4.5 CHEMISTRY (233)

4.5.1 Chemistry Paper 1 (233/1)

1. (a) State **one** property that can be used to distinguish between a proton and a neutron. (1 mark)

(b) An ion of element **Y** has the formula:

$^{40}_{20}Y^{2+}$

(i) Write the electron arrangement of the ion. (1 mark)

(ii) Identify the group and period in the Periodic Table to which the element belongs.

Group ..... (½ mark)

Period ..... (½ mark)

2. (a) Complete **Table 1** by writing the formula and naming the structure of the chlorides of the elements.

Table 1

Element	**Sodium**	**Magnesium**	**Silicon**	**Phosphorus**
Formula of chloride				
Name of the Structure of chloride				

(2 marks)

(b) Select from **Table 1** an acidic chloride and write the equation for its reaction with water. (1 mark)

3. (a) Write a thermochemical equation for the formation of carbon(II) oxide. (1 mark)

(b) Use the energy level diagram in **Figure 1** to answer the questions that follow.

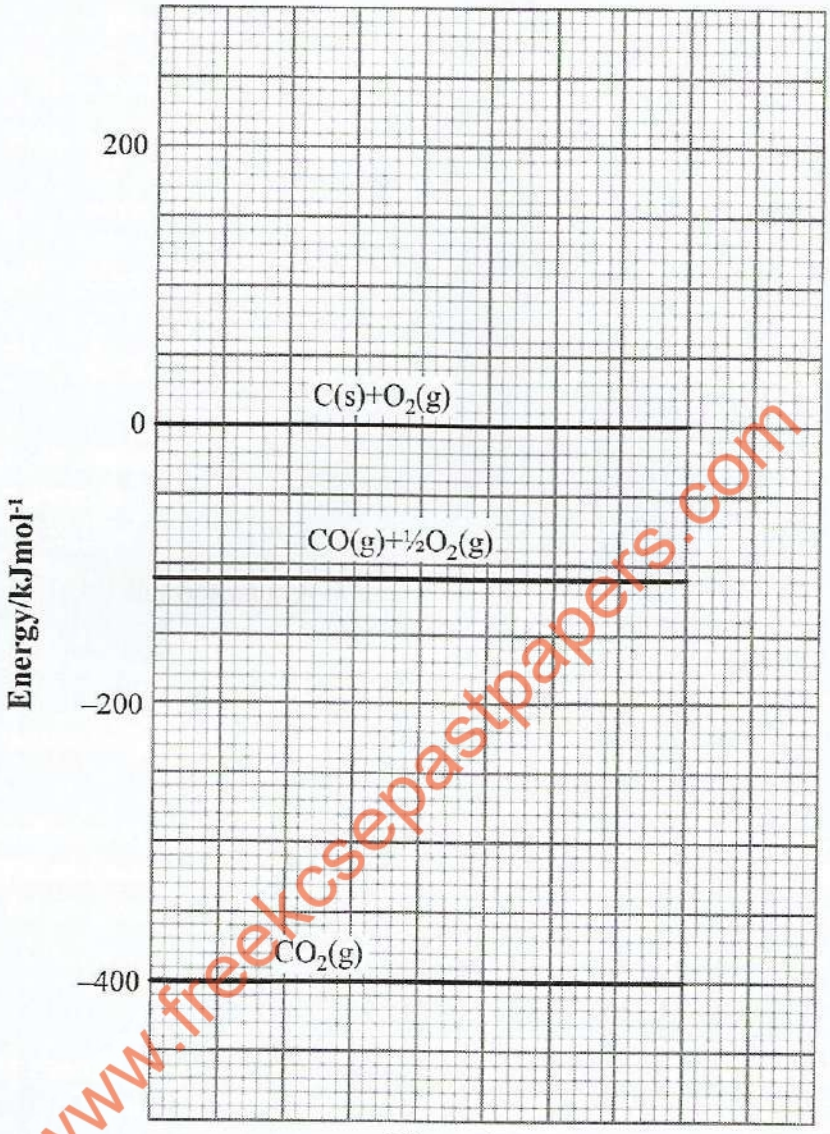


Figure 1 Reaction path

Determine the enthalpy change of:

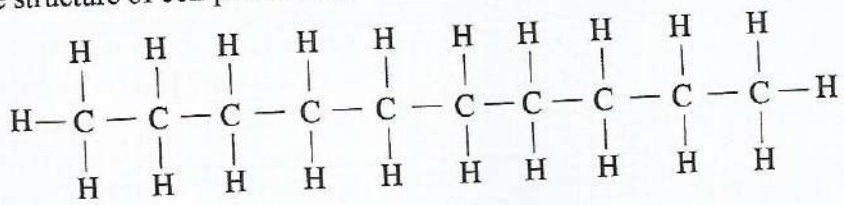
(i) formation of carbon(II) oxide (1 mark)

(ii) combustion of carbon(II) oxide (1 mark)

4. (a) Give a reason why painting or galvanising iron sheets protects them from rusting. (1 mark)

(b) Explain the advantage of galvanising over painting of iron sheets. (2 marks)

5. (a) The structure of compound **A** is:



Give its:

(i) name (1 mark)

(ii) empirical formula (1 mark)

(b) Draw the structure of an alkanoic acid whose molecular formula is $C_5H_{10}O_2$. (1 mark)

6. The following equilibrium exists in a closed system.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g); \quad \Delta H = +27.5\,kJ$$
(Pale yellow) (Brown)

State and explain **two** conditions under which the intensity of the brown colour of the equilibrium mixture can be increased.

Condition I (1½ marks)

Condition II (1½ marks)

7. (a) Determine the oxidation numbers of:

(i) hydrogen in $\mathbf{CaH_2}$ (1 mark)

(ii) oxygen in $\mathbf{OF_2}$ (1 mark)

(b) Write an ionic equation for the reaction between aqueous sodium hydrogen carbonate and ethanoic acid. (1 mark)

8. The mass of one molecule of a hydrocarbon is 9.33×10^{-23}g.
(Avogadro's number = 6.0×10^{23} mol^{-1}, C = 12.0; H = 1.0)

(a) Determine its:

(i) molecular mass (1 mark)

(ii) molecular formula (1 mark)

(b) Draw a structure of the hydrocarbon in 8(a). (1 mark)

9. (a) Water reacts with hydrogen ions:

(i) write the formula of the product formed (½ mark)

(ii) Name the type of bond formed (½ mark)

(b) The melting point of iodine is higher than that of chlorine. Explain. (2 marks)

10. A sample of ammonia gas can be prepared by heating a mixture of ammonium bromide and barium hydroxide.

(a) Write an equation for the reaction. (1 mark)

(b) State why the gas cannot be dried using anhydrous calcium chloride. (1 mark)

(c) Name a suitable drying agent. (1 mark)

11. In an experiment to test for hardness of water from different boreholes, soap solution was added to 1000 cm^3 of water and the volume of soap solution required for lather to start forming recorded. The results are given in **Table 2.**

Table 2

Water sample (1000 cm^3)	Volume of soap solution added (cm^3)	
	Before boiling	After boiling
1	25	3
2	12	8
3	10	10
4	3	3
5	25	24

(a) Select water samples that show:

(i) temporary hardness (½ mark)

(ii) no hardness (½ mark)

(iii) both temporary and permanent hardness (½ mark)

(b) Describe how water hardness can be removed using an ion exchange resin. (1½ marks)

12. Products of electrolysis at the electrodes for aqueous solutions depend on three factors. Two of these factors are concentration of electrolyte and nature of electrode.

(a) State another factor that affects the products of electrolysis. (1 mark)

.....

(b) Complete **Table 3** to show products of electrolysis for dilute calcium chloride and concentrated calcium chloride at the anode and cathode.

Table 3

Electrolyte	Anode	Cathode
Dilute calcium chloride		
Concentrated calcium chloride		

(2 marks)

13. (a) Carbon exhibits different boiling points. Explain. (1 mark)

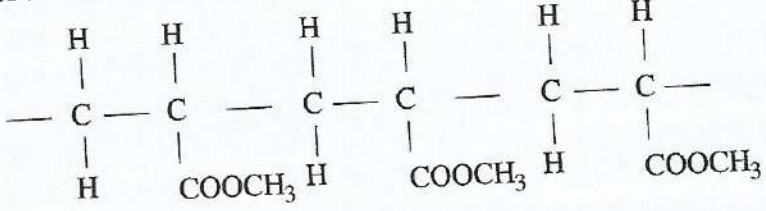
(b) It takes 44 seconds for nitrogen(IV) oxide gas to effuse through an opening. Calculate how long it will take for an equal volume of chlorine gas to effuse through the same opening (2 marks)
(N = 14.0; O = 16.0; Cl = 35.5).

14. (a) Give an example of a natural polymer made of:

(i) cellulose material (½ mark)

(ii) a hydrocarbon (½ mark)

(b) Part of the structure of perspex is:



(i) Draw the structure of the monomer of perspex. (1 mark)

(ii) Give **two** properties of perspex that make it suitable for use in making lenses. (1 mark)

15. Two allotropes of carbon are graphite and diamond.

(a) Explain why the density of diamond is higher than that of graphite. (1 mark)

(b) Give **one** use of each of the allotropes and relate the use to properties of the allotrope.

I. Graphite

use (½ mark)

property (½ mark)

II. Diamond

use (½ mark)

property (½ mark)

16. (a) The graph in **Figure 2** shows radioactive decay curve of a radioactive isotope.

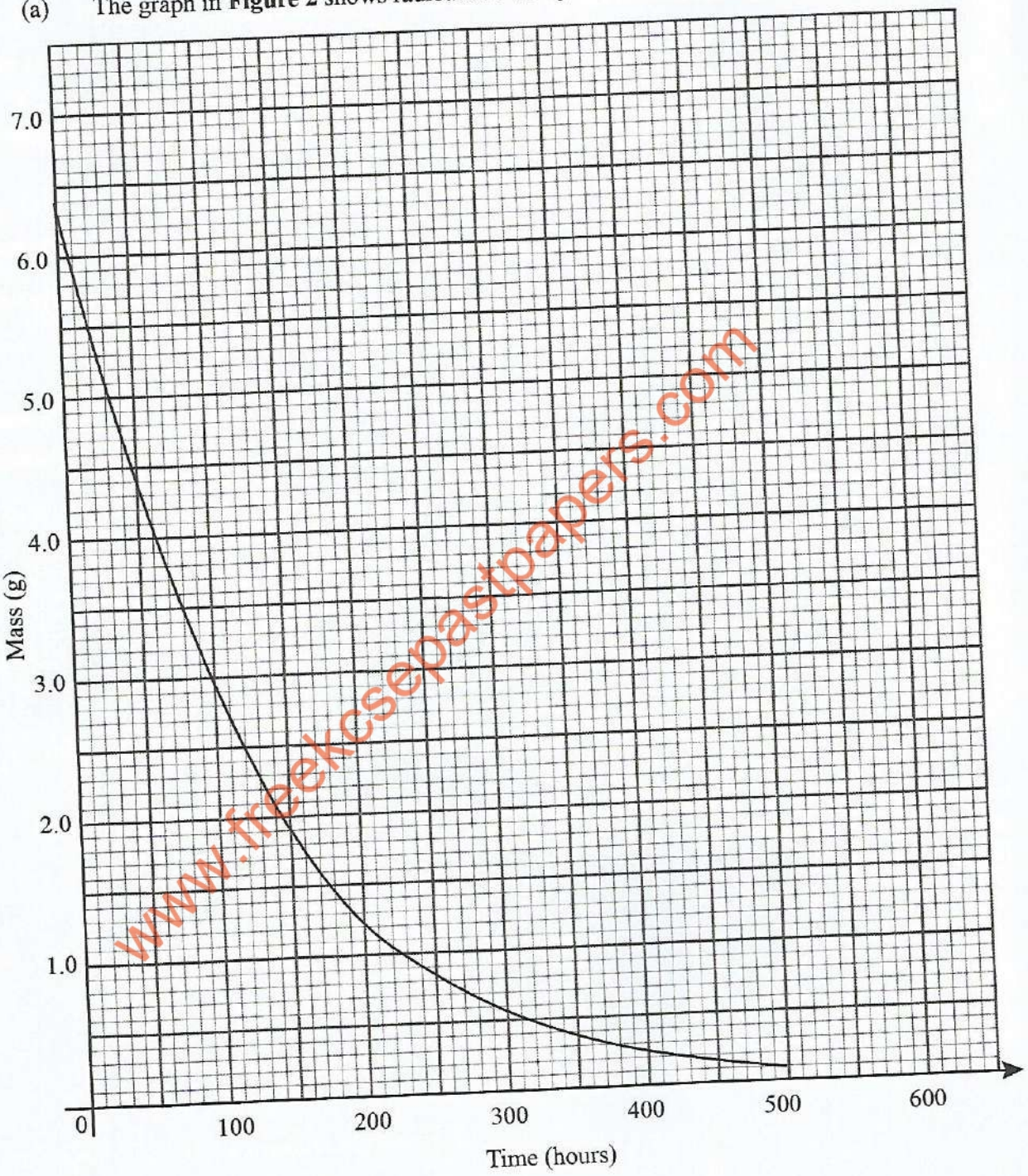


Figure 2

Use the graph to determine the:

(i) half life of the radioactive isotope (1 mark)

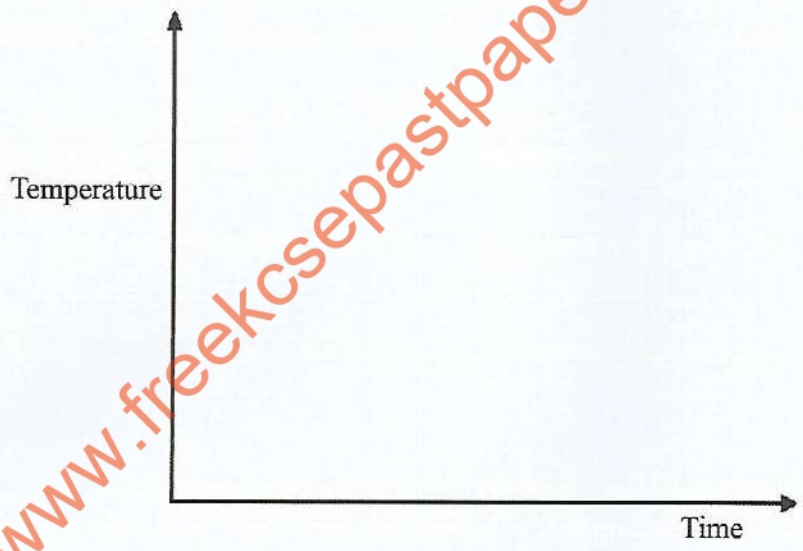
(ii) rate of decay at time 150 hours (1 mark)

(b) The half life of two radioactive isotopes **A** and **B** are 8 days and 5.2 years respectively. Given that both of them emit beta radiation, explain why **A** would be more suitable in the treatment of a disease. (1 mark)

17. The formula of a hydrated salt of manganese is $MnSO_4 \cdot XH_2O$. Given that the salt contains 24.7% manganese, determine the value of **X**. (Mn = 55.0; S = 32.0; O = 16.0; H = 1.0) (3 marks)

18. Describe the correct procedure of heating a liquid in a test tube using a Bunsen burner. (3 marks)

19. The melting and boiling points of naphthalene are 80 °C and 218 °C, respectively. A sample of naphthalene was cooled from 250 °C to 25 °C. On the axes provided, sketch and label the cooling curve that would be obtained. (3 marks)



20. Draw a labelled diagram of a setup that can be used to prepare a dry sample of chlorine gas using potassium manganate(VII) and concentrated hydrochloric acid. (3 marks)

21. **Table 4** gives the boiling points of three liquids.

Table 4

Liquid	Boiling point (°C)
Hexane	68.7
Butanol	99.5
Water	100.0

Describe how the following mixtures can be separated:

(a) hexane and butanol (1½ marks)

(b) hexane and water (1½ marks)

22. Complete **Table 5** by writing the observations made when aqueous ammonia and aqueous sodium sulphate are added to solutions containing calcium, aluminium and iron(II) ions.

Table 5

Ions present	Aqueous ammonia	Aqueous sodium sulphate
Ca^{2+}		
Al^{3+}		
Fe^{2+}		

(3 marks)

23. (a) Iron is extracted from haematite ore. If the ore contains oxides of silicon and aluminium, explain how these impurities are removed. (2 marks)

(b) The extraction process of iron produces waste gases. State how these waste gases can be used to lower the operational cost of the extraction process. (1 mark)

24. When chlorine is bubbled into a sample of water, the solution smells strongly of chlorine. If aqueous sodium hydroxide is added to the solution, the smell of chlorine disappears:

The following equation shows the reaction that occurs.

$$Cl_2(g) + H_2O(l) \rightleftharpoons HCl(aq) + HOCl(aq)$$

With reference to the equation for the reaction, explain why the:

(a) solution smells strongly of chlorine (1 mark)

(b) addition of sodium hydroxide removes the smell (2 marks)

25. **Figure 3** shows how nitric(V) acid can be obtained.

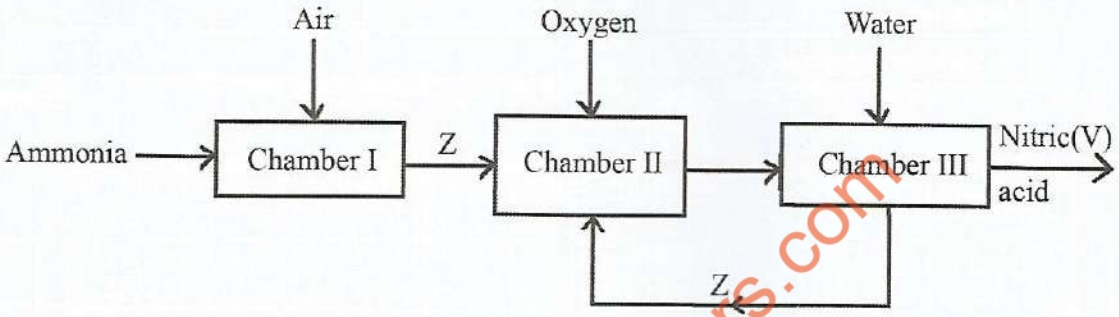


Figure 3

(a) Identify the chamber in which a catalyst is used. (1 mark)

(b) Name substance **Z**. (1 mark)

(c) Write an equation for the reaction that takes place in Chamber **III**. (1 mark)

26. The formula of the complex ion formed when aqueous zinc sulphate reacts with aqueous sodium hydroxide is given as:

$$[Zn(OH)_4]^x$$

Explain how the value of **x** is determined. (2 marks)

27. Copper can be obtained from copper(II) oxide using carbon(II) oxide or coke.

(a) Name another reagent that can be used to obtain copper from copper(II) oxide. (1 mark)

(b) The equation for the reaction with carbon(II) oxide is:

$$CuO(s) + CO(g) \rightarrow Cu(s) + CO_2(g)$$

Calculate the maximum mass of copper that would be obtained using 200 dm^3 of carbon(II) oxide (Cu = 63.5; Molar volume of gas = 24.0 dm^3). (2 marks)

4.5.2 Chemistry Paper 2 (233/2)

1. (a) Aluminium and phosphorus form oxides with general formula M_2O_3. Complete **Table 1** by writing the properties of the oxides.

Table 1

Property	Al_2O_3	P_2O_3
Structure		
Bonding		
Acid/base character		

(3 marks)

(b) The grid in **Figure 1** shows part of the Periodic Table. Use it to answer the questions that follow.

Figure 1

(i) Give the total number of elements that can be placed in:

I. period I (½ mark)

II. period 5 (½ mark)

(ii) Place each of the following elements in the grid:

I. Element X, whose atomic number is 14 (1 mark)

II. Element Y, with the highest first ionisation energy (1 mark)

III. Element Z, with the lowest first ionisation energy (1 mark)

IV. Element L, whose ion L^{2-} has electron arrangement 2.8 (1 mark)

V. Element D, whose ion D^{2+} has electron arrangement 2.8.8 (1 mark)

VI. Element Q, a halogen with the highest atomic radius (1 mark)

VII. Element R, a period 3 element that exists as a monoatomic gas (1 mark)

2. The general formula of alkanols is $C_nH_{2n+1}OH$.

(a) Draw the structure and give the name of the alkanol with n = 5. (2 marks)

Structure

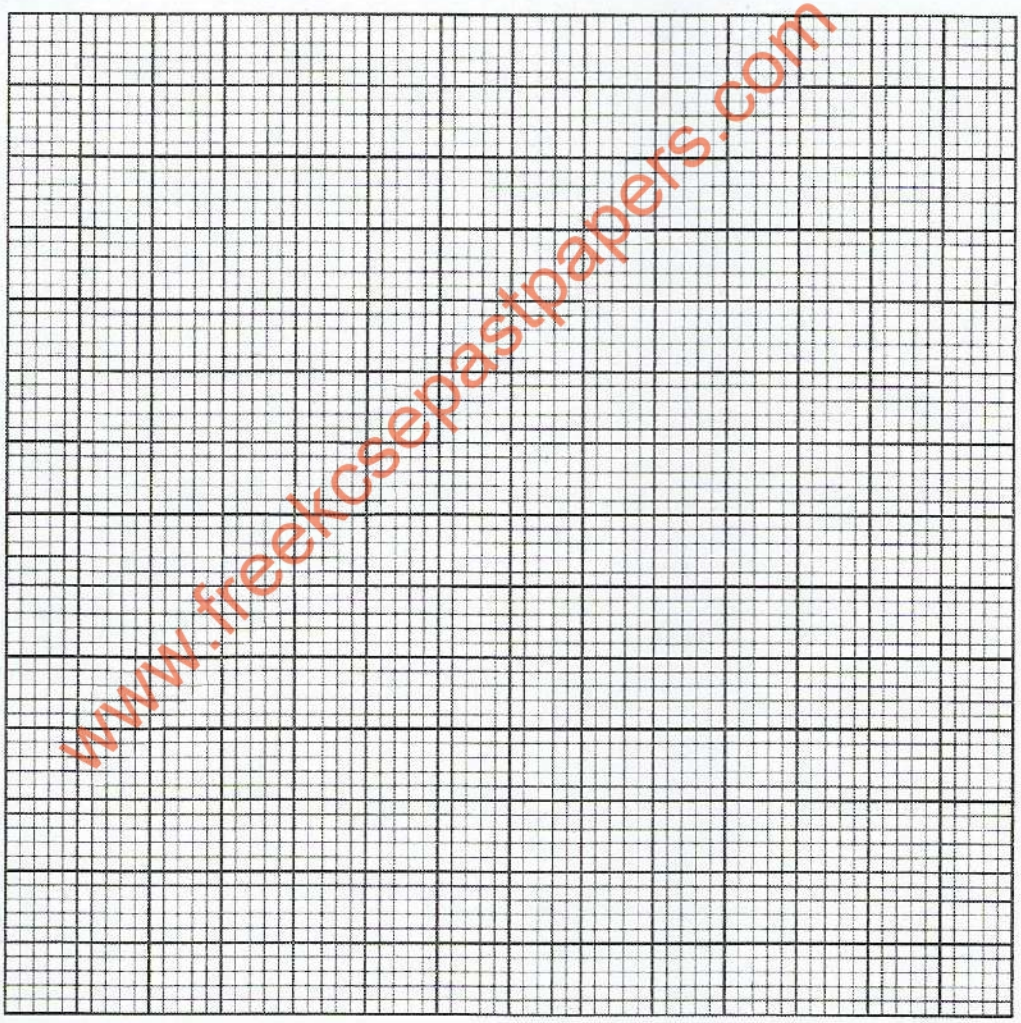
Name

(b) **Table 2** gives the boiling points of some alkanols.

Table 2

n	Boiling point/°C
2	78.5
3	97.2
4	117.0

(i) On the grid provided, draw the graph of boiling point against number of carbon atoms, **n**. (3 marks)



(ii) From the graph, determine the boiling point of the alkanol with n = 5. (1 mark)

(iii) The boiling point of the alkanol with n = 2 is much higher than that of butane. Explain (C = 12.0; H = 1.0; O = 16.0). (2 marks)

(c) Alkanols are used as fuel.

(i) Give another use of alkanols. (1 mark)

(ii) Write an equation for the combustion of the alkanol with n = 2. (1 mark)

(iii) Use the bond energies in **Table 3** to calculate the enthalpy change of combustion of the alkanol with n = 2. (3 marks)

Table 3

Bond	Energy kJ/mol
C – C	348
C – H	412
C – O	360
O – H	463
O = O	496
C = O	743

3. (a) Use the following cell notation to answer the questions that follow:

$Al(s)/Al^{3+}(aq)$ // $Pb^{2+}(aq)$ / Pb(s); $E^{\theta}_{cell} = +1.53\,V$

(i) State what the symbol / represents. (1 mark)

(ii) Write the equation for the cell reaction. (1 mark)

(iii) Given that E^{θ} value for $Pb^{2+}(aq)$ / Pb(s) is $-0.13\,V$ calculate the E^{θ} value for $Al^{3+}(aq)/Al(s)$. (2 marks)

(iv) State **one** use of electrochemical cells. (1 mark)

(b) **Figure 2** shows a cell used to electrolyse water.

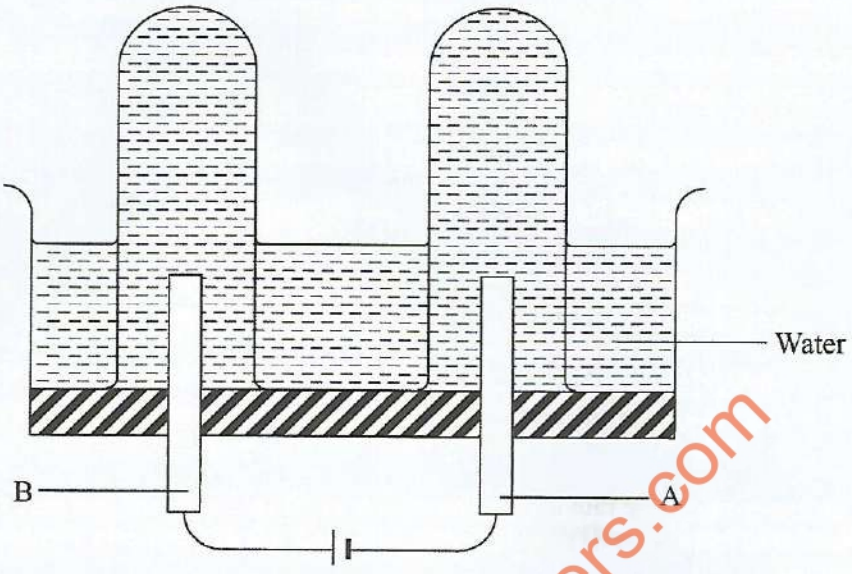


Figure 2

(i) State why it is necessary to add dilute sulphuric(VI) acid to the water. (1 mark)

(ii) State the electrode at which oxygen is produced and give a reason. (1 mark)

(iii) Write an equation for the formation of oxygen. (1 mark)

(iv) After electrolysing the water for 88 seconds, the volume of oxygen gas collected was 23.0 cm^3. Determine the:

I. volume of hydrogen gas collected (1 mark)

II. amount of current used (3 marks)
(1 Faraday = 96500C)

4. (a) State and explain how a catalyst affects:

(i) rate of a reaction (2 marks)

(ii) yield of the products (1 mark)

(b) Rates of reactions are measured using various methods. In the decomposition of hydrogen peroxide, the rate is measured by recording the volume of oxygen gas produced with time.

Other than measuring volume of gas produced, describe a method that can be used to measure the rates of each of the following reactions.

(i) Sodium thiosulphate with hydrochloric acid.

$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(g) + H_2O(l)$ (2 marks)

(ii) Acidified potassium manganate(VII) with iron(II) sulphate.

$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$ (1 mark)

(c) In an experiment, the rate of decomposition of 50 cm^3 of hydrogen peroxide in the presence of manganese(IV) oxide was measured. **Figure 3** shows a graph of the results obtained.

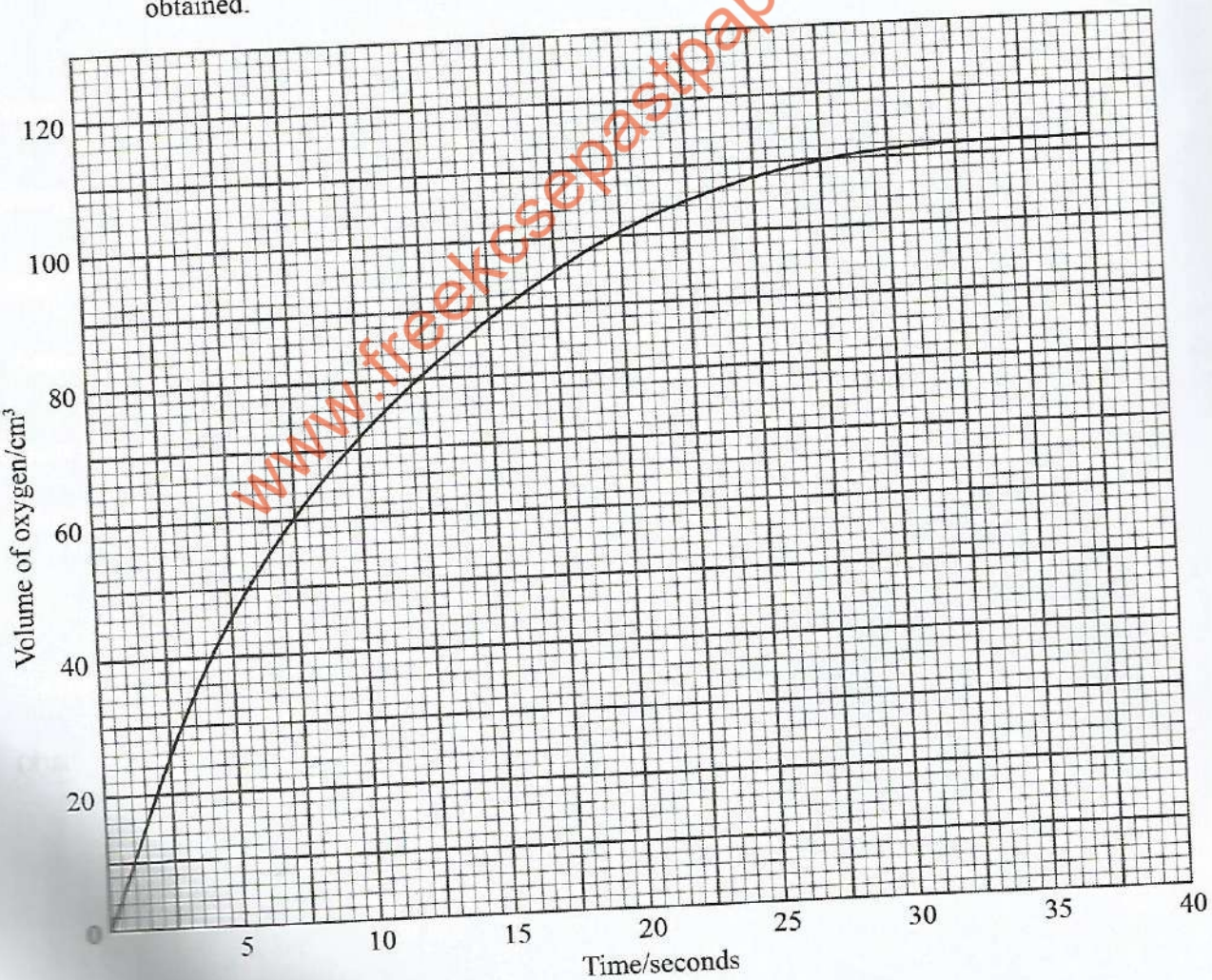


Figure 3

(i) Write an equation for the reaction. (1 mark)

(ii) Using the graph, determine the maximum number of moles of oxygen produced. (Molar gas volume at room temperature and pressure = 24 dm^3). (2 marks)

(iii) Calculate the concentration in moles per litre of hydrogen peroxide. (2 marks)

(iv) Determine the rate of decomposition at the 18th second. (1 mark)

(v) State and explain **one** factor that would increase the rate of decomposition of 50 cm^3 of the hydrogen peroxide. (1 mark)

5. (a) Explain how concentrated sulphuric(VI) acid can be prepared from sulphur(VI) oxide gas and distilled water. (2 marks)

(b) Concentrated sulphuric(VI) acid acts as a dehydrating and as a drying agent.

(i) Give an example of a gas that can be dried using concentrated sulphuric(VI) acid. (1 mark)

(ii) Complete the following equations to show how concentrated sulphuric(VI) acid acts as a dehydrating agent.

I. $C_{12}H_{22}O_{11} \longrightarrow$ (1 mark)

II. $CoCl_2 \cdot 6H_2O \longrightarrow$ (1 mark)

(iii) State the observations made when concentrated sulphuric(VI) acid dehydrates:

I. $C_{12}H_{22}O_{11}$ (1 mark)

II. $CoCl_2 \cdot 6H_2O$ (1 mark)

(c) State the properties of concentrated sulphuric(VI) acid which are illustrated by the following reactions:

(i) $S(s) + 2H_2SO_4(l) \rightarrow 3SO_2(g) + 2H_2O(l)$ (1 mark)

(ii) $NaNO_3(s) + H_2SO_4(l) \rightarrow HNO_3(aq) + NaHSO_4(s)$ (1 mark)

(d) When a mixture of 5 cm^3 ethanol, 1 cm^3 concentrated sulphuric(VI) acid and 5 cm^3 ethanoic acid was heated in a beaker, a pleasant smelling compound was formed.

(i) state the role of the concentrated sulphuric(VI) acid. (1 mark)

(ii) write the formula of the pleasant smelling compound. (1 mark)

6. Various types of cells are used to electrolyse concentrated sodium chloride. One of them is the mercury cell.

(a) Name another type of cell used. (1 mark)

(b) The mercury cell uses titanium or graphite as anode and mercury as cathode. State why steel is not used for the anode. (1 mark)

(c) At the anode, chloride ions and not hydroxide ions are oxidised. Give a reason. (1 mark)

(d) Describe using equations, how sodium hydroxide and hydrogen are produced in the cell. (3 marks)

(e) Give **two** reasons why it is necessary to recycle the mercury used in the cell. (2 marks)

(f) The products of electrolysis of concentrated sodium chloride find extensive use in industries. State the role of chlorine and sodium hydroxide in the paper industry.

(i) Chlorine (1 mark)

(ii) Sodium hydroxide (1 mark)

7. (a) (i) Give the formulae of **two ionic** compounds that can be used to prepare lead(II) sulphide salt. (1 mark)

(ii) Two moles of aqueous ammonia reacted with one mole of phosphoric(V) acid. Write an equation for the reaction that took place. (1 mark)

(b) Solid copper(II) sulphate is available either as anhydrous or hydrated salt. **Figure 4** shows enthalpy changes involved when water is added to each solid.

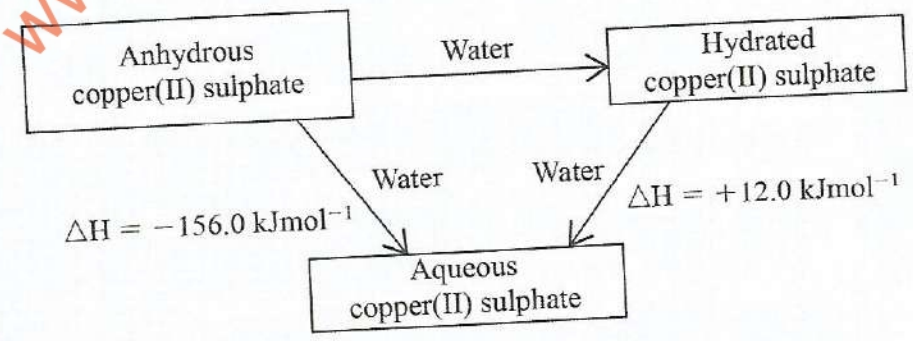


Figure 4

(i) Calculate the enthalpy change for the process:

$$CuSO_4(s) \xrightarrow{\text{Water}} CuSO_4 \cdot 5H_2O(s)$$ (1 mark)

(ii) Describe how each of the following can be prepared starting with aqueous copper(II) sulphate.

I. hydrated copper(II) sulphate. (2 marks)

II. anhydrous copper(II) sulphate. (1 mark)

(c) Aluminium hydroxide is used as an antacid.

(i) Name another compound that is used as an antacid. (1 mark)

(ii) The concentration of hydrochloric acid in the stomach is 0.01 M. If an antacid containing aluminium hydroxide is used, calculate the mass of the antacid required to neutralise 100.0 cm^3 of the stomach acid.

(Al = 27.0; O = 16.0; H = 1.0). (3 marks)

4.5.3 Chemistry Paper 3 (233/3)

1. (a) You are provided with the following:

- **Solution A** – Indicator solution
- **Solution B** – 0.05 M compound B
- **Solution C1** – Hydrochloric acid to be used in Questions 1(a) and 1(b)

You are required to determine the concentration in moles per litre of hydrochloric acid in solution C1.

PROCEDURE I (a)

(i) Place two test tubes in a test tube rack. To the first test tube, place about 2 cm^3 of solution B. To the second test tube, place about 2 cm^3 of solution C1.

(ii) Add 2 drops of indicator solution A to each of the test tubes, shake and note the colour of each solution. Record the colours in **Table 1**.

Table 1

Solution	Colour
Solution B + indicator solution A	
Solution C1 + indicator solution A	

(1 mark)

Complete the following statement:

In the titration of solution B (in a conical flask) with hydrochloric acid using indicator solution A, the colour change at the end point is from ..... to .....

(1 mark)

PROCEDURE II (a)

(i) Using a pipette and pipette filler, pipette 25.0 cm^3 of **solution C1** into a 250 ml volumetric flask. Add distilled water to the mark. Label this as **solution C2**.

(ii) Fill a burette with **solution C2**.

(iii) Using a clean pipette and pipette filler, place 25.0 cm^3 of **solution B** in a 250 ml conical flask.

(iv) Titrate **solution B** with **solution C2** using 3 drops of indicator **solution A**. Record the results in **Table 2**.

Table 2

	I	II	III
Final burette reading			
Initial burette reading			
Volume of solution **C2** used, cm^3			

(4 marks)

Calculate the:

(i) average volume of **solution C2** used. (1 mark)

(ii) number of moles of **compound B** used. (1 mark)

(iii) number of moles of hydrochloric acid used (1 mole of compound B reacts with 2 moles of hydrochloric acid). (1 mark)

(iv) concentration in moles per litre, of hydrochloric acid in **solution C2**. (1 mark)

(v) concentration in moles per litre, of hydrochloric acid in **solution C1**. (1 mark)

(b) You are provided with **two** portions of **solid D**, sodium hydrogen carbonate each weighing **2.5 g**.

You are required to determine the heat of reaction of hydrochloric acid with aqueous sodium hydrogen carbonate.

PROCEDURE I (b)

(i) Using a 100 ml measuring cylinder, measure 30 cm^3 of distilled water and place it in a 100 ml plastic beaker.

(ii) Measure the temperature of the distilled water and record in **Table 3**.

(iii) Add one of the portions of **solid D** to the water. Stir with the thermometer and measure the minimum temperature reached. Record the reading in **Table 3**.

Table 3

Final temperature of the solution, °C	
Initial temperature of water, °C	
Temperature change, °C	

(1½ marks)

Calculate the:

(i) heat change of the solution (assume specific heat capacity of solution = 4.2 Jg^{-1} per degree, density of solution = 1.00 g cm^{-3}) (1 mark)

(ii) number of moles of sodium hydrogen carbonate, **solid D** used (relative formula mass = 84) (1 mark)

(iii) heat change, ΔH_1 in $kJmol^{-1}$ of sodium hydrogen carbonate (1 mark)

PROCEDURE II (b)

(i) Clean the 100 ml plastic beaker.

(ii) Repeat **procedure I (b)** using the second portion of **solid D** and 30 cm^3 of **solution C1** instead of 30 cm^3 of distilled water.

(iii) Record the results in **Table 4**.

Table 4

Final temperature of solution °C	
Initial temperature of solution C1, °C	
Temperature change, °C	

(1½ marks)

Calculate the:

(i) heat change of the solution (assume specific heat capacity of solution = 4.2 Jg^{-1} per degree, density of solution = 1.00 g cm^{-3}) (1 mark)

(ii) heat change, ΔH_2 in $kJmol^{-1}$ of sodium hydrogen carbonate (1 mark)

(iii) heat change, $\Delta H_3 = \Delta H_2 - \Delta H_1$ for the reaction of hydrochloric acid and one mole of aqueous sodium hydrogen carbonate (1 mark)

2. You are provided with an organic compound, **solid M**.

Carry out the following tests and record the observations and inferences in the spaces provided.

(a) Place about one-fifth of **solid M** on a metallic spatula and burn it using a Bunsen burner flame.

Observations	Inferences

(1 mark) (1 mark)

(b) Place the remaining amount of **solid M** in a boiling tube. Add about 15 cm^3 of distilled water and shake to dissolve. Use about 2 cm^3 portions of the solution, in a test tube, for each of the following tests.

(i) To the first portion, add 3 drops of acidified potassium dichromate(VI). Warm the mixture.

Observations	Inferences

(1 mark) (1 mark)

(ii) To the second portion, add 3 drops of bromine water.

Observations	Inferences

(1 mark) (1 mark)

(iii) To the third portion, add **all** the solid sodium carbonate provided. Test any gases produced with a burning splint.

Observations	Inferences

(1 mark) (1 mark)

3. You are provided with **solution N**. Carry out the following tests and record the observations and inferences in the spaces provided. Use about 2 cm^3 portions, in a test tube, for each of the tests.

(a) To the first portion, add aqueous sodium hydroxide dropwise until in excess.

Observations	Inferences

(1 mark) (1 mark)

(b) Warm the second portion and then add aqueous ammonia dropwise until in excess.

Observations	Inferences

(1 mark) (1 mark)

(c) To the third portion, add 3 drops of aqueous barium nitrate. Shake and then add about 1 cm^3 dilute nitric(V) acid.

Observations	Inferences

(2 marks) (1 mark)

(d) Place about 1 cm^3 of aqueous sodium hydroxide in a test tube, then add the fourth portion of **solution N**.

(i) Heat the mixture and test any gases produced with red litmus paper.

Observations	Inferences

(1 mark) (1 mark)

(ii) Rewarm the mixture obtained in (d)(i) above, then add the piece of folded aluminium foil provided. Test any gases produced with red litmus paper.

Observations	Inferences

(1 mark) (1 mark)

Identify a cation and two anions in **solution N**.

Cation: (½ mark)

Anions: (½ mark)