2915/205
PHYSICAL CHEMISTRY II
Oct./Nov. 2021
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ANALYTICAL CHEMISTRY

MODULE II

PHYSICAL CHEMISTRY II

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Scientific calculator.
*This paper consists of **TWO** sections; **A** and **B**.*
*Answer **ALL** the questions in section **A** and **THREE** questions from section **B**.*
*Each question in section **A** carries **4** marks while each question in section **B** carries **20** marks.*
Maximum marks for each part of a question are indicated.
Candidates should answer the questions in English.

This paper consists of 6 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

Turn over

SECTION A (40 marks)

*Answer **ALL** the questions in this section.*

1. State any **four** factors that have an affect on equilibrium constant. (4 marks)

2. The rate of a reaction X, triples when the temperature is changed from $20°C$ to $50°C$. Given that $R = 8.134\,J/k/mol$. Calculate its activation energy. (4 marks)

3. (a) Define the following terms:

   (i) real gas; (1 mark)

   (ii) ideal gas. (1 mark)

   (b) Give **two** reasons, for the deviation of real gas from ideal gas. (2 marks)

4. Nitric Oxide, reacts with bromine gas and gives nitrosyl bromide as follows:

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

   When 0.087 moles of NO and 0.0437 moles of Br_2 are mixed in a closed container at a container temperature, 0.0518 moles of NOBr is obtained. Calculate the amount of NO present at equilibrium point. (4 marks)

5. Using a graphical representation, show the difference between a first order, second order and zero order reaction. (4 marks)

6. Using an appropriate equation, differentiate homogenous catalyst from heterogenous catalyst. (4 marks)

7. Sucrose (common sugar), decomposes in acidic medium into glucose and fructose in a first order rate law with $t_{½}$ 3.00 hrs. Calculate the fraction of sugar left after 8 hours of decomposition given that one mole of sugar was used. (4 marks)

8. Define the following terms:

   (a) order of reaction;

   (b) promoters;

   (c) inhibitors;

   (d) collision diameter.

   (4 marks)

9. Write the Van der Waals equation , describing all the terms in it. (4 marks)

10. The equation below, shows a first order reaction that decomposes thermally.
$C_2H_5Cl \longrightarrow C_2H_{5\,(g)} + HCl$

Time/Sec	Total pressure/atmosphere
0	0.30
300	0.50

Calculate the rate constant. (4 marks)

SECTION B (60 marks)

*Answer any **THREE** questions in this section.*

11. (a) State any **four** characteristics of enzyme catalysis. (4 marks)

(b) Ammonia gas, can be transformed to nitrogen (II) oxide as shown in the equation below.
$4NH_3 + 5O_2 \leftrightarrows 4NO + 6H_2O \quad \Delta H = -905.48kJ$

Explain what would happen to the yield of nitrogen (ii) oxide if the temperature of the system is increased. (2 marks)

(c) Sketch an energy level diagram, to show the effect of the presence of a catalyst. (4 marks)

(d) Consider the following equation at equilibrium

$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$

Given that the measured concentration at equilibrium of PCl_3 is 0.5×10^{-1}mol/l. Find the concentration of PCl_3 and Cl_2 in the system if $Kc = 8.3 \times 10^{-3}$. (5 marks)

(e) Derive an equation , to show the relationship between *Kc* and *Kp*. (5 marks)

12. (a) Define the following terms:

(i) allotropy; (1 mark)

(ii) monotropy; ($1\frac{1}{2}$ marks)

(iii) polymorphism. ($1\frac{1}{2}$ marks)

(b) Two modes of NH_3 are enclosed in a five litre flask at $27°C$. Calculate the pressure exerted by the gas assuming that the gas behave like:

(i) an ideal gas; (2 marks)

(ii) a real gas. (3 marks)

$\{R = 0.0821\, litre\, atm/mol/°C\,;\ a = 4.14\, litre\, atm/mol^{-2}\,;\ b = 0.037\, litr\, mol^{-1}\}$

(c) (i) Name **two** general characteristics of gases. (2 marks)

(ii) Using the kinetic theory of matter, deduce Boyle's law. (3 marks)

(d) (i) State Daltons law of partial pressure. (2 marks)

(ii) Calculate the pressure exerted on a 10 litre vessel if a mixture of 2.0 g of $H_{2(g)}$ and 8.0 g of $N_{2(g)}$ at 273 °K are pumped into it. (4 marks)

13. (a) Define the following terms:

(i) rate of a reaction; (1 mark)

(ii) molecularity of a reaction; (1 mark)

(iiii) instantaneous rate of a reaction; (1 mark)

(iv) catalyst poison. (1 mark)

(b) State any **two** applications of reaction kinetics in the industry. (2 marks)

(c) The data in the table I was obtained for a series of experiments for the reaction:

$2NO + H_2 \rightarrow N_2 + 2H_2O \quad T = 904°C$

Table I

Expt	Initial (NO)	Initial (H_2)	Rate of production of $N_2(mol/L/s)$
1	0.210	0.122	0.0339
2	0.210	0.244	0.0678
3	0.210	0.366	0.102
4	0.420	0.122	0.136
5	0.630	0.122	0.305

(i) Use the data in table I to calculate the order of the reaction with respect to NO. (3 marks)

(ii) Using the graphical method, determine the order of reaction, with respect to hydrogen. (10 marks)

(iii) Write the rate law equation for the equation above. (1 mark)

14. (a) Draw a well labelled diagram, for the sulphur system. (7 marks)

(b) Define the following terms:

(i) phase; (1 mark)

(ii) eutetic point; (1 mark)

(iii) triple point. (1 mark)

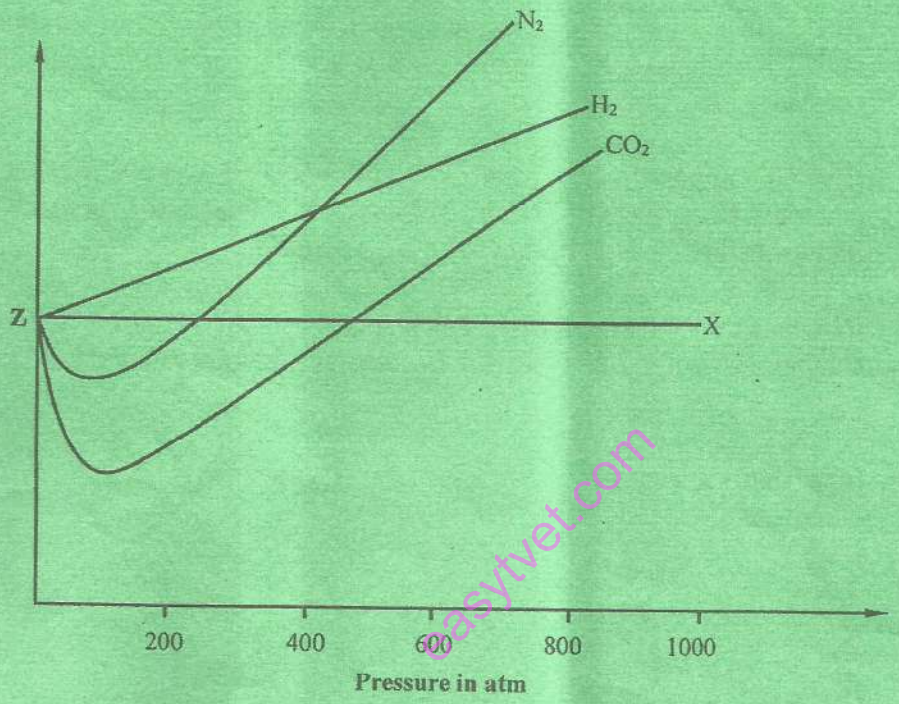

Fig. 1

Figure 1 shows a graph of Z compressibility factor against pressure in atmosphere.

(i) Give a mathematical expression for the compressibility factor Z of gas X above. (2 marks)

(ii) State the gas X. (1 mark)

(iii) State the effect of pressure on the value of Z for the gases X , N_2, H_2 and CO_2 . (7 marks)

15. (a) Ethyl acetates, can be formed according to the reaction below

$$CH_3COOH_{(l)} + CH_2H_5OH_{(l)} \rightleftharpoons CH_3COOC_{(2)}H_{5(l)} + H_2O_{(l)}$$

Assuming water is not a solvent hence not in excess.

(i) Write the reaction quotient for the reaction. (2 marks)

(ii) Write an equation that represent the equilibrium constant for this reaction. (2 marks)

(iii) At 293 °K, if 1.0 mole of acetic acid and 0.18 moles of ethanol are used then the final equilibrium has 0.171 moles of ethyl acetate. Calculate the equilibrium constant. (5 marks)

(iv) Given 0.5 moles of ethanol and 1.0 moles of acetic add at 293 K as the starting materials, then after some time 0.214 moles of ethylacetate is produced. Show whether the equilibrium has been reached. (5 marks)

(b) (i) Calculate the mole fraction of ethylene glycol $(C_2H_6O_2)$ in water. Given that it contains 20% of $(C_2H_6O_2)$ by mass. Assume that the solution is 100 g. (4 marks)

(ii) State Henry's law. (2 marks)

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