Chemistry II

014

23/07/ 2021 08.30 AM - 11.30 AM

NESA NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

ADVANCED LEVEL NATIONAL EXAMINATIONS, 2020-2021

SUBJECT: CHEMISTRY II

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 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. **(70 marks)**
   Section B: Attempt **only three** questions. **(30 marks)**
4) **Geometrical instruments and silent non-programmable calculators may be used.**
5) **You do not need the periodic table.**
6) Use a **blue** or **black** pen for answering and a **pencil** for drawing.

SECTION A: Attempt all questions (70 marks)

1) The atomic number of manganese (Mn) is 25.

a) Write the electronic configuration of manganese in terms of s, p, d and f notation. **(1 mark)**

b) Give two reasons to explain why Mn is considered to be a transition metal. **(2 marks)**

c) Explain why Mn^{2+} ions are more stable than Mn^{3+} ions. **(2 marks)**

2) a) The first seven ionization energies of element W are shown below:

1st	2nd	3rd	4th	5th	6th	7th
785	1581	3231	4361	16002	20001	23602

(i) What is meant by the term "**first ionization energy**" of an element? **(1 mark)**

(ii) State two factors that determine the magnitude of the first ionization energy. **(2 marks)**

b) (i) What is meant by the term "**electronegativity**"? **(2 marks)**

(ii) What are the factors that determine the magnitude of electronegativity of an element? **(2 marks)**

3) Ions of F^- , Na^+ and Mg^{2+} have the same number of electrons.
(Atomic number: F=9, Na =11, Mg =12)

a) Write the electronic configuration of Mg^{2+} using s, p, d and f notation. **(1 mark)**

b) Arrange the ions given above in order of ascending ion size (ionic radius). **(2 marks)**

4) Hydrogen sulfide, H_2S is a gas at room temperature and pressure whereas sodium fluoride, NaF is a solid with a high melting point.
a) Mention the type of bond that form each of the compounds. **(2 marks)**

b) Explain, in terms of bond nature, why their melting points are different. **(2 marks)**

5) An electrochemical cell is represented as follows:

$Mn_{(s)}$ /$Mn^{2+}_{(aq)}$ // $Cu^{2+}_{(aq)}$/ $Cu_{(s)}$

Use the data given below to answer the questions that follow:

$Mn^{2+}_{(aq)} + 2e \rightleftharpoons Mn_{(s)}$ $E^{\theta} = -1.18$ V

$Cu^{2+}_{(aq)} + 2e \rightleftharpoons Cu_{(s)}$ $E^{\theta} = +0.34$ V

(a) Calculate the e.m.f of this cell. **(2 marks)**

(b) Indicate and explain (using chemical equations) how the e.m.f of the cell would change if the concentration of $Mn^{2+}_{(aq)}$ was increased on the left side of the cell. **(3marks)**

(c) Describe the difference between an electrochemical cell and an electrolytic cell. **(2 marks)**

6) A solution contains 0.089 gl^{-1} of anhydrous calcium chloride, $CaCl_2$ and has an electrolytic conductivity of 2.69 X 10^{-4} Ohm^{-1} cm^{-1} at 25 ^{0}C.

a) Calculate the molar conductivity of calcium chloride in this solution.
(Atomic mass: Ca=40, Cl=35,5) **(2 marks)**

b) The molar ionic conductivity of calcium ions at 25 ^{0}C is 104 Ohm^{-1} cm^2 mol^{-1}. Calculate the molar ionic conductivity of chloride ions in the solution. **(3 marks)**

7) a) One of the properties of transition metals is complex ion formation.
(i) Define the term "complex ion" **(1 mark)**

(ii) Explain why transition metals form many complexes. **(2 marks)**

b) $Fe(CN)_6^{3-}$ and $CuCl_4^{2-}$ are complexes formed by iron and copper respectively. Deduce the:
(i) Oxidation number of iron and copper in the above complexes. **(1 mark)**

(ii) Co-ordination numbers of iron. **(1 mark)**

8) Explain each of the following observations:

a) Propan-1-ol boils at 97 ^{0}C and 1-aminopropane boils at 49 ^{0}C although both compounds have almost the same molecular masses. **(2 marks)**

b) Phenol is more acidic than phenyl methanol. **(2 marks)**

c) Beryllium chloride is more soluble in ethanol than in water whereas magnesium chloride is more soluble in water than in ethanol. **(1 mark)**

9) The dissociation constant, Ka of propanoic acid (CH_3CH_2COOH) is $1.3x10^{-5}$ mole dm^{-3}.

a) Calculate the concentration of H^+ ions in mole dm^{-3} of a 0.1 mole dm^{-3} CH_3CH_2COOH solution. **(2 marks)**

b) Calculate the pH of the 0.1 mole dm^{-3} CH_3CH_2COOH solution. **(2 marks)**

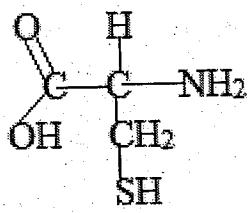
10) The atomic number of aluminium and bromine are 13 and 35 respectively.

a) Draw the Lewis structure of Al_2Br_6 . **(1 mark)**

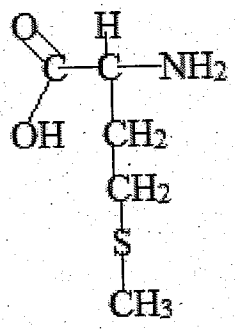
b) Explain why $AlBr_3$ is considered to be an acid according to Lewis theory of acid-base. **(2 marks)**

c) Explain why $MgBr_2$ is more ionic than $AlBr_3$ **(2 marks)**

11) Study the structure of cysteine and methionine amino acids given below and answer the questions that follow:



Cysteine amino acid



Methionine amino acid

a) Draw the structure of the zwitterion form of cysteine amino acid shown above. **(2 marks)**

b) Draw the structure of the dipeptide formed when cysteine amino acid combines with methionine amino acid in aqueous solution at 30 ^0C **(2 marks)**

12) An alkyne Z reacts with a solution of copper I chloride in aqueous ammonia to give a red precipitate and has the molecular formula C_5H_8.

a) Write the structural formula of Z. **(1 mark)**

b) Write the names and structural formulae of 2 possible isomers of Z. **(2 marks)**

c) Write the equation for the reaction between Z and excess hydrogen bromide HBr. **(1 mark)**

13) Explain the following observations:

a) Iodine is sparingly soluble in water but dissolves readily in aqueous potassium iodide. **(2 marks)**

(a) Hydrogen fluoride, HF has a higher boiling point than hydrogen chloride, HCl. **(2 marks)**

14) The addition of 114 grams of substance Q to 1000 grams of water lowers the vapour pressure of water from 17.540 KPa to 17.435 KPa. Calculate the molecular mass of substance Q. **(4 marks)**
(Molar mass of water = 18g/mole)

15) The volume of 20 cm^3 of a sample of a saturated solution of calcium hydroxide $Ca(OH)_2$ was neutralized by 18.2 cm^3 of a 0.022 mole dm^{-3} hydrochloric acid HCl.

a) Calculate the concentration of OH^- (mole dm^{-3}) in the saturated solution of $Ca(OH)_2$. **(2 marks)**

b) Calculate the solubility product, Ksp of $Ca(OH)_2$. **(2 marks)**
Equation: $Ca(OH)_{2(aq)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + 2H_2O_{(l)}$

SECTION B: Attempt three questions only (30 marks)

16) An organic compound Q, with the molecular formula $C_2H_4O_2$ contains two functional groups.

a) The first functional group was tested as follows:

I. The pure compound Q reacted with sodium to give out hydrogen gas and a compound with the molecular formula of $C_2H_3O_2Na$.

II. When compound Q was heated with ethanoic acid with some drops of concentrated sulphuric acid, the product with the molecular formula of $C_4H_6O_3$ was formed and gave out a sweet smell.

(i) Write the formula and the name of the first functional group. **(2 marks)**

(ii) Write the name of the functional group formed in a)(II). **(1 mark)**

b) The second functional group was tested as follows:

I. Some drops of Q were added to 2,4-dinitrophenyl hydrazine and a yellow precipitate was formed.

II. A drop of Q was mixed in a solution of $[Ag(NH_3)_2]^+$, Tollens reagent and heated. A silver mirror was formed on the interior side of the test tube.

Write the name and the formula of the second functional group. **(1 mark)**

c) Write the structural formula of organic compound Q. **(1 mark)**

d) Write the structural formula of two possible geometric isomers of the compound with the molecular formula $C_2H_4O_2$. **(2 marks)**

e) Compound Q was oxidized to give an acid with the molecular formula $C_2H_2O_4$. Write the structural formula of $C_2H_2O_4$. **(1 mark)**

f) Compound Q was reduced to give a compound with the molecular formula $C_2H_6O_2$. Write the structural formula of $C_2H_6O_2$. **(1 mark)**

g) Write the structural formula of the compound formed from the reaction of $C_2H_6O_2$ with excess HBr. **(1 mark)**

17) Nitrogen monoxide reacts with chlorine as shown in the following equation:

$$2NO_{(g)} + Cl_{2(g)} \rightarrow 2NOCl_{(g)}$$

The variations of concentrations of reactants and the rate of the reaction at a certain temperature and constant pressure are shown in the table below:

Experiment	**Initial [NO] concentration in (mol dm^{-3})**	**Initial [Cl_2] concentration in (mol dm^{-3})**	**Initial rate of the reaction in (mol $dm^{-3}S^{-1}$)**
1	0.03	0.01	$3.4x10^{-4}$
2	0.015	0.01	$8.5x10^{-5}$
3	0.015	0.04	$3.4x10^{-4}$

a) Determine the order of the reaction with respect to NO and the order of the reaction with respect to Cl_2 . **(3 marks)**

b) Write the mathematical expression for the rate of the reaction between NO and Cl_2 . **(1 mark)**

c) Calculate the rate constant by using values of experiment 1 and give its units. **(2 marks)**

d) Briefly explain the effect of increasing the temperature on the rate of the reaction. **(2 marks)**

e) Using the concept of activation energy, briefly explain how a catalyst affects the rate of the reaction. **(2 marks)**

18) The atomic number of beryllium and aluminium are 4 and 13 respectively.

a) State 2 similarities between Be and Al in terms of chemical properties. **(2 marks)**

b) Explain why the solubility of sulphates of group 2 elements decreases as you move down the group. **(2 marks)**

c) Study the standard electrode potentials given below and answer the question that follow:

$Mg^{2+}_{(aq)} + 2e \rightarrow Mg_{(s)}$ $\quad E^{\theta} = -2.37$ V

$Fe^{2+}_{(aq)} + 2e \rightarrow Fe_{(s)}$ $\quad E^{\theta} = -0.44$ V

(i) Explain why magnesium is used to galvanize iron. **(2 marks)**

(ii) State the colour change that takes place when an excess amount of magnesium metal is put in a green aqueous solution of $Fe^{2+}_{(aq)}$ then is left to react completely and explain why. **(3 marks)**

d) State 1 use of beryllium on a large scale. **(1 mark)**

19) a) State "Raoult's law" for ideal mixtures of liquids. **(2 marks)**

b) An ideal mixture of two liquids A and B contained 1 mole of A and 4 moles of B. The vapour pressure of pure A was 10 KPa and that of B was 12.5 KPa.

(i) Calculate the partial vapour pressure of A in the mixture. **(1.5 marks)**

(ii) Calculate the partial vapour pressure of B in the mixture. **(1.5 marks)**

(iii) Calculate the total vapour pressure of the liquid. **(1 mark)**

c) Calculate the osmotic pressure in atmospheres at 298 K of a solution (suspension) containing 60 g/litre of solid particles each particle having a mass of $1.10X10^{-19}$ gram. **(4 marks)**

(Avogadro constant = 6.02 X 10^{23})

(Gas constant, R = 0.0823 litre.atm/mol.K)

20) The mass of 6.5g impure copper was dissolved in excess concentrated nitric acid (HNO_3). The solution obtained was made up to 200 ml with water. To 20 ml of this solution, excess aqueous potassium iodide (KI) was added. The reaction that took place is given by the following equation:

$$2Cu^{2+}_{(aq)} + 4I^-_{(aq)} \rightarrow 2CuI_{(aq)} + I_{2(aq)}$$

The iodine (I_2) liberated reacted with 20 ml of 0.5 M sodium thiosulphate ($Na_2S_2O_3$) solution according to the equation:

$$I_{2(aq)} + 2S_2O_3^{2-}{}_{(aq)} \rightarrow 2I\text{-}(aq) + S_4O_6^{2-}{}_{(aq)}$$

a) Calculate the number of moles of thiosulphate ions, $S_2O_3^{2-}$ that reacted in the 20 ml solution. **(2 marks)**

b) Calculate the number of moles of iodine molecules, I_2 formed. **(2 marks)**

c) Calculate the number of moles of copper ions, Cu^{2+} formed in the 200 ml solution. **(2 marks)**

d) Calculate the mass of copper, Cu that reacted in the 6.5g impure sample. **(2 marks)**

e) Calculate the percentage purity by mass of copper, Cu in the 6.5g impure sample. **(2 marks)**

(Atomic mass: Cu=63.5)