THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

233/2 — CHEMISTRY — Paper 2

(THEORY)

Mar. 2021 – 2 hours

Name ..... **Index Number** .....

Candidate's Signature ..... **Date** .....

Instructions to candidates

(a) *Write your name and index number in the spaces provided above.*
(b) *Sign and write the date of examination in the spaces provided above.*
(c) *Answer **all** the questions in the spaces provided in this booklet.*
(d) ***Non-programmable** silent electronic calculators and KNEC mathematical tables may be used.*
(e) *All working **must** be clearly shown where necessary.*
(f) ***This paper consists of 15 printed pages.***
(g) ***Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.***
(h) ***Candidates should answer the questions in English.***

For Examiner's Use Only

Question	Maximum Score	Candidate's Score
1	13	
2	14	
3	13	
4	12	
5	14	
6	14	
Total Score	80	

1. Crude oil is a mixture of hydrocarbons which are separated by fractional distillation. One of the components obtained contains an alkane **A**, with eleven carbon atoms.

(a) Write the molecular formula of **A**. (1 mark)

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(b) Pentane can be obtained from compound **A** as shown.

A → Pentane + B

(i) Give the name of this conversion process. (1 mark)

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(ii) State the conditions used in this process. (1 mark)

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(iii) Give the name of compound B. (1 mark)

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(c) Draw and name **two** isomers of pentane. (4 marks)

Isomer 1 **Structure** **Name**

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Isomer 2	Structure	Name

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(d) Incomplete combustion of pentane may result in air pollution. Write an equation to illustrate this combustion. (1 mark)

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(e) The main component in natural gas is methane. Describe how methane in natural gas is formed. (2 marks)

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(f) In the laboratory, methane can be prepared from salts of alkanoic acids. Describe how methane is prepared from sodium ethanoate. (2 marks)

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2. (a) (i) State what is meant by the term 'dynamic equilibrium'. (1 mark)

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(ii) Dichromate(VI) ions are orange in colour while chromate(VI) ions are yellow. Consider the following equilibrium.

$Cr_2O_7^{2-}(aq) + 2OH^-(aq) \rightleftharpoons 2CrO_4^{2-}(aq) + H_2O(l)$

State and explain the observation that will be made if sulphuric(VI) acid is added to the mixture. (2 marks)

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(b) One of the reactions in the manufacture of nitric(V) acid involves catalytic oxidation of ammonia as shown in the equation.

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)\ ;\ \Delta H = -909\ kJmol^{-1}$

The reaction is carried out at a pressure of 10 atmospheres and a temperature of 900 °C

(i) Other than nitric(V) acid, name another product that is formed. (1 mark)

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(ii) State and explain the effect on the position of equilibrium if the reaction is carried out:

I. at 10 atmospheres pressure and 450 °C; (2 marks)

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II. at 900 °C and 20 atmospheres pressure; (2 marks)

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III. in the absence of a catalyst. (1 mark)

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(c) State and explain the effect on the rate of the reaction if the reaction is carried out at 10 atmospheres and 450 °C. (2 marks)

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(d) A factory uses 100 kg of ammonia each day to produce 160 kg of nitrogen(II) oxide. Calculate the percentage yield of nitrogen(II) oxide. (3 marks)

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3. (a) One of the ores of iron is haematite, Fe_2O_3. Give the name and formula of **two** other ores of iron. (2 marks)

	Name	Formula
(i)	.....	.....
(ii)	.....	.....

(b) In a certain factory, iron is extracted from the haematite ore using the blast furnace as shown in **Figure 1**. The other raw materials are coke, limestone and air. The melting and boiling points of iron are 1535 °C and 3000 °C, respectively.

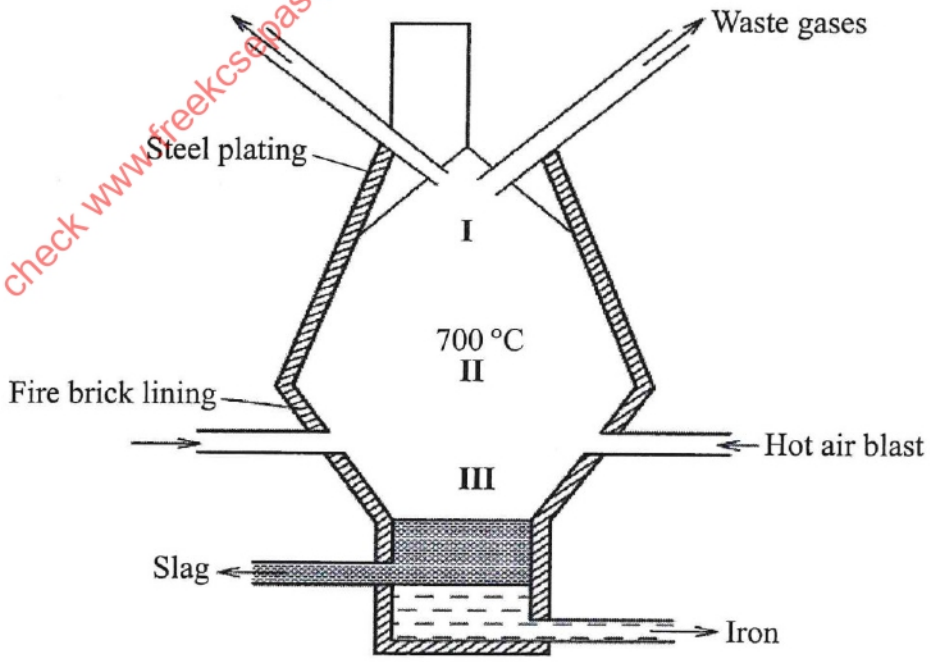

Figure 1

(i) State how the temperature in region **I** compares with that in region **II**. Give a reason. (1 mark)

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(ii) The main reducing agent in the furnace is carbon(II) oxide formed by the reaction:

$CO_2(g) + C(s) \rightarrow 2CO(g)$

Write **two** equations to show how carbon(IV) oxide is formed in the furnace. (2 marks)

I. .....

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II. .....

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(iii) Suggest a value for the temperature in region **III**. Give a reason. (2 marks)

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(iv) Name the main component in the slag. (1 mark)

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(v) State **one** role that slag plays in the blast furnace. (1 mark)

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(vi) The iron produced in the blast furnace is brittle due to presence of impurities.

I. Name the main impurity in this iron. (1 mark)

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II. State **one** use of this iron. (1 mark)

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(vii) Recycling is one method used to reduce production costs. State and explain the by products that can be recycled in this factory. (2 marks)

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4. **Table 1** shows the elements in period 3 of the periodic table. Study it and answer the questions that follow.

Table 1

Element	Na	Mg	Al	Si	P	S	Cl	Ar

(a) Write the formulae of **two** oxides, for each of the following:

(i) sodium: Oxide I ..... Oxide II ..... (1 mark)

(ii) chlorine Oxide I ..... Oxide II ..... (1 mark)

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(b) The products of the reaction between phosphorus and chlorine depend on the conditions used. Write the equation for the reaction when chlorine reacts with excess phosphorus. (1 mark)

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(c) Identify the element with the highest electrical conductivity. Give a reason. (2 marks)

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(d) Describe an experiment that can be used to illustrate the variations in reaction of sodium, magnesium and aluminium with water. (3 marks)

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(e) State and explain the differences in the melting points of:

(i) chlorine and argon. (2 marks)

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(ii) magnesium oxide and silicon(IV) oxide. (2 marks)

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5. **Table 2** gives standard reduction potentials for some half cells.

Table 2

Half cell	Half cell equation	E^{θ} / V
I	$Fe^{3+}(aq) + e \rightarrow Fe^{2+}(aq)$	**+ 0.77**
II	$K^{+}(aq) + e \rightarrow K(s)$	**– 2.92**
III	$Ag^{+}(aq) + e \rightarrow Ag(s)$	**+ 0.80**
IV	$Pb^{2+}(aq) + 2e \rightarrow Pb(s)$	**– 0.13**
V	$I_2(aq) + 2e \rightarrow 2I^{-}(aq)$	**+ 0.54**

(a) State the standard conditions of an electrochemical cell. (2 marks)

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(b) An electrochemical cell was constructed using half-cells **III** and **IV**.

(i) Complete **Figure 2** by labelling the parts of the cells indicated as $A_1 - A_4$ (2 marks)

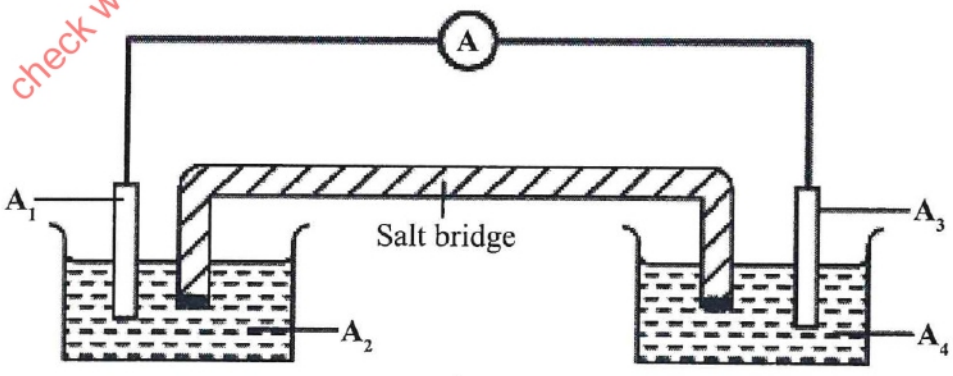

Figure 2

A_1 .....

A_2 .....

A_3 .....

A_4 .....

(ii) Write an equation for the cell reaction and calculate the e.m.f. of the cell.

Equation (1 mark)

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e.m.f. (1 mark)

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(iii) The salt bridge helps in completing the circuit. Explain why a saturated solution of potassium chloride is **not** suitable for use in the salt bridge in this electrochemical cell.

(1 mark)

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(c) State why it is **not** possible to construct a similar electrochemical cell using half-cells **II** and **III**. (1 mark)

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(d) State and explain the observations made when aqueous potassium iodide is added to aqueous iron(III) sulphate. (2 marks)

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(e) Acidified potassium dichromate(VI) and acidified potassium manganate(VII) may be used in determining concentration of Fe^{2+} ions in a sample. If acidified potassium dichromate(VI) is used, an indicator is added to determine the end point but for acidified potassium manganate(VII), no indicator is added.

(i) Explain why it is **not** necessary to use an indicator when acidified potassium manganate(VII) is used. (1 mark)

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(ii) An alloy containing iron was dissolved in an acid and the total volume made up to 250 cm^3. 25.0 cm^3 of this solution required 18.0 cm^3 of 0.15 M acidified potassium dichromate(VI) to react completely. The equation for the reaction is:

$Cr_2O_7^{2-}(aq) + 6Fe^{2+}(aq) + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$

Calculate the mass of iron in the alloy (Fe = 56.0). (3 marks)

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6. (a) Water containing hydrogen carbonate, HCO_3^-, and calcium Ca^{2+} ions, is said to be hard water.

(i) Describe **one** way in which HCO_3^- ions get into river water. (1 mark)

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(ii) Explain the disadvantage of using this type of water in boilers. (2 marks)

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(b) Analysis of a river water sample showed the presence of the following ions: Ca^{2+}, Na^+, Cl^-, NO_3^-.

(i) Name the type of water hardness present in the sample. (1 mark)

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(ii) Describe **one** precipitation method that can be used to soften the water. (2 marks)

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(iii) The water sample was passed through a resin as shown in **Figure 3.**

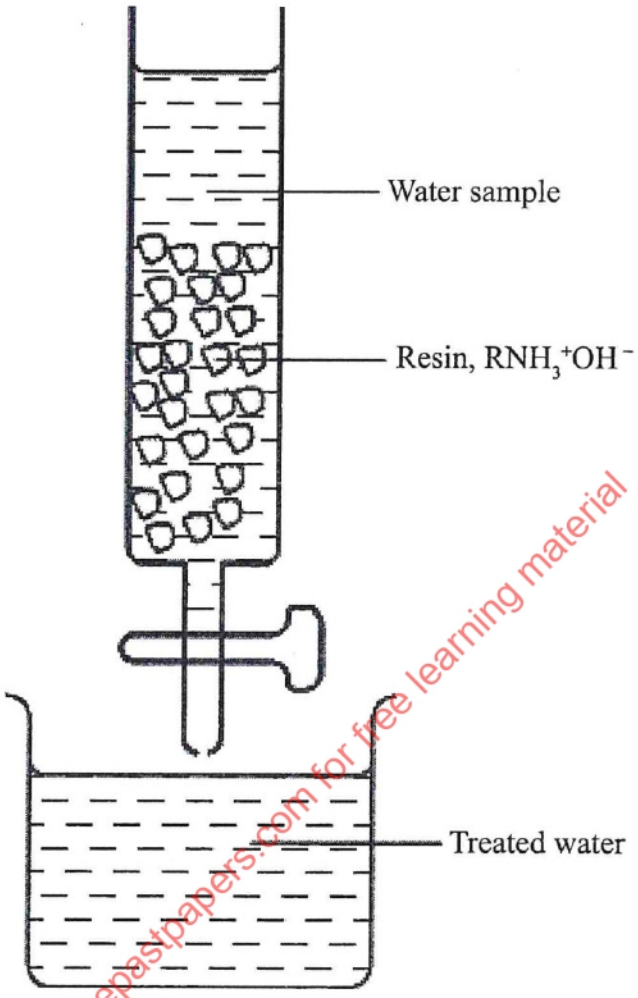

Figure 3

I. Write an equation for a reaction that took place in the column. (1 mark)

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II. Complete treatment of the water sample required passing it through another resin. Give the formula of this resin. (1 mark)

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III. Explain why a river water sample that has been treated using resins may still require boiling to make it safe for drinking. (2 marks)

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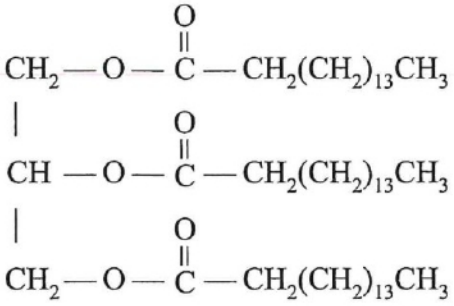
(c) Compound **C** was used to prepare a potassium soap.



Compound **C**

(i) Give the formula of the potassium soap obtained. (1 mark)

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(ii) State **one** difference in the properties of potassium and sodium soaps. (1 mark)

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(d) A soapless detergent has the formula
$CH_3(CH_2)_{10}CH_2OSO_3Na$

With reference to this formula, identify the hydrophobic and the hydrophilic parts of the detergent.

Hydrophobic (1 mark)

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Hydrophilic (1 mark)

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THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

233/3 — CHEMISTRY — Paper 3

(PRACTICAL)

Apr. 2021 – 2¼ hours

Name ..... Index Number .....

Candidate's Signature ..... Date .....

Instructions to candidates

(a) *Write your name and index number in the spaces provided above.*
(b) *Sign and write the date of examination in the spaces provided above.*
(c) *Answer **all** the questions in the spaces provided in the question paper.*
(d) *You are **not** allowed to start working with the apparatus for the first 15 minutes of the 2¼ hours allowed for this paper. This time is to enable you to read the question paper and make sure you have all the chemicals and apparatus that you may need.*
(e) *All working **must** be clearly shown where necessary.*
(f) ***Non-programmable** silent electronic calculators and KNEC mathematical tables may be used.*
(g) ***This paper consists of 8 printed pages.***
(h) ***Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.***
(i) ***Candidates should answer the questions in English.***

For Examiner's Use Only

Question	Maximum Score	Candidate's Score
1	21	
2	10	
3	09	
Total Score	40	

1. You are provided with:

- 5.3 g **solid A**, sodium carbonate;
- **Solution B**, hydrochloric acid.

You are required to determine the:

- Molar heat of the solution of **solid A**;
- Concentration of the hydrochloric acid, **solution B**.

PROCEDURE I

Using a burette, place 30.0 cm^3 of distilled water in a 100 ml plastic beaker. Stir the water with a thermometer and measure its temperature after every half-minute interval. Record the readings in **Table 1**.

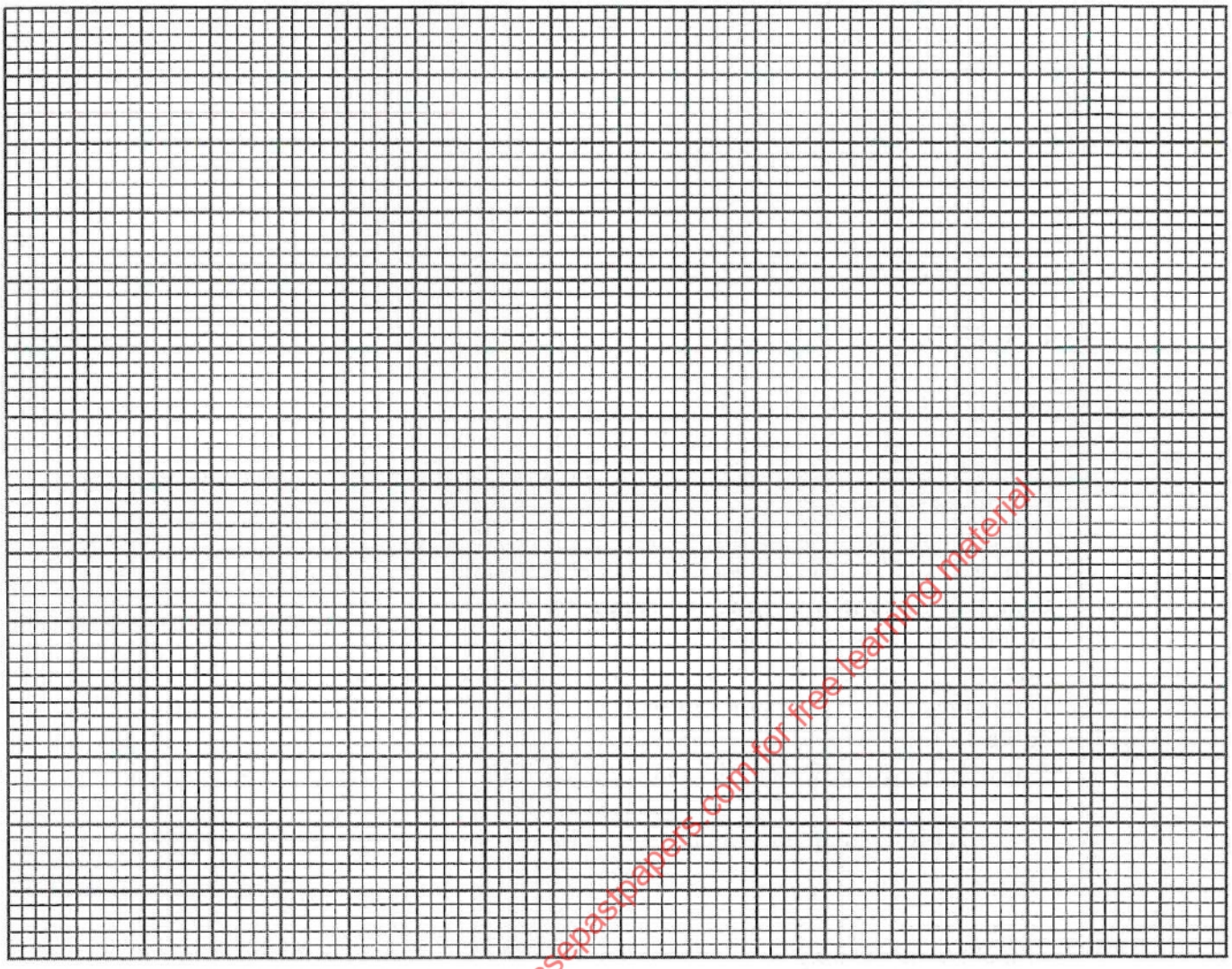
At exactly 2 minutes, add **all** of solid **A** to the water at once. Stir well and continue measuring the temperature of the mixture after every half-minute interval. Record the readings in **Table 1**. **Retain the mixture in the beaker for use in Procedure II.**

(a) **Table 1**

Time (minutes)	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Temperature (°C)	25	26	25	25	X	32	33	34	34	34	34

(3 marks)

(b) On the grid provided, plot a graph of temperature (vertical axis) against time.



(3 marks)

(c) Determine from the graph, the temperature change, ΔT. (1 mark)

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(d) Calculate the:

(i) number of moles of **solid A** used. (RFM = 106) (1 mark)

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(ii) molar enthalpy of solution, ΔH_{soln} and show the sign of ΔH_{soln}.
(Assume that for the solution, density = $1.0\,gcm^{-3}$ and specific heat capacity = $4.2\,Jg^{-1}K^{-1}$) (2 marks)

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PROCEDURE II

(i) Fill a burette with **solution B**.
(ii) Transfer all of the mixture in the 100 ml plastic beaker from **procedure I** into a 250 ml volumetric flask. Add distilled water to make up to the mark and shake. Label the mixture as **solution A**.
(iii) Using a pipette and pipette filler, place 25.0 cm^3 of **solution A** into a 250 ml conical flask. Add two or three drops of phenolphthalein indicator and titrate with **solution B**. **Do not pour out the contents of the conical flask.**
Record the readings in **Table 2**
Add two or three drops of methyl orange indicator to the contents of the conical flask. Titrate the mixture with **solution B** and record the readings of this second titration in **Table 3**.
Repeat **Procedure II**, step **(iii)** and complete **Tables 2** and **3**.

(e) (i) **Table 2**, using phenolphthalein indicator.

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

(3 marks)

Average volume, V_1, of **solution B** used = ... ($\frac{1}{2}$ mark)

(ii) **Table 3**, using methyl orange indicator.

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

(3 marks)

Average volume, V_2, of **solution B** used = ($\frac{1}{2}$ mark)

(f) Calculate the:

(i) concentration, in moles per litre, of sodium carbonate in **solution A**. (1 mark)
RFM = 106

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(ii) number of moles of sodium carbonate in 25.0 cm^3 of **solution A**. (1 mark)

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(iii) number of moles of hydrochloric acid in the total volume, $V_1 + V_2$, of **solution B**. (1 mark)

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

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2. You are provided with **solid C**. Carry out the following tests. Write the observations and inferences in the spaces provided.

Place **all** of **solid C** in a boiling tube. Add about 20 cm^3 of distilled water and shake until all of the solid dissolves. Label the solution as **solution C**. Use about 2 cm^3 of **solution C** in a test tube for each of the following tests.

(a) Add aqueous sodium hydroxide dropwise until in excess.

Observations	Inferences

(1 mark) (2 marks)

(b) Add **three** drops of aqueous sodium sulphate.

Observations	Inferences

(1 mark) (1 mark)

(c) Add **three** drops of aqueous barium nitrate.

Observations	Inferences

(1 mark) (2 marks)

(d) Add **three** drops of aqueous lead(II) nitrate. Heat the mixture.

Observations	Inferences

(1 mark) (1 mark)

3. You are provided with an organic compound, **solid D**. Carry out the following tests. Record the observations and inferences in the spaces provided.

(a) Describe the appearance of **solid D**. (1 mark)

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(b) Divide **solid D** into **four** portions.

(i) Place the first portion of **solid D** on a watch glass and burn it with a Bunsen burner flame.

Observations	Inferences

(1 mark) (1 mark)

(ii) Place the second portion of **solid D** in a test tube. Add about 3 cm^3 of aqueous sodium hydroxide and shake.

Observations	Inferences

(1 mark) (1 mark)

(iii) Place the third portion of **solid D** in a test tube. Add about 3 cm^3 of distilled water. Heat the mixture and add **three** drops of acidified potassium manganate(VII).

Observations	Inferences

(1 mark) (1 mark)

(iv) Place the fourth portion of **solid D** in a test tube. Add about 3 cm^3 of distilled water. Heat the mixture and add **all** the solid sodium hydrogen carbonate provided.

Observations	Inferences

(1 mark) (1 mark)

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