (1 mark)

iii) The total number of moles (1 mark)

iv) The mole fractions of CH_2Cl_2 and $CHCl_3$ (1 mark)

v) The vapour pressure of the solution (1 mark)

c) i) State Henry's law (1 mark)

ii) List two conditions for applicability of Henry's law (2 marks)

d) i) Define an ideal solution. (1 mark)

ii) Briefly describe the properties of an ideal solution. (2 marks)

e) It takes nitrogen gas 2 minutes to diffuse through an orifice. Calculate the time that methane (CH_4) gas will take to diffuse through the same orifice. (4 marks)