JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL, PHYSICAL, MATHEMATICS AND ACTUARIAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE/BSc BIOLOGICAL SCIENCE

1ST YEAR 1ST SEMESTER 2022/2023

REGULAR, MAIN CAMPUS

COURSE CODE: SPB 9101

COURSE TITLE: PHYSICAL CHEMISTRY/BASIC CHEMISTRY 1

EXAM VENUE: **STREAM: BED SCI/BSC BIO**

DATE: **EXAM SESSION:**

TIME: 2:00 HRS

Instructions:

1. **Answer question 1 (Compulsory) in Section A and ANY other 2 questions in Section B.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room**

Useful data

R= 0.0821 L atm. K-1mol-1
Molar mass N = 14 $g.mol^{-1}$
Molar mass O = 16 $g.mol^{-1}$
Molar mass C = 12 $g.mol^{-1}$
Molar mass H = 1.01 $g.mol^{-1}$
Molar mass of He = 4 $g.mol^{-1}$

INSTRUCTIONS: Answer Question 1 and any other TWO questions

QUESTION ONE (30 marks)

a. Write the equilibrium constant expression for a simple gas phase isomerization reaction involving the conversion of cis-2-butene to trans-2-butene (2 marks)

b. Derive the Van der Waal's equation and explain its significance (4 marks)

c. If the volume of a sample of helium is 0.0227 M3 at 273 K and 1.00 x 10^5 Pa, what is its volume at 293K and 1.04 x 10^5 Pa (4 marks)

d. 50g (0.146 mole) of solute sugar is placed in 117 g (6.5 mole) of the solvent water. The vapor pressure for pure water at 25°C is 23.8 torr.

   i. What is the mole fraction of sugar in water 2 marks
   ii. What is the molality of sugar in water 3 marks
   iii. What is the molarity of sugar in water 3 marks
   iv. Calculate the vapor pressure depression 3 marks
   v. Calculate the boiling point elevation (the boiling point elevation constant for water is 0.512 °C/molal) 3 marks
   vi. Calculate the freezing point depression (the freezing point depression constant for water is 1.86 °C/molal 3 marks
   vii. Calculate the osmotic pressure change 3 marks

QUESTION TWO (20 marks)

a. Balance the following chemical equations.

   i. $CO_2 + H_2O$ ----> $C_6H_{12}O_6 + O_2$
   ii. $Pb(NO_3)_2 + KI$ -----> $PbI_2 + KNO_3$ [3 marks]

b. Define the term 'Colligative Properties' and describe four types of colligative properties (5 marks)

c. The pressure of a 0.0239 M^3 sample of N2 is 1.02 x 10^5 Pa. The gas is compressed to a volume of 0.0210 m^3 while the temperature remains constant at 293 K. What is the new pressure of the gas (3 marks)

d. Zinc reacts with hydrochloric acid according to the equation;

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

What mass of zinc is required to react completely with 30.0 cm^3 1.00 M hydrochloric acid?

(3 marks)

e. Write the oxidation and reduction half reactions for the following reaction Zn (s) + Cu^{2+} (aq) ====> Zn^{2+} + Cu (s) [2 marks]

f. Calculate the volume occupied by one mole of CO2 at 300 K and 1 bar pressure. [4 marks]

QUESTION THREE (20 marks)

a. A quantity of cis-2-butene is added to a 2 liter flask and heated to 400 Oc for 2 years. The concentration of trans-2-butene was then determined to be 0.5 M. What is the concentration of cis-2-butene in the flask (3 marks)

b. h) Abottle of metal hydrate $BaCl_2.2H_2O$ is mixed with an unknown amount of KCl. In order to find the purity of the $BaCl_2.2H_2O$, we heat 9.51g of the metal hydrate mixture to remove water from the sample. After heating, the sample has a reduced mass of 9.14g.
   i) calculate change in sample mass (1 mark)
   ii) Calculate the moles of evaporated water (1 mark)
   iii) calculate moles of $BaCl_2.2H_2O$ (1 mark)
   iv) calculate mass of $BaCl_2.2H_2O$ in grams (1 mark)
   v) calculate the mass percent of $BaCl_2.2H_2O$ in the original sample (1 mark)

c. State Dalton's Law of Partial Pressures 2 marks

d. Discuss any **five** factors that affect the position of a chemical equilibrium. [5 marks]

e. Derive the Nernst equation and explain the terms in it. [5 marks]

QUESTION FOUR (20 marks)

a. Define the following terms;
   i. Physical chemistry [2 marks]
   ii. Grahams law of effusion [2 marks]

b. Differentiate between an ideal gas and real gas. [4 marks]

c. The equilibrium concentrations for the reaction between carbon monoxide and molecular chlorine to form $COCl_2g$ at 74°C are CO=0.012 M, Cl_2 =0.054 M and $COCl_2$ =0.14 M. Calculate the equilibrium constants K_c and K_p (4 marks)

d. Consider the following equilibrium process between dinitrogen tetrafluorie and nitrogen difluoride;

$$N_2F_4(g) \rightleftharpoons 2NF_2(g) \qquad \Delta H^\circ = 38.5 \text{ kJ}$$

Predict the changes in the equilibrium if;

i. The reacting mixture is heated at constant volume [2 marks]
ii. NF_2 gas is removed from the reacting mixture at constant temperature and volume [2 marks]
iii. The pressure on the reacting mixture is decreased at constant temperature [2 marks]
iv. An inert gas, such as helium is added to the reacting mixture at constant volume and temperature [2 marks]

QUESTION FIVE (20 marks)

a. Using relevant examples, distinguish between a physical and chemical equilibria (4 marks)

b. Briefly describe any **three** types chemical reactions. [3 marks]

c. A mixture of 0.500 mol H_2 and 0.500 mol I_2 was placed in a 1.00-L stainless steel flask at 430 °C. The equilibrium constant Kc for the reaction is 54.3 at this temperature. Calculate the concentrations of H_2, I_2 and HI at equilibrium. [6 marks]

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

d. Explain the terms;
   i) Redox reactions (1 mark)
   ii) oxidation (1 mark)
   iii) reduction (1 mark)

e. Determine the oxidation number of each element in these compounds
   i) CaO (1 mark)
   ii) KNO_3 (1 mark)
   iii) $NaHSO_4$ (1 mark)
   iv) $CaCO_3$ (1 mark)