Chemistry II

014

24/11/ 2017   08.30 AM - 11.30 AM

REB

Rwanda Education Board

ADVANCED LEVEL NATIONAL EXAMINATIONS, 2017

SUBJECT: CHEMISTRY

PAPER II: THEORY

COMBINATIONS: - BIOLOGY-CHEMISTRY-GEOGRAPHY (BCG)
  - MATHEMATICS-CHEMISTRY-BIOLOGY (MCB)
  - PHYSICS-CHEMISTRY-BIOLOGY (PCB)
  - PHYSICS-CHEMISTRY-MATHEMATICS (PCM)

DURATION: 3 HOURS

INSTRUCTIONS:

1. Write your names and index number on the answer booklet as written on your registration form, and **DO NOT** write your names and index number on additional answer sheets of paper if provided.

2. Do not open this question paper until you are told to do so.

3. This paper consists of two sections: **A** and **B**.

    Section A: Attempt **all** questions.   **(70marks)**

    Section B: Attempt any **three** questions.   **(30marks)**

4. **A sample of the Periodic Table is provided on page 8.**

5. Silent non-programmable calculator may be used.

6. Use a **blue** or **black** pen.

SECTION A: Attempt all questions.   (70marks)

1) (a) Describe the term "covalent bond".   **(2marks)**

   (b) Draw diagrams to show the shapes of the following molecules
       and in each case state the name of the shape.   **(3marks)**
   (i) $BeCl_2$
   (ii) BF_3
   (iii) SF_6.
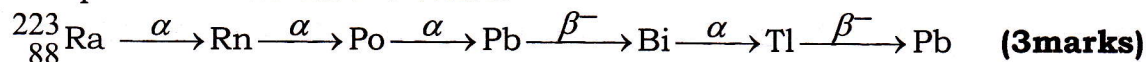   (Atomic number: Be=4, Cl=17, B=5, F=9, S=16)

2) Explain the following observations:

   *(a) In group Ia of the periodic table, metallic character increases as
        you move down the group.   **(2marks)**

   (b) The shape of CO_2 (carbon dioxide) is linear whereas that of
       water (H_2O) is bent (V-shaped).   **(4marks)**
       (Atomic number: C=6, O=8, H=1)

3) (a) Complete this radioactive series:

   $$^{223}_{88}Ra \xrightarrow{\alpha} Rn \xrightarrow{\alpha} Po \xrightarrow{\alpha} Pb \xrightarrow{\beta^-} Bi \xrightarrow{\alpha} Tl \xrightarrow{\beta^-} Pb$$ **(3marks)**

   (b) A stable nuclide absorbs a neutron, emits an electron, and then
       splits into two α particles. Identify the nuclide.   **(3marks)**

   (c) (i) One can produce sodium-24 by exposing stable sodium $^{23}_{11}Na$
           to a flux of neutrons. Write down the formation reaction of
           sodium-24.   **(1mark)**

   (ii) Sodium-24 is radioactive by emission of β^- and its half-life is
        15 hours. Write down the equation for the decay of sodium-24.   **(1mark)**

   (iii) One injects into the blood of an individual 10cm³ of a solution
         initially containing sodium-24 with a concentration of $10^{-3}mol.l^{-1}$.
         What is the number of moles of sodium-24 that have been injected
         into the blood? How much of it will remain after 6 hours?   **(2marks)**

4) Zinc oxide, ZnO is amphoteric. It dissolves in alkali to give the
   ion $Zn(OH)_4^{2-}$.

   (a) Write the ionic equation for the reaction between ZnO and
       sodium hydroxide in water.   **(2marks)**
   (b) Write the equation of reaction of ZnO with hydrogen ions.   **(2marks)**

2:8:6

x−4 = −2
x = −2+4
  = 2

$ZnO + 2H^+ \longrightarrow Zn + H_2O$

5) (a) When $Mn(OH)_2$ is made by adding an alkali to a solution containing Mn^{2+} ions, the white precipitate formed quickly turns to brown and eventually goes black in an open test tube.
Write the chemical formula of the compound that forms:

(i) Brown precipitate. **(1mark)**

(ii) Black precipitate. **(1mark)**

(b) Write a chemical reagent that you would use to distinguish between Mg^{2+} and Zn^{2+} ions in solution indicating the observable change and a chemical equation for a positive test if possible in any case. **(3marks)**

6) Nitrogen monoxide (NO) can be converted to nitrogen dioxide (NO_2) gas when nitric acid is to be manufactured:

$$2 \, NO_{(g)} + O_{2(g)} \rightleftharpoons 2 \, NO_{2(g)} \quad \Delta H = -114 \text{ KJ mol}^{-1}$$
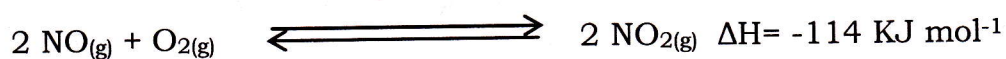
(a) State the colour of NO_2 gas. **(1mark)**

(b) State and explain the effect of reducing pressure of the reacting mixture to the position of equilibrium. **(2marks)**

7) Acetone and ethyl acetate are organic liquids that form an ideal mixture and are used as solvents. At 30^0C, the vapour pressure of pure acetone is 285 mmHg and the vapour pressure of pure ethyl acetate is 118 mmHg.
Calculate the total vapour pressure at 30^0C of a solution prepared by dissolving 25.0g of acetone and 225 g of ethyl acetate. **(5marks)**
(Molar mass: Acetone = 58.0 g mol^{-1} , ethyl acetate = 88 g mol^{-1})

8) (a) There are various factors that affect the speed of migration of ions in solution during electrolysis.
Mention 3 of those factors. **(3marks)**

(b) Explain the reason why lithium ion, Li^+ moves through a solution less rapidly than other cations such as Na^+ during electrolysis, despite the fact that it (Li^+) is far smaller than other metal ions. **(2marks)**

9) An organic compound of 5.0 g by mass is dissolved in 100 g of benzene. The boiling point of this solution is 82.42 ^0C. The boiling point of pure benzene is 80.10 ^0C;
Calculate the molar mass of the organic compound. **(4marks)**
(Ebullioscopic constant, Kb= 2.53 ^0C/m and m=mol Kg^{-1})

10) Write chemical equations of reaction (structural formulae) of the organic compounds given below and the products formed.

(a) 2-Pentene + ozone $\longrightarrow$ **(2marks)**

(b) 2-Methyl 3-hexene + MnO_4^- $\xrightarrow[Water]{}$ **(2marks)**

11) By giving appropriate reagents to be used in different equations of the steps of synthesis, write equations of reaction that enable the synthesis of methyl amine (CH_3NH_2) from chloroethane (CH_3CH_2Cl).   **(3marks)**

12) (a) Draw the structural formulae and write the IUPAC names (scientific names) of the products resulting from the reaction of lithium aluminium hydride and the following compounds:

(i) Ethanal.   **(2marks)**

(ii) 2-pentanone.   **(2marks)**

(b) Write the structural formulae of compounds obtained by the reaction of 3-butanone and iodine in the presence of sodium hydroxide.   **(2marks)**

13) (a) Octane can be cracked and converted into pentane and substance B (hydrocarbon).

Give the name of substance B.   **(1mark)**

(b) To improve octane's ability to behave as a good fuel, it undergoes catalytic reforming to obtain a branched isomer C.

Draw the structure of isomer C and give its IUPAC name.   **(2marks)**

14) The dissociation constant of ammonia is 1.8×10^{-5}.
Calculate the pH of a 0.2 mole/litre solution of ammonia.   **(3marks)**

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

(NH_3 is a weak base).

15) Diethyl ether (ethoxyethane) is an organic compound, $(CH_3CH_2O)_2$;

(a) Write an equation of reaction including structural formula of Reactants to produce ethoxyethane.   **(2marks)**

(b) Mention 2 uses of ethoxyethane.   **(2marks)**

SECTION B: Attempt only three questions.   **(30marks)**

16) (a) Ammonia is manufactured by Haber-Bosch process. Explain how nitrogen to be used in this process is obtained on a large scale.   **(2marks)**
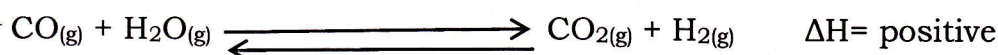
(b) The manufacture of ammonia requires N_2 and H_2 gases.

Production of hydrogen gas (H_2) requires a two stage process, primary and secondary reforming in which a mixture of hydrocarbons (naphtha) is passed in steam over a nickel catalyst.

<u>Primary stage</u>

$$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3\ H_{2(g)} \quad \Delta H = \text{positive}$$

<u>Secondary stage :</u>
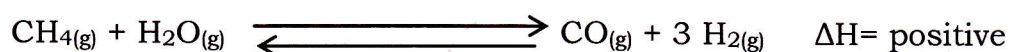
$$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)} \quad \Delta H = \text{positive}$$

(i) Briefly state a chemical substance that can be used to remove CO_2 gas from the by-products of the reaction.   **(1mark)**

(ii) Explain the necessity of the use of nickel catalyst.   **(1mark)**

(iii) If 60 dm³ of CH_4 of gas were made to react completely with 60 dm³ of H_2O gas; calculate the volume of H_2 gas produced in the primary stage.   **(2marks)**

(iv) State and explain the effect of reducing pressure to the position of equilibrium in the primary stage reaction.   **(2marks)**

(c) Ammonia is used to produce nitric acid; this requires the reaction between NH_3 and O_2 to produce NO gas.

Write a balanced chemical equation of reaction between NH_3 and O_2 to get NO gas.   **(2marks)**

17) (a) Given the following molar conductivities at infinite dilution Λ^∞ :

NaCl=126.4, NaOH=248.4, NH₄Cl=149.8, Na⁺=50.1, OH⁻=198.3, Cl⁻=76.3.

(Units of molar conductivity at infinite dilution (Λ^∞) are: S cm² mol⁻¹).

Calculate the molar conductivity of NH_4OH at infinite dilution.   **(3marks)**

(b) An experiment shows that for a strong electrolyte, a graph of molar conductivity Λ against $\sqrt{concentration}$ (i.e $\sqrt{c}$) is a straight line provided the concentration is not too large.

(i) Plot a sketch graph of molar conductivity against $\sqrt{concentration}$ using the results of sodium hydroxide solution below. **(4marks)**

C/NaOH (mol dm^{-3})	0.01	0.04	0.09	0.16	0.25	0.36
Λ (S cm^{2}mol^{-1})	238	230	224	217	210	202

(ii) Show the point where molar conductivity corresponds to infinite dilution (Λ^{∞}). **(1mark)**

(iii) Explain the meaning of the term "Ionic interference" of strong electrolytes such as aqueous NaOH solution. **(2marks)**

18) (a) When phosphorous (P) burns in air, it reacts with oxygen to produce an oxide.

(i) Write a chemical equation for the reaction of phosphorous with oxygen. **(2marks)**

(ii) Write a chemical equation for the reaction of the resultant phosphorous oxide and water. **(2marks)**

(b) Phosphorous pentachloride (PCl_5) can react with water (H_2O) to give products.

(i) Write the chemical equation of the reaction between phosphorous pentachloride (PCl_5) and water. **(2marks)**

(ii) Deduce the oxidation state of phosphorous atom in phosphorous pentachloride (PCl_5) molecule. **(1mark)**

(iii) Calcium phosphate $Ca_3(PO_4)_2$ reacts with sulphuric acid (H_2SO_4), write the equation of reaction that occurs between these two substances. **(2marks)**

(iv) Mention one use of calcium dihydrogenophosphate. **(1mark)**

19) (a) Write equations (successively) of reaction using structural formulae and appropriate reagents required for the conversion of benzoic acid to 3-amino methyl benzene.   **(4marks)**
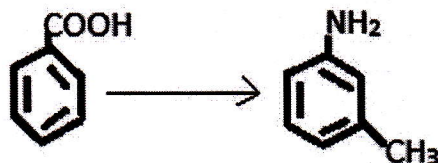
(b) Write the mechanism of reaction between propanoyl chloride, (C_3H_5OCl) and ammonia (NH_3).   **(3marks)**

(c) Write the structural formula of the following amino acids: **(3marks)**
   (i) Glutamine.
   (ii) Arginine.
   (iii) Methionine.

20) Nitrogen monoxide gas (NO) was allowed to react with hydrogen gas (H_2) in a 1 litre container according to the equation:

$$2NO_{(g)} + 2H_{2(g)} \rightleftharpoons N_{2(g)} + 2H_2O_{(g)}$$
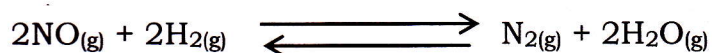
Initially before the reaction started; the concentration of each gas was:
$NO_{(g)}$ = 0.10 mole/litre, $H_{2(g)}$ = 0.050 mole/litre, $H_2O_{(g)}$ = 0.10 mole/litre, $N_{2(g)}$ = 0.00 mole/litre.

When the reaction reached equilibrium, the concentration of NO gas was equal to 0.062 mole/litre.

(a) Write the mathematical expression of equilibrium constant, Kc.   **(1mark)**

(b) Calculate the equilibrium constant, Kc.   **(4marks)**

(c) Determine the mathematical expression of equilibrium constant, Kp in relation to the equilibrium constant Kc.   **(2marks)**

(d) Calculate Kp, by using the value of Kc (in 20.b) above.   **(3marks)**
   (R = 0.082 l .atm.K^{-1}mol^{-1}, temperature K = 298 Kelvin)

The Periodic Table

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr