Chemistry I
001
28/07/2023   08:30 AM – 11:30 AM

NESA | NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2022-2023

SUBJECT: CHEMISTRY I

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 **THREE** sections: **A, B** and **C**.

   - **Section A**: Attempt **ALL** questions.   **(55 marks)**
   - **Section B**: Attempt any **THREE** questions.   **(30 marks)**
   - **Section C:** Attempt any **ONE** question.   **(15 marks)**

4) **You do not need the periodic table.**

5) Silent-non programmable calculators may be used.

6) Use only a **blue** or **black** pen for answering and a **pencil** for drawing.

SECTION A: ATTEMPT ALL QUESTIONS IN THIS SECTION (55 marks)

1) Air is essentially a mixture of gases and it can be polluted. Read carefully the following statements and answer with True (**T**) or False (**F**).

   a) Carbon monoxide is an air pollutant which causes acidic rain. **(1 mark)**

   b) Catalytic converters are control devices which are added to automobiles and they increase air pollution. **(1 mark)**

   c) Chlorofluorocarbons, CFCs, are responsible for ozone layer depletion.

   (1 mark)

2) In daily life, we use many substances that scientists call acids and bases.

   a) What is an acid-base indicator? **(1 mark)**

   b) Fill in the blanks with a missing correct term:

   (i) The vinegar used in salad dressing contains .... **(1 mark)**

   (ii) When milk turns sour, it contains .... **(1 mark)**

3) In chemistry, salts can be soluble**,** slightly soluble or insoluble.

   a) Define the term "solubility" of a salt. **(1 mark)**

   b) Ammonium carbonate, $(NH_4)_2CO_{3(s)}$ decomposes on heating and gives off three products. Write a balanced chemical equation. **(2 marks)**

   c) The solubility of a salt **AX** in water, is 90 at 20^0C and 105 at 40^0C. Explain. **(1 mark)**

4) Alkanes are saturated hydrocarbons obtained from crude oil.

   a) What is meant by saturated hydrocarbon? **(1 mark)**

   b) State the process by which components of alkanes are obtained from crude oil**.** **(1 mark)**

   c) On which physical property the process in (b) above is based? **(1 mark)**

   d) Give the IUPAC name for a non-branched saturated hydrocarbon with four (4) carbon atoms. **(1 mark)**

5) Ensuring the laboratory safety is the responsibility of everyone working in the laboratory. Choose a correct answer about the safety rules of a laboratory and provide a short explanation to support your choice.

  a) In a laboratory you are allowed to eat and drink only: **(2 marks)**

    (i) If you are very hungry.

    (ii) If you have washed your hands well.

    (iii) If the food is healthy and can be digested fast and easily.

    (iv) If the food has been covered well to avoid contamination.

    (v) None of the above.

  b) In case of acid splashes onto your skin while working in a laboratory, immediately apply: **(2 marks)**

    (i) Oil or lotion.

    (ii) Soap to wash out acids.

    (iii) A strong base to neutralize the acid.

    (iv) Plenty of clean water.

6) The conversion of reactants into products in a chemical reaction is often accompanied by some features (characteristics) which can be observed easily.

  a) State any two characteristics of chemical reactions.   **(2 marks)**

  b) What type of reaction is the reaction below and which of the characteristics of chemical reactions does it exhibit?   **(2 marks)**

$$AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$$

7) Under certain conditions, alkenes can be converted into alcohols and vice versa.

a) Write the reaction equation, with all conditions, to show the product formed when propan-1-ol is heated with sulphuric acid at 170^0C.

(2 marks)

b) Both ethanol and butane are organic compounds. The molecular weight of butane (58) is higher than the molecular weight of ethanol (46), but the boiling point of ethanol (351K) is higher than the boiling point of butane (272K). Explain such a difference.

(2 marks)

8) Carbon dioxide is a colorless, odorless gas produced either by burning carbon or burning organic compounds and by respiration. It is naturally present in air.

a) State one environmental problem caused by the increase of carbon dioxide in the atmosphere. **(1 mark)**

b) Describe any one process or phenomenon that acts to remove carbon dioxide from the atmosphere. **(3 marks)**

9) Carboxylic acids can be obtained by oxidation of alcohols.

a) Give the IUPAC name or chemical formula of an alcohol which can be used to prepare ethanoic acid. **(1 mark)**

b) Write the equation of preparation of ethanoic acid by oxidation of the alcohol in (**a**) above. **(1 mark)**

c) State any three uses of ethanoic acid. **(3 marks)**

10) In a laboratory, oxygen can be prepared by carrying out a thermal decomposition of potassium chlorate in the presence of manganese (IV) oxide as depicted in figure 1.
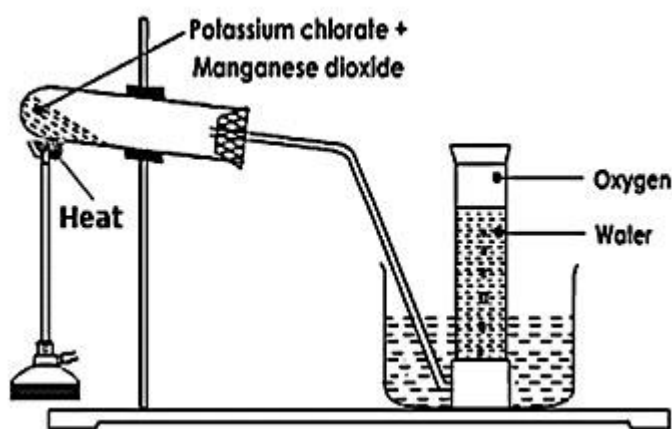

Figure 1

a) Give the chemical formula of manganese (IV) oxide and explain its role in this reaction. **(2 marks)**

b) Oxygen exists in two forms known as allotropes.

(i) Define the term "allotropes". **(1 mark)**

(ii) One of the allotropes of oxygen plays a big role in protecting living things on earth. Give the name or chemical formula for this allotrope. **(1 mark)**

11) A few crystals of lead (II) nitrate were heated strongly. There was formation of a solid residue and two different gases.

a) Write a well-balanced chemical equation for the reaction which occurs. **(1 mark)**

b) The solid residue dissolves in dilute nitric acid to give a colourless solution **Y,** which in turn reacts with potassium iodide solution, KI(aq), to form a yellow precipitate **Z**.

(i) Write the reaction equation of solid residue and dilute nitric acid and identify **Y.** **(2 marks)**

(ii) Give the ionic equation between **Y** and iodide ions to form **Z**. **(2 marks)**

12) A dilute solution of hydrochloric acid, HCl(aq) reacts with magnesium ribbons and magnesium powder in two different reactions as follows:

Reaction (1): HCl(aq) reacts with magnesium ribbons.
Reaction (2): HCl(aq) reacts with magnesium powder.

a) Write the reaction equation between HCl(aq) and magnesium metal with all state symbols for chemicals. **(2 marks)**

b) State the main factor which affects the rates of the two reactions above. **(1 mark)**

c) Compare the reaction (1) with the reaction (2) in terms of rate and amount of products formed. **(2 marks)**

13) When phosphorus burns in air, a bright yellow flame is observed and white fumes of phosphorus (V) oxide are produced.

a) Write a balanced chemical equation for this reaction. **(2 marks)**

b) Air is a mixture of gases in proportions: 78%, 21% and 1% of nitrogen, oxygen and other trace gases, respectively. Given that 133.5 dm^3 of air was required to burn phosphorus completely.

(i) Find the volume, in dm^3, of oxygen which reacted. **(1 mark)**

(ii) Deduce the amount, in grams, of oxygen which reacted. **(1 mark)**

(iii) Calculate the amount, in grams, of phosphorus (V) oxide produced. **(2 marks)**

(Atomic mass: P= 31, O= 16; molar gas volume = 22.4 dm^3/mole)

SECTION B: ATTEMPT ANY THREE (3) QUESTIONS (30 marks)

14) During a laboratory investigation, a student was given a sample that was a mixture of 3.0 grams of NaCl (aq) and 4.0 grams of sand, which was mostly SiO_2(s). The purpose of the investigation was to separate and recover the compounds in the sample. In the first step, a student placed the sample in a 250-mL flask. Secondly, 50 grams of distilled water were added to the flask, and the content was thoroughly stirred. The mixture in the flask was then separated, using the equipment represented by the diagram in figure 2 below.
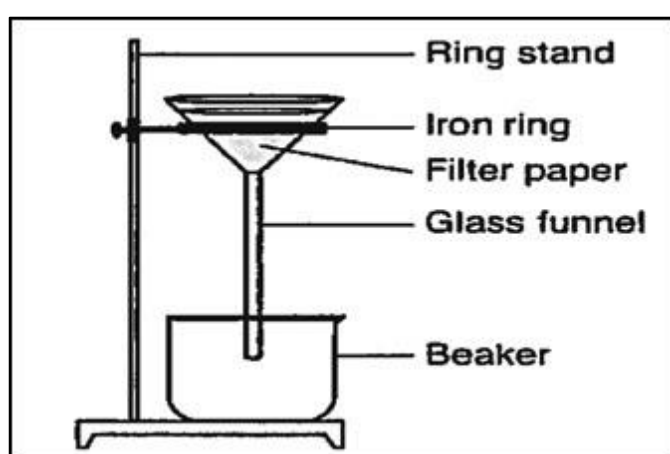

Figure 2

a) Name the technique used to separate the above mixture. **(1 mark)**

b) Explain, in terms of solubility, why the mixture in the flask remains heterogeneous even after thorough stirring. **(2 marks)**

c) State and describe the process which can be used to remove water from the mixture that passes through the filter and collect it in the beaker. **(2 marks)**

d) Differentiate between a mixture and a compound (at least two differences). **(2 marks)**

e) Calculate the percentage of NaCl, sand and water in the mixture NaCl-SiO_2-water. **(3 marks)**

15) During electrolysis two points called electrodes are involved: One which allows the current to enter the electrolyte and another which allows the current to leave the electrolyte.

    a) Name the electrode which allows the current to enter the electrolyte. Give its polarity. **(2 marks)**

    b) Name the electrode which allows the current to leave the electrolyte. Give its polarity. **(2 marks)**

    c) State any two applications of electrolysis. **(2 marks)**

    d) Consider electrolysis of dilute sodium chloride, $NaCl(aq)$ using graphite electrodes.

        (i) Show all the ions present in the solution. **(2 marks)**

        (ii) Which product is obtained at the positive electrode and which one is obtained at the negative electrode? **(2 marks)**

16) Plastic carrier bags and single-use plastics have been identified to negatively impact the environment. This is one of the major reasons which pushed the Government of Rwanda to take a decision of banning such materials (plastic carry bags and single-use plastics).

    a) Define the term "waste material". **(1 mark)**

    b) Differentiate between a biodegradable and a non-biodegradable waste, with one supporting example in each case. **(3 marks)**

    c) State and explain the impact of these plastic carry bags and single-use plastics on environment; soil, water (lakes, oceans), air and health. **(4 marks)**

    d) Formulate any two alternative solutions of materials which can be used in place of plastic carry bags and single-use plastics with less or no impact to the environment. **(2 marks)**

17) The most common laboratory method for preparation of chlorine is to heat manganese (IV) oxide with concentrated hydrochloric acid according to experimental set up shown by figure 3 below.
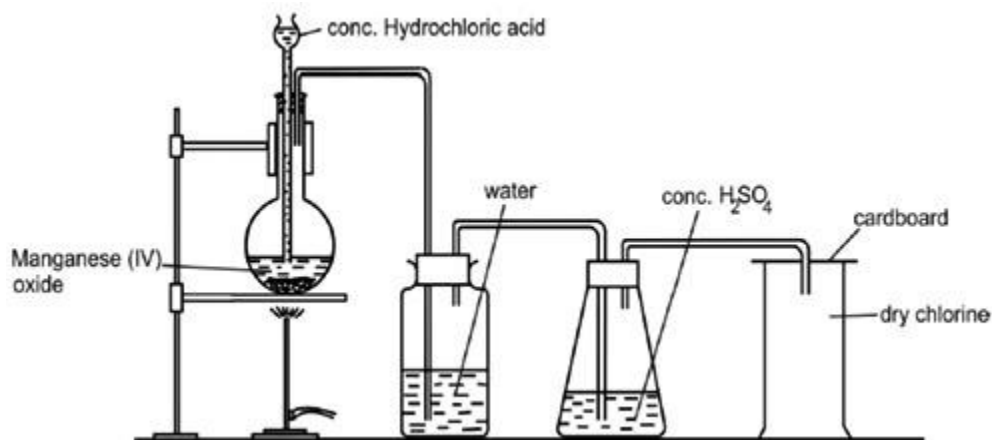

Figure 3

a) Write a balanced chemical equation between manganese (IV) oxide and concentrated hydrochloric acid. **(2 marks)**

b) Explain the role of water and sulphuric acid in this experiment.

(2 marks)

c) Name the method used to collect chlorine gas. **(1 mark)**

d) Justify the choice of collecting chlorine gas by the method named in (**c**) above. **(2 marks)**

e) Outline any three uses of chlorine and its compounds. **(3 marks)**

18) a) On analysis, a compound **P** gave the following percentage composition:

$$Na = 43.4\%, C = 11.3\%, O = 45.3\%$$

(i) Define the term empirical formula of a substance. **(1 mark)**

(ii) Calculate the empirical formula of **P**.
(Atomic mass: Na = 23, C = 12, O = 16) **(4 marks)**

(iii) If **P** has a molecular mass of 106, deduce the molecular formula. **(2 marks)**

b) (i) State the Boyle's law. **(1 mark)**

(ii) A certain mass of a gas occupies 48 mL at a pressure of 720 mm
of Hg. What is the volume when the pressure is increased to
960 mm of Hg? (Temperature remains constant) **(2 marks)**

SECTION C: ATTEMPT ANY ONE (1) QUESTION (15 marks)

19) Crystals of zinc sulphate were prepared using the method described below.
Excess zinc carbonate was mixed with aqueous sulphuric acid in a beaker.
The mixture was warmed until the reaction stopped.
The mixture was filtered to remove the unreacted zinc carbonate.
The filtrate was evaporated until a small volume remained.
The remaining solution was left to cool to form crystals.

a) Write a balanced chemical equation for the reaction between
zinc carbonate and sulphuric acid. **(2 marks)**

b) Why was excess zinc carbonate used? **(1 mark)**

c) Why will a similar method not be suitable for preparing lead
(II) sulphate? **(1 mark)**

d) A salt of zinc sulphate has the formula: $ZnSO_4.7H_2O$. How can
you show with a chemical test that the compound contains
water of crystallization? **(2 marks)**

e) Calculate the percentage by mass of water in $ZnSO_4.7H_2O$.
(Zn = 65; S = 32; O = 16; H = 1) **(3 marks)**

f) The solubility of a solute at 30°C is 40. What amount of water
is required to make a saturated solution of 80 grams of the solute?

(2 marks)

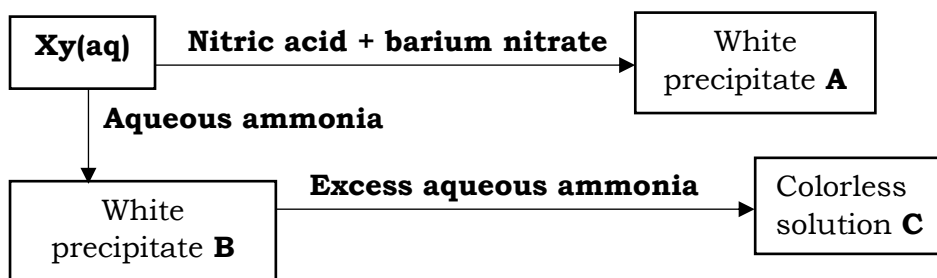g) A reaction scheme involving an unkown salt XY(aq) is shown in the figure 4 below.

Figure 4

Give the names or chemical formulae for: **(4 marks)**

(i) Solutions **XY** and **C**.

(ii) Precipitates **A** and **B**.

20) Students carried out a titration experiment in a laboratory. During that titration, 20 cm^3 of sodium carbonate (Na_2CO_3) reacted completely with 0.15M hydrochloric acid (HCl) in excess, using phenolphthalein indicator. The table below has been used to record the volume of HCl used. (Na = 23, Cl = 35.5, C = 12, O = 16, H = 1, phenolphthalein indicator: colorless-pink)

Titration number	1st	2nd	3rd
Final burette reading (cm^3)	25.0	49.5	73.9
Initial burette reading (cm^3)	0.00	25.0	49.5
Volume of hydrochloric acid used (cm^3)	V1	V2	V3

a) State the expected colour change observed. **(1 mark)**

b) Find the average volume of HCl used. **(2 marks)**

c) Write a balanced chemical equation for the reaction that took place. **(2 marks)**

d) State any other observable change made as the reaction occurs. **(1 mark)**

e) Find:

   (i) The mole ratio between Na_2CO_3: HCl. **(1 mark)**

   (ii) The number of moles of hydrochloric acid used and deduce the moles of Na_2CO_3 reacted. **(2 marks)**

   (iii) The concentration of sodium carbonate, in mol/dm^3. **(2 marks)**

   (iv) The concentration of sodium carbonate, in g/dm^3. **(2 marks)**

f) Draw a typical experimental set up expected to be used in this titration with all necessary equipment labeled. **(2 marks)**

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