MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINNERING

SUPPLEMENTARY EXAMINATION

ECU 102: CHEMISTRY FOR ENGINEERS II

DATE: 30/8/2017 **TIME:**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.
- R = 8.314 $JK^{-1}mol^{-1}$ = 0.08206 L atm K^{-1} mol^{-1}
- 1 atm = 760 mmHg

SECTION A - COMPULSORY.

QUESTION ONE

a) Derive:

i. The ideal gas equation (4 marks)

ii. The Van der Waals equation (3 marks)

iii. An equation for the pressure at the base of a column of liquid of mass density ρ (rho) and height *h* at the surface of the Earth. (2 marks)

b) A sample of 3.50 moles of NH_3 gas occupies 5.2 L at 47 °C. Calculate the pressure of the gas (in atm) using:

i. The ideal gas equation (1 mark)

ii. The Van der Waals equation given a_{NH3}= 4.17 atm L/mol^2 and b_{NH3} = 0.0371 L/mol. (1 mark)

c) i A certain anesthetic compound contains 64.9% carbon, 13.5% hydrogen and 21.6% oxygen. At 120 °C and 760 mmHg, 1.00 L of the gaseous compound weighs 2.30 g. What is the molecular formula of the compound? (5 marks)

ii. In an industrial process, nitrogen is heated to 500 K in a vessel of constant volume. If it enters the vessel at 100 atm and 300 K, what pressure would it exert at the working temperature if it behaved as a perfect gas? (2 marks)

d) i State the Le Chatelier's principle. (2 marks)

ii The equilibrium constant K for the formation of nitrosyl chloride from nitric oxide and chlorine:

$2NO_{(g)} + Cl_{2(g)} \leftrightarrow 2NOCl_{(g)}$ is 6.5 x 10^4 at 35 °C. In which direction will the reactions proceed to reach equilibrium if the starting NO, Cl and NOCl are 1.1 x 10^{-3} mol/L, 3.5 x 10^{-4} mol/L and 1.9 mol/L respectively. (4 marks)

e) Given the reversible equation: $2SO_{2(g)} + O_{2(g)} \leftrightarrow 2SO_{3(g))}$ $\Delta H = -196$ kJmol^{-1}

i. Give an equation for equilibrium constant (K_p). (1 mark)

ii. The K_p for the above equilibrium reaction is 1.45 x 10^{-5} at 500 °C. Calculate the partial pressure of SO_3 when the partial pressure of SO_2 is 0.928 atmospheres and that of O_2 is 0.432 atmospheres. (2 marks)

iii. Calculate the value of K_c at a temperature of 800 °C. (1 mark)

iv. Explain the effect of (i) increasing pressure (ii) increasing temperature to the above reversible reaction. (2 marks)

SECTION B: ANSWER ANY TWO QUESTIONS
QUESTION TWO

a) Define the following terms;

i. Redox reaction

ii. Rate constant

iii. Rate of reaction

iv. Order of a reaction

v. Reaction intermediate (5 marks)

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

c) For a 1st order reaction: $2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$ has a rate constant of 1.06×10^{-3} min^{-1}. If the initial $(H_2O_2)_0 = 0.020$ mol/L, then what percentage of it remains after 100 minutes of reaction time. (5 marks)

d) The reaction: $2NOBr_{(g)} \rightarrow 2NO_{(g)} + Br_{2(g)}$ is a second order reaction with respect to NOBr. $k = 0.810\ M^{-1}\ s^{-1}$ at 10 °C. If $(NOBr)_o = 7.5 \times 10^{-3}$ M, how much NOBr will be left after a reaction time of 10 minutes? Determine the half-life of this reaction. (5 marks)

QUESTION THREE

a) Define the following terms;

i. Standard electrode potential

ii. An anode

iii. An electrolytic cell

iv. Electromotive force (4 marks)

b) i Explain the limitations to the use of standard electrode potential. (2 marks)

ii State the Nernst equation of electrochemical reactions and define all the terms. (3 marks)

iii An electrochemical cell is made of X (standard electrode potential; (E^0) = +0.7100 V) and Y (E^0 = +0.34 V) electrodes.

- Using standard sign conventions, construct a cell expression made of X and Y electrodes (2 marks)
- If the (X^+) = 0.01 M and (Y^{2+}) = 0.1 M for the above cell, what would be the instantaneous EMF of the cell at 25 °C. (4 marks)

c) i Write the balanced net ionic equation for the reaction:

$$MnO_4^- + VO^{2+} \rightarrow Mn^{2+} + V(OH)_4^-$$ (3 marks)

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

QUESTION THREE

a) i State Henry's law. (2 marks)

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

b) i What is an ideal solution? (1 mark)

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

iii Sketch plots of vapour pressure versus mole fractions for the binary solution toluene-benzene obeying Raoult's law over the whole concentration range at a certain temperature. Comment on your observations. (4 marks)

iv Calculate the vapour pressure of a solution containing 11.7 g benzene (MW = 78) and 4.6 g methylbenzene (MW = 92) at 50 °C, if the vapour pressures of the pure components at this temperature are 3.6×10^4 Nm^{-2} and 1.12×10^4 Nm^{-2}, respectively. (4 marks)

c) i) What is osmosis? (1 mark)

ii) A biochemical engineer isolates a bacterial gene fragment and dissolves a 17.6 mg sample of the material in enough water to make 31.5 mL of solution. The osmotic pressure of the solution is 0.340 torr at 25.0 °C. Calculate the molar mass of the gene fragment. (4 marks)

QUESTION FIVE

a) i) What are colligative properties? (1 mark)

ii) Give three examples of colligative properties. (3 marks)

iii) Boiling point elevation is a colligative property. Explain (2 marks)

iv) Explain the Van't Hoff factor in colligative properties equation. (2 marks)

v) With an aid of a labeled diagram, describe Landsberger's method for determining the elevation in boiling point of a solvent on dissolving a non-volatile solute in it. (6 marks)

b) i) What is pH of a solution? (2 marks)

ii) The dissociation constant of acetic acid at 25 °C is 1.75×10^{-5}. Calculate the degree of dissociation and the pH of the solution in a 0.500 M acetic acid solution. (4 marks)