



Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination
Sample 2

Chemistry

Ordinary Level

2 hours 30 minutes

300 marks

Examination Number

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Date of Birth

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For example, 3rd February
2005 is entered as 03 02 05

Centre Stamp

Instructions

There are seven questions on this paper. Each question carries 50 marks.

Answer **Question 1** and any **five other** questions.

Write your Examination Number and your Day, Month and Year of Birth in the boxes on the front cover.

Write your answers in blue or black pen. You may use pencil in graphs and diagrams only.

This examination booklet will be scanned and your work will be presented to an examiner on screen. All of your work should be presented in the answer areas, or on the given graphs, or diagrams. Anything that you write outside of these areas may not be seen by the examiner.

Write all answers into this booklet. There is space for extra work at the back of the booklet. If you need to use it, label any extra work clearly with the question number and part.

The superintendent will give you a copy of the *Formulae and Tables* booklet. You must return it at the end of the examination. You are not allowed to bring your own copy into the examination.

Data from the *Formulae and Tables* booklet, including atomic numbers and relative atomic masses, should be used wherever necessary.

You may lose marks if your solutions do not include relevant supporting work.

You may lose marks if the appropriate units of measurement are not included, where relevant.

You may lose marks if your answers are not given in their simplest form, where relevant.

Diagrams are generally not drawn to scale.

Write the make and model of your calculator(s) here:

Question 1

- (a)** The Russian scientist Dmitri Mendeleev developed an early version of the periodic table of the elements.
- (i)** State two ways in which the modern periodic table differs from that developed by Mendeleev.

[illegible]

The element potassium (K) is located in Group 1 of the periodic table. Potassium is highly reactive.

- (ii) Explain how the reactive nature of potassium is related to its position in the periodic table.

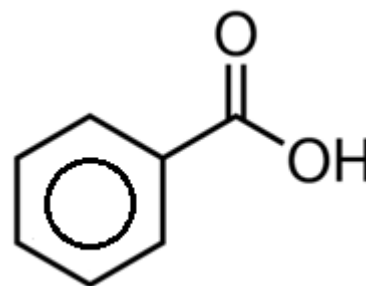
[illegible]

The element neon (Ne) is located in Group 18 of the periodic table. Neon is highly unreactive.

- (iii) Explain how the unreactive nature of neon is related to its position in the periodic table.

A large rectangular area filled with a light gray grid pattern, intended for drawing or sketching. The grid consists of small squares. A thick black vertical line runs along the left edge of the grid, separating it from the writing area.

- (b)** Benzoic acid can be prepared in the laboratory by means of chemical synthesis. A molecule of benzoic acid is shown in the diagram.



- (i) Two of the compounds listed below are used in the laboratory synthesis of benzoic acid.
Place a tick (✓) in the correct boxes to identify which two compounds are used.

hydrogen peroxide (H_2O_2)

11

phenylmethanol (benzyl alcohol)

11

phenolphthalein

11

potassium permanganate (KMnO_4)

1

- (ii) Describe how a student could measure the melting point of a sample of benzoic acid prepared in the laboratory.
(A labelled diagram may help your answer.)

[illegible]

- (c) People with a deficiency of iron in their blood sometimes take tablets containing iron compounds.

In an investigation to determine the percentage of elemental iron in a certain type of these tablets, a student ground up five tablets and used them to prepare a solution of iron(II).

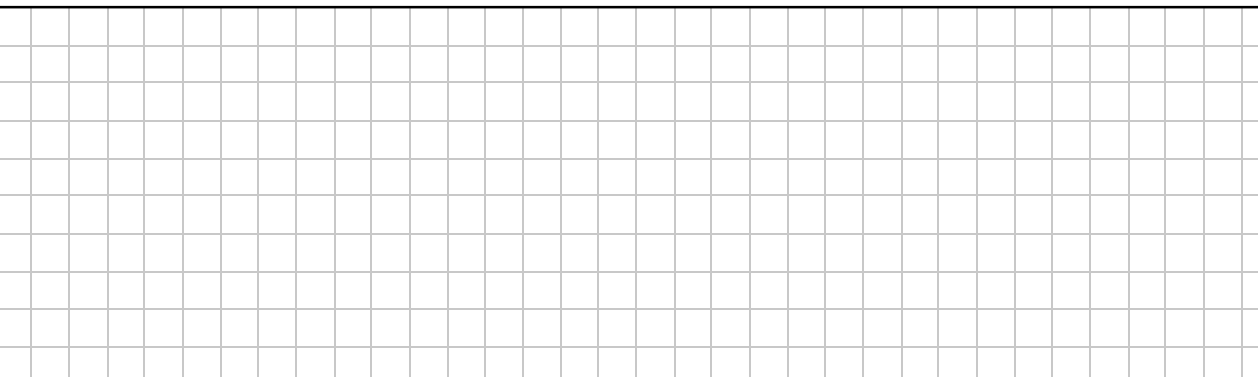
The student then carried out a titration of their iron(II) solution against a solution of potassium permanganate (KMnO_4) of known concentration.

- (i) Name the apparatus the student could have used to grind up the iron tablets.

[illegible]

When measuring the volume of potassium permanganate solution in a burette, the student read from the top of the meniscus.

- (ii) Explain why the student did not read the volume from the bottom of the meniscus.

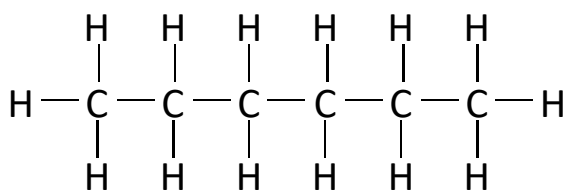
A large grid of graph paper, consisting of 20 columns and 10 rows of squares, intended for drawing a picture.

Each of the five tablets had a mass of 0.3 g. The student found that the total mass of elemental iron in the tablets was 0.18 g.

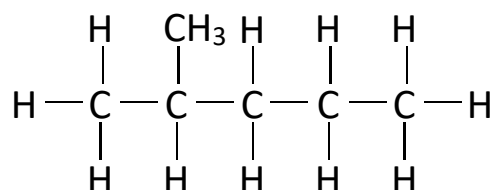
- (iii) Calculate the percentage of elemental iron in the tablets.

A full-page sheet of white graph paper with a light gray grid. The grid consists of small squares, approximately 10 units wide by 10 units high. A thick black border runs along the top and left edges of the page.

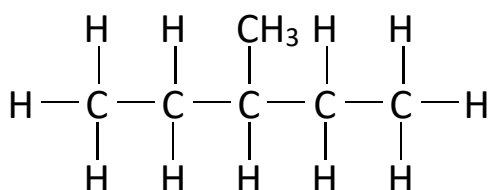
(d) The diagrams below shows five isomers with the chemical formula C₆H₁₄.



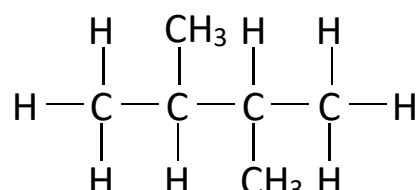
V



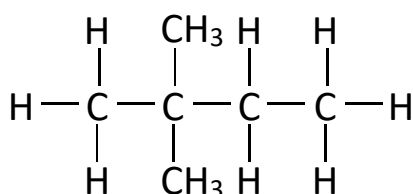
W



X



Y

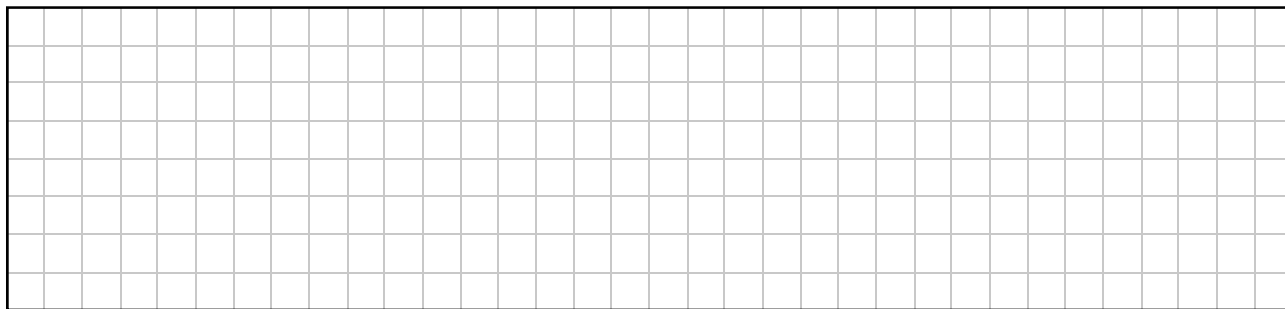


Z

In the table below, match the IUPAC name of each isomer with the letter (V, W, X, Y or Z) used to label it.

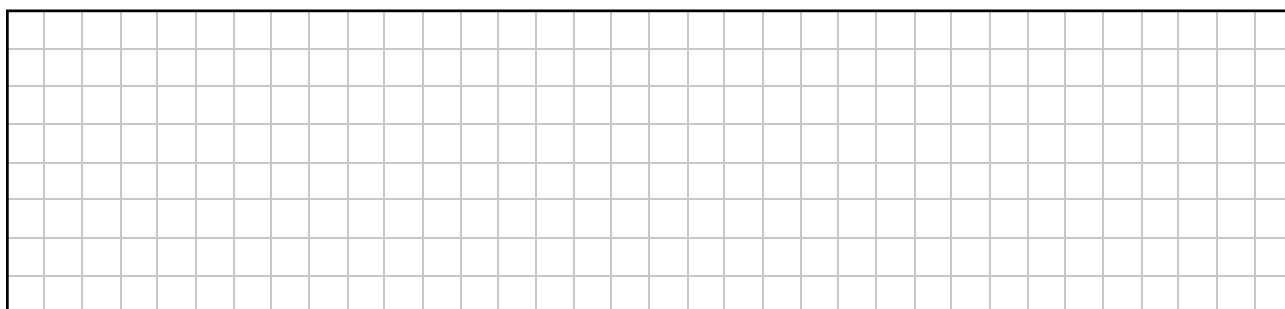
name	letter (V, W, X, Y or Z)
2-methylpentane	
2,2-dimethylbutane	
hexane	
3-methylpentane	
2,3-dimethylbutane	

- (e)** The work of scientists relies on evidence, clear communication, international conventions, peer review, repeatability and reproducibility.
- (i)** Explain what is meant by peer review.



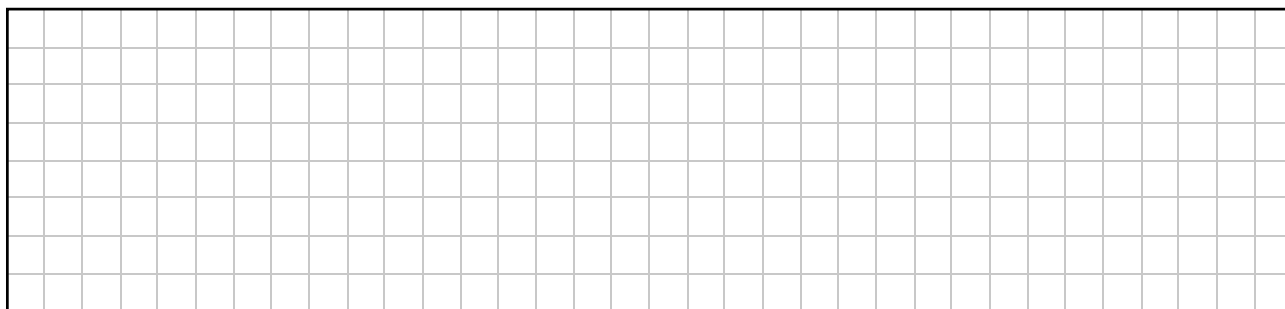
Scientists use primary data and secondary data when investigating.

- (ii)** Explain the difference between primary data and secondary data.

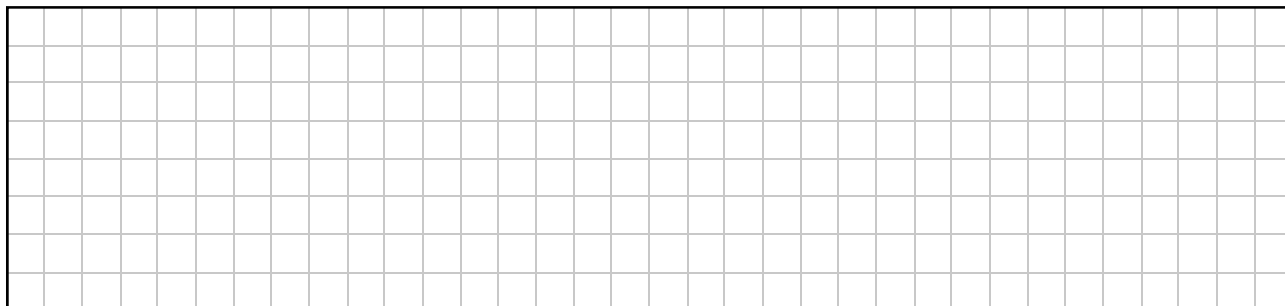


Scientists use both quantitative data and qualitative data when investigating.

- (iii)** Describe one example of quantitative data that you recorded as part of your studies in Chemistry.

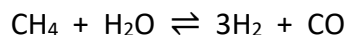


- (iv)** Describe one example of qualitative data that you recorded as part of your studies in Chemistry.

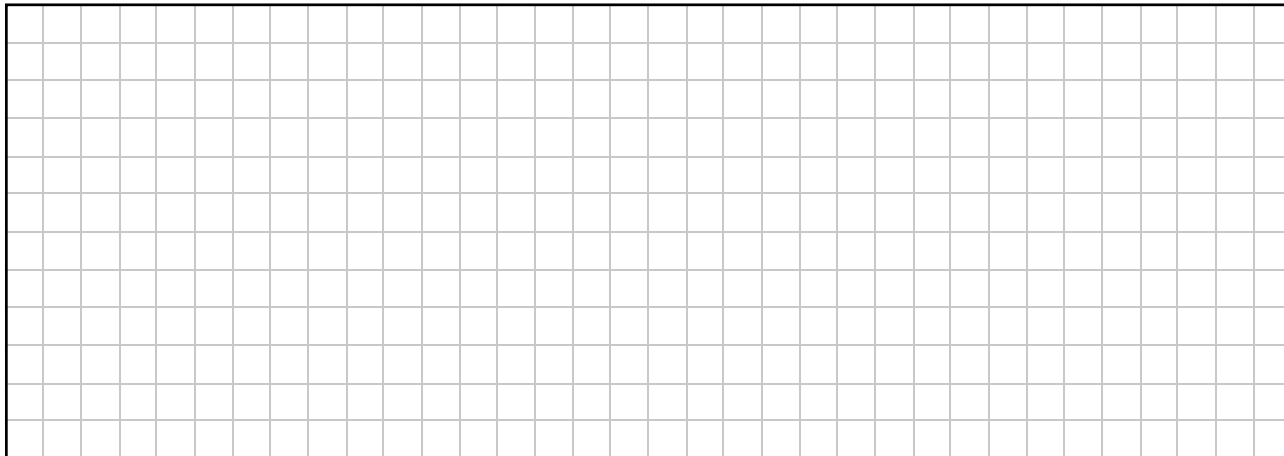


Question 2

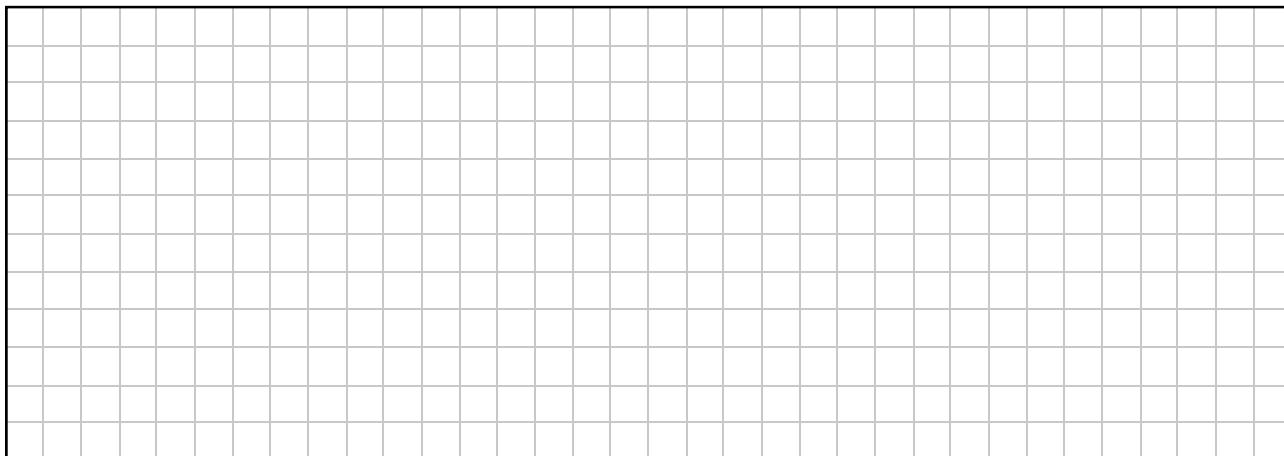
During steam reforming, natural gas (methane) and water vapour react to produce hydrogen and carbon monoxide. This process is described by the following balanced chemical equation:



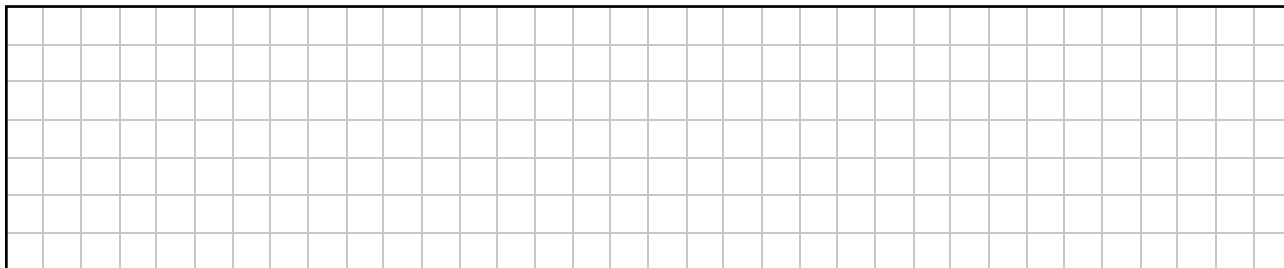
- (a) A Lewis diagram shows the bonding between atoms in a molecule, as well as the lone pairs of electrons that may exist in the molecule.
- (i) Draw a Lewis diagram to show the bonding in H_2 .



- (ii) Draw a Lewis diagram to show the bonding in H_2O .



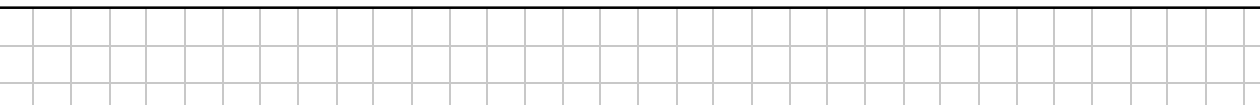
- (iii) The bonding in both water and hydrogen is covalent.
Classify the bonding in each molecule as either polar covalent or pure covalent.
(Note that the electronegativity values of the elements may be found on page 81 of the *Formulae and Tables* booklet.)



The boiling points of methane, water, hydrogen and carbon monoxide are shown in the table below.

substance	boiling point
methane	– 161.5 °C
water	100.0 °C
hydrogen	– 252.9 °C
carbon monoxide	– 191.5 °C

(iv) Explain why methane has a much lower boiling point than water.



(v) Explain why methane has a much higher boiling point than hydrogen.

[illegible]

- (b)** Steam reforming is an equilibrium reaction, during which a dynamic equilibrium is reached. This equilibrium can be affected by various factors.

The balanced chemical equation for the reaction is:



All reactants and products in this reaction are gases.

- (i)** Explain what is meant by dynamic equilibrium.

[illegible]

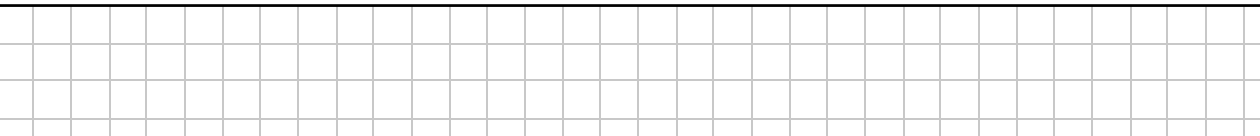
- (ii) Write an expression for the equilibrium constant (K_c) for this reaction.

[illegible]

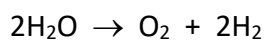
- (iii) If the pressure on the equilibrium mixture is increased, does the concentration of methane increase or decrease?
Justify your answer.

[illegible]

- (iv)** If the temperature of the equilibrium mixture is increased, does the concentration of methane increase or decrease?
Justify your answer.



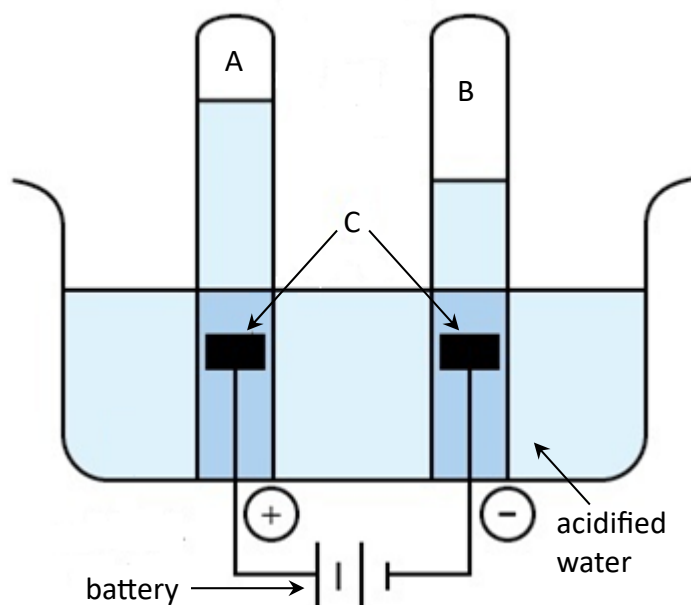
- (c)** The electrolysis of water is another way of producing hydrogen. The electrolysis of water is described by the following balanced chemical equation:



- (i) Explain what is meant by electrolysis.

[illegible]

The diagram below shows the electrolysis of water.



- (ii) Identify gas A.

[illegible]

- (iii) Identify gas B.

[illegible]

- (iv)** Identify the parts on the diagram labelled C.

[illegible]

Question 3

All models are wrong, but some are useful.

– George E.P. Box, British mathematician (1919 – 2013)

- (a) A molecule of ethane has two carbon atoms and six hydrogen atoms. A molecule of ethane can be modelled in several ways.

One way of modelling ethane is by using chemical formulae. Three different types of chemical formulae for ethane are shown in the table below.

empirical formula	molecular formula	condensed structural formula
CH ₃	C ₂ H ₆	CH ₃ CH ₃

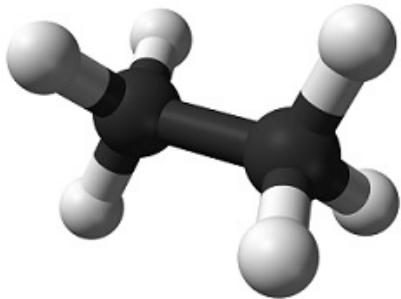
- (i) Explain what is meant by empirical formula.

--

- (ii) Explain how the condensed structural formula for ethane gives more information than the molecular formula.

--

Another way of modelling ethane is by using 2D and 3D molecular structures, as shown in the table below.

2D molecular structure	3D molecular structure
$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}-\text{C}-\text{H} \\ & \\ \text{H} & \text{H} \end{array}$	

- (iii) Explain how the 3D molecular structure for ethane gives more information than its 2D molecular structure.

[illegible]

- (iv)** State one piece of information about the structure of ethane that is not given in either of the tables.

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A molecule of butane has four carbon atoms and ten hydrogen atoms.

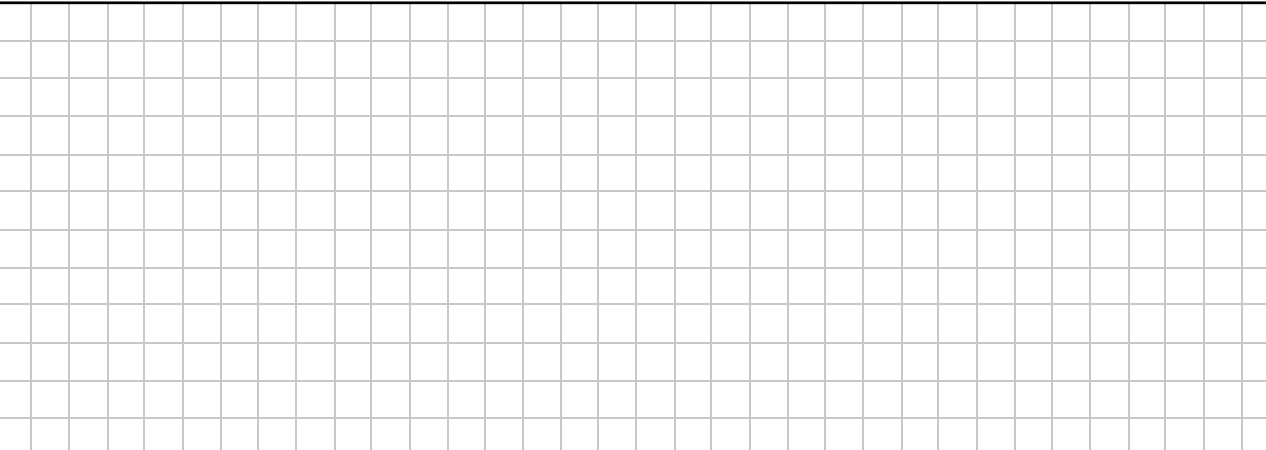
- (v) In the table below, write the empirical formula for butane and the molecular formula for butane. Draw the 2D molecular structure for butane.

empirical formula	molecular formula	2D molecular structure

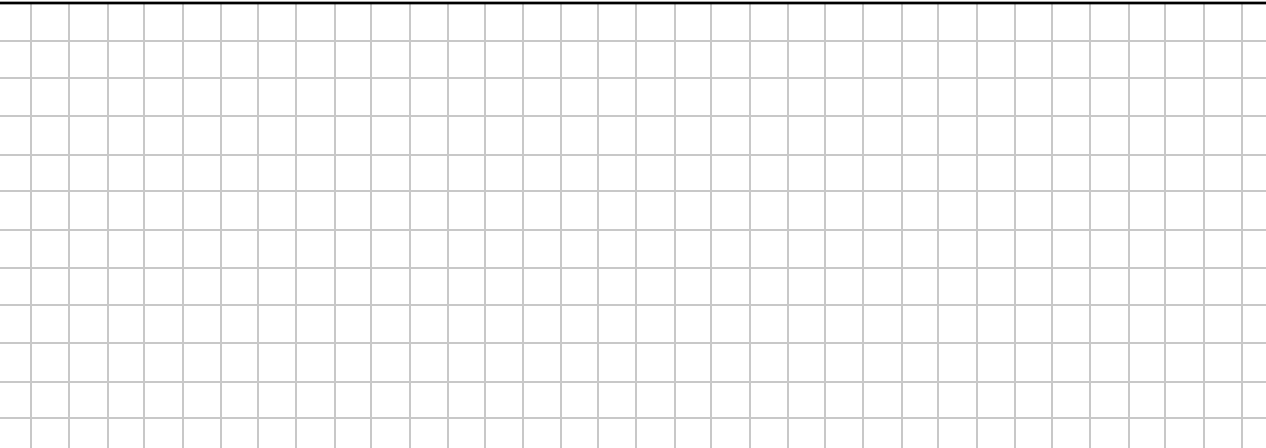
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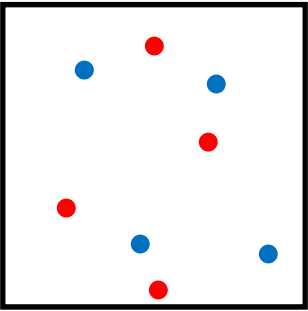
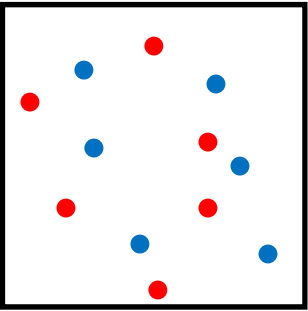
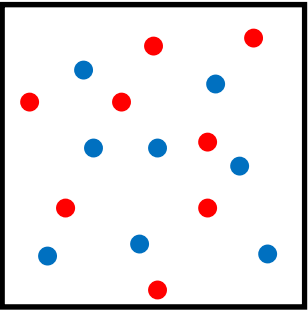
A large grid of graph paper, consisting of 20 columns and 10 rows of squares, intended for drawing a picture.

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[illegible]

- (c)** According to collision theory, the rate of a chemical reaction can be affected by a number of different factors.

A certain chemical reaction involving two reactants is modelled using red dots to represent the first reactant and blue dots to represent the second reactant. Examine the table below which uses this model to show the reaction happening in three different situations.

A	B	C
		

- (i)** Identify the factor being changed in the table above.

[illegible]

- (ii)** Which situation, A, B or C will have the greatest rate of reaction? Justify your answer.

[illegible]

- (iii) Does the rate of a reaction increase or decrease when temperature increases? Justify your answer.

[illegible]

Question 4

- (a)** The text below has been adapted from *Ireland's State of the Environment Report*, published by the Environmental Protection Agency (EPA) in 2024.



Greenhouse gas emissions in Ireland decreased by 6.8% in 2023 and are below the 1990 baseline for the first time in three decades. The decrease in greenhouse gas emissions is reflected in all of the large economic sectors, with the exception of a slight increase in the transport sector.

- (i)** Explain what is meant by the term 'greenhouse gas'.

[illegible]

Many of the most significant greenhouse gases contain carbon.

- (ii) Identify two examples of greenhouse gases that don't contain carbon.

[illegible]

- (iii) Explain the difference between the natural greenhouse effect and the enhanced greenhouse effect.



According to the EPA report, there was a slight increase in greenhouse gas emissions due to transport in 2023.

The hydrogen fuel cell is an alternative, clean energy source for transport.

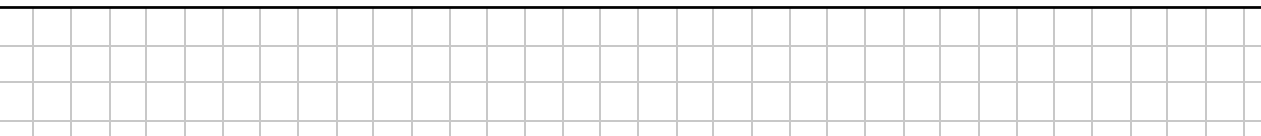
Hydrogen fuel cells are used in buses such as the one in the picture.



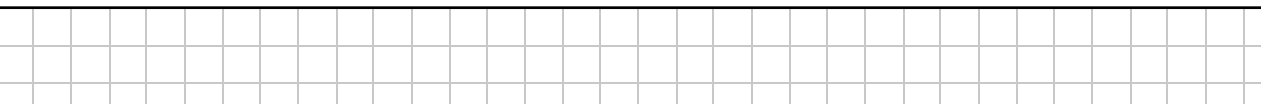
(iv) Explain the operation of a simple hydrogen fuel cell.

[illegible]

(v) Explain the difference between a chemical cell and a fuel cell.

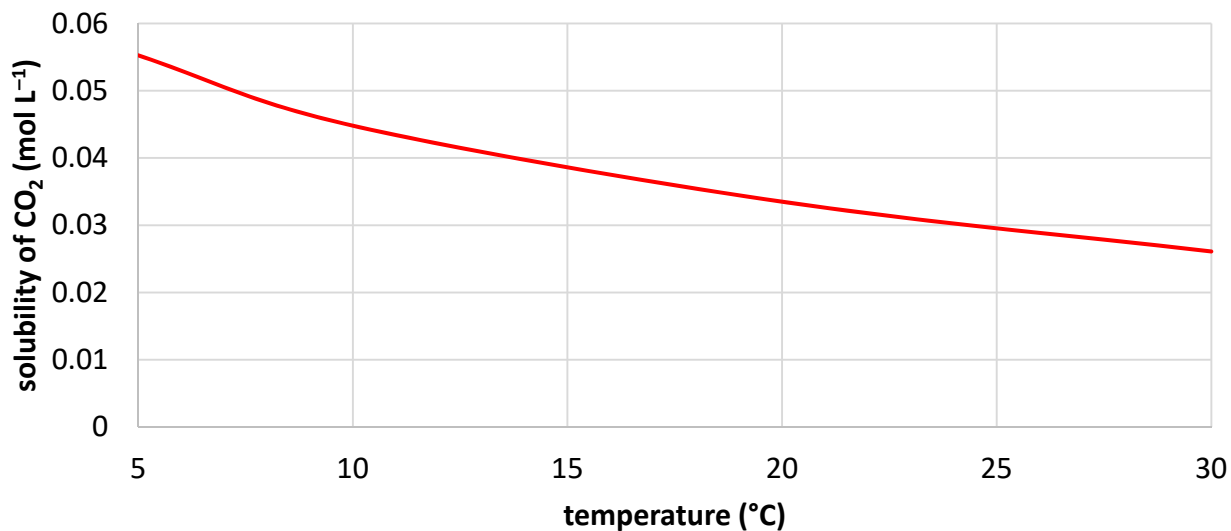


(vi) Other than those related to transport, state two sources of greenhouse gas emissions in Ireland.



- (b)** Carbon dioxide from the atmosphere can be captured when it dissolves in the water of the Earth's oceans.

One concern related to the increase of Earth's temperature is the effect this has on the oceans' ability to capture carbon. The graph below shows how the solubility of carbon dioxide in seawater changes with temperature, measured at atmospheric pressure.



- (i)** Explain what is meant by carbon capture.

[illegible]

- (ii) Use the graph to describe the relationship between the solubility of carbon dioxide and the water temperature.

[illegible]

- (iii) Explain how increasing sea temperature could affect the concentration of carbon dioxide in the atmosphere.

- (iv) Use the graph to find the number of moles of carbon dioxide that could dissolve in 1 litre of seawater at 15 °C.

The relationship between n , the number of moles of a gas, and V , the volume of the gas is given by the formula:

$$PV = nRT$$

on page 64 of the *Formulae and Tables* booklet, where $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$.

- (v) Use this formula to calculate the volume that the number of moles you found in part (iv) occupies at a pressure, P , of 101 325 Pa and a temperature, T , of 298 K.

Question 5

Many chemical substances have similar appearances and it can be difficult to tell them apart. The tests used to distinguish between these chemical substances often rely on colour.

- (a) A student was given samples of three different salts: sodium chloride (NaCl), potassium chloride (KCl), and copper chloride (CuCl₂).

The student was asked to identify each sample.

The student decided to use flame tests to identify each sample.

- (i) Describe how the student could carry out a flame test on one of the samples. Your description should include the name of each piece of apparatus used and an explanation of how they were used.

[illegible]

The flame test was carried out for each of the three salts.

The colours observed are shown in the table below.

- (ii)** Identify each salt in the table based on the colour observed.

flame colour	 blue-green	 yellow-orange	 lilac
salt			

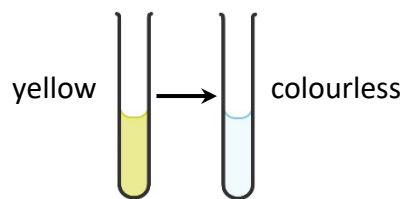
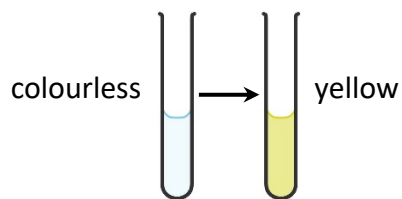
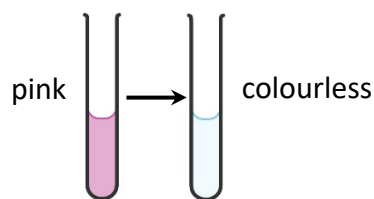
- The student decided to use a test for unsaturation to distinguish between the two gases.

- [illegible]

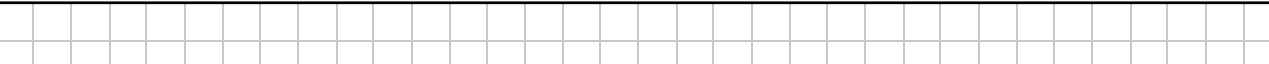
(ii) Identify a chemical solution suitable for testing for unsaturation.

[illegible]

- 
- A diagram showing two test tubes. The first test tube on the left contains a light blue liquid and is labeled "colourless". An arrow points from this test tube to a second test tube on the right. The second test tube contains a pink liquid and is labeled "pink".

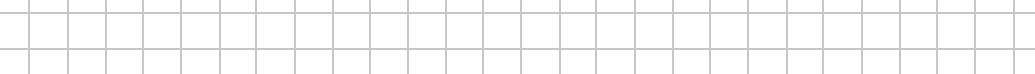


- The student decided to use universal indicator to distinguish between the two acids.

- 

-

-



- [illegible]

(d) In a titration investigation, a solution of sodium thiosulfate (in a burette) is added to a solution of iodine (in a conical flask). When the iodine solution is a pale yellow colour, starch indicator is added to it.

(i) Which of the colours listed below is the colour of the solution in the conical flask immediately after the starch indicator has been added?

Place a tick (✓) in the correct box.

brick red

☐

colourless

☐

blue-black

☐

milky white

☐

(ii) Which of the colours listed below is the colour of the solution in the conical flask when the endpoint has been reached?

Place a tick (✓) in the correct box.

brick red

☐

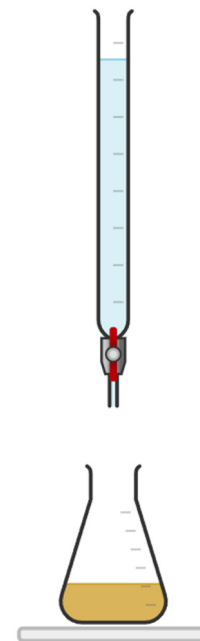
colourless

☐

blue-black

☐

milky white

☐

Question 6

A student wanted to standardise the strong acid hydrochloric acid (HCl) using the weak base sodium carbonate (Na_2CO_3) as a primary standard.

In order to make a standard solution of sodium carbonate the student used the equipment shown below.

(i) Name the pieces of equipment pictured in the table.

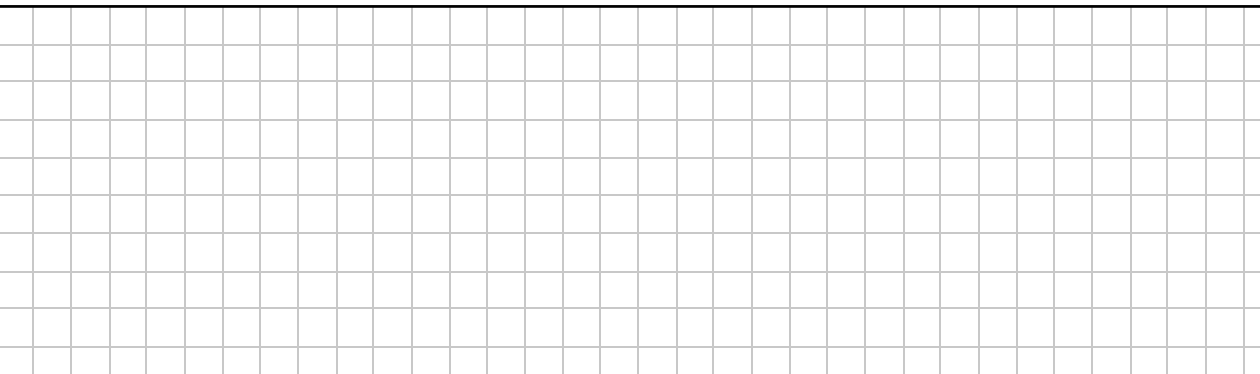
picture			
name			

(ii) Describe the procedure to measure out 10.6 g of sodium carbonate and make it up to a 250 cm³ solution.

[illegible]

Only certain compounds can be used as primary standards.

(iii) State one reason why sodium carbonate is suitable for use as a primary standard.

A large grid of graph paper, consisting of 20 columns and 10 rows of squares, intended for drawing a picture.

To determine the concentration of the hydrochloric acid, the student carried out titrations using 25.0 cm³ portions of their solution of sodium carbonate.

(iv) Name a suitable indicator that could be used in this titration.

[illegible]

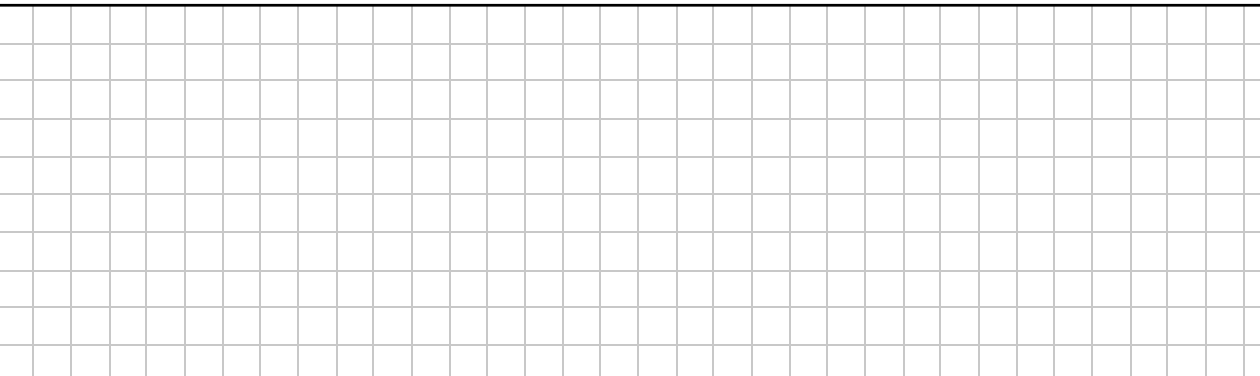
(v) State what colour this indicator is in hydrochloric acid.

[illegible]

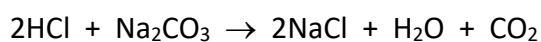
(vi) State what colour this indicator is in sodium carbonate solution.

[illegible]

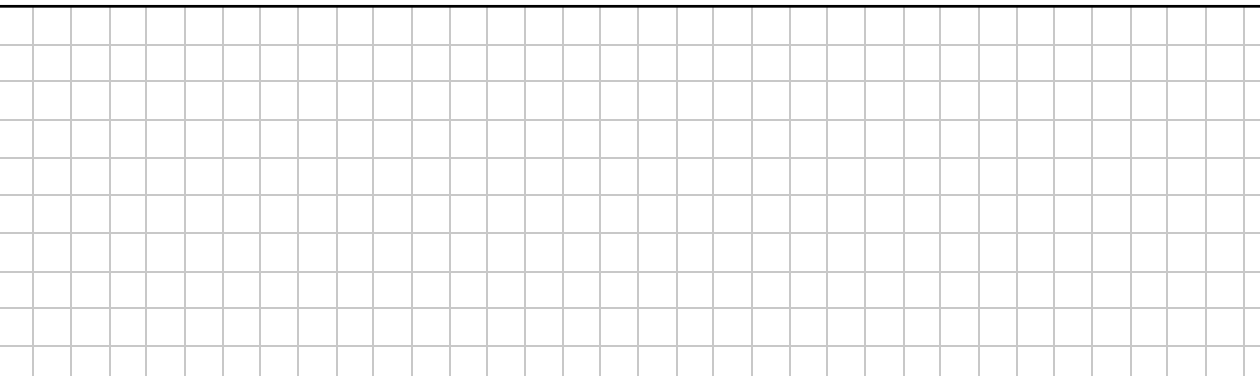
(vii) State two precautions which the student could have taken to increase the accuracy of their endpoint.

A large grid of graph paper, consisting of 20 columns and 10 rows of squares, intended for drawing a picture.

The student titrated the hydrochloric acid against 25.0 cm³ portions of their solution of sodium carbonate. The reaction is described by the following balanced chemical equation:

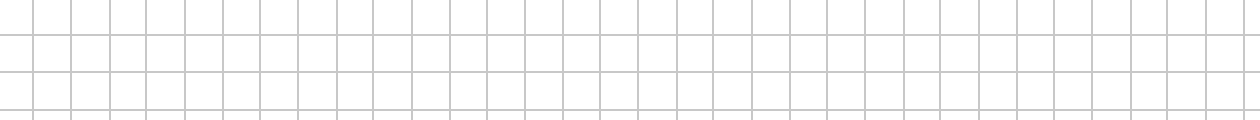


(viii) Calculate the number of moles of sodium carbonate (Na_2CO_3) in 10.6 g.

A large grid of graph paper, consisting of 20 columns and 10 rows of squares, intended for drawing a picture.

The 10.6 g of sodium carbonate were dissolved in enough water to make up 250 cm³ of solution. A 25.0 cm³ portion of the solution was removed.

(ix) Calculate the number of moles of Na_2CO_3 in the 25.0 cm^3 portion.



(x) Calculate the number of moles of HCl needed to react with the Na_2CO_3 in the 25.0 cm^3 portion.

[illegible]

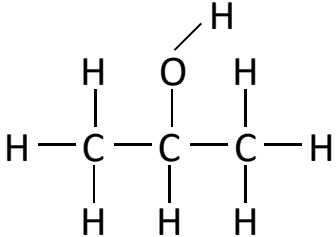
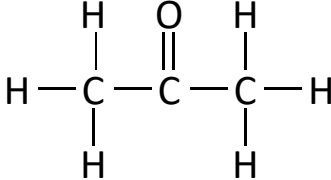
Question 7

- (a) The table below contains information about different compounds. Each of them contains exactly three carbon atoms, but each has a different functional group.

homologous series	name	molecular structure
ketone	propanone	$\begin{array}{ccccc} & \text{H} & & \text{O} & & \text{H} \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & \\ & \text{H} & & & & \text{H} \end{array}$
alkane		$\begin{array}{ccccc} & \text{H} & & & & \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} \\ & & & & & \\ & \text{H} & & & & \end{array}$
	propan-1-ol	$\begin{array}{ccccc} & \text{H} & & & & \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} \\ & & & & & \\ & \text{H} & & & & \end{array}$
carboxylic acid		$\begin{array}{ccccc} & \text{H} & & & & \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} \\ & & & & & \\ & \text{H} & & & & \end{array}$

- (i) In the table above, complete the drawing of each of the three incomplete molecular structures, showing all of the atoms and bonds.
- (ii) Complete the table by filling in each missing name or homologous series.

- (b)** Propan-2-ol can be converted to propanone using a suitable reagent. The molecular structures of propan-2-ol and propanone are shown in the table below.

propan-2-ol	propanone
 Structural formula of propan-2-ol: A three-carbon chain. The first carbon is bonded to three hydrogens. The second carbon is bonded to one hydrogen and one hydroxyl group (oxygen bonded to a hydrogen). The third carbon is bonded to three hydrogens.	 Structural formula of propanone: A three-carbon chain. The first carbon is bonded to three hydrogens. The second carbon is double-bonded to an oxygen atom and single-bonded to two hydrogens. The third carbon is bonded to three hydrogens.

- (i) On the molecule of propan-2-ol in the table, circle the bond(s) broken during this reaction.
- (ii) On the molecule of propanone in the table, circle the bond(s) formed during this reaction.
- (iii) Which of these two compounds contains a planar carbon atom?

[illegible]

The conversion of propan-2-ol into propanone can be classified as a redox reaction. It can also be classified as another type of reaction.

- (iv)** Classify the conversion of propan-2-ol into propanone as an addition reaction, a substitution reaction, or an elimination reaction.

Place a tick (✓) in the correct box.

addition reaction

9

substitution reaction

10

elimination reaction

1

- (c) The ketone propanone has a structural isomer, the aldehyde propanal.
- (i) Draw the molecular structure for propanal in the table below.

propanone	propanal
$\begin{array}{ccccc} & \text{H} & \text{O} & \text{H} & \\ & & & & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{H} \\ & & & & \\ & \text{H} & & \text{H} & \end{array}$	

- (ii)** Explain what is meant by the term 'structural isomers'.

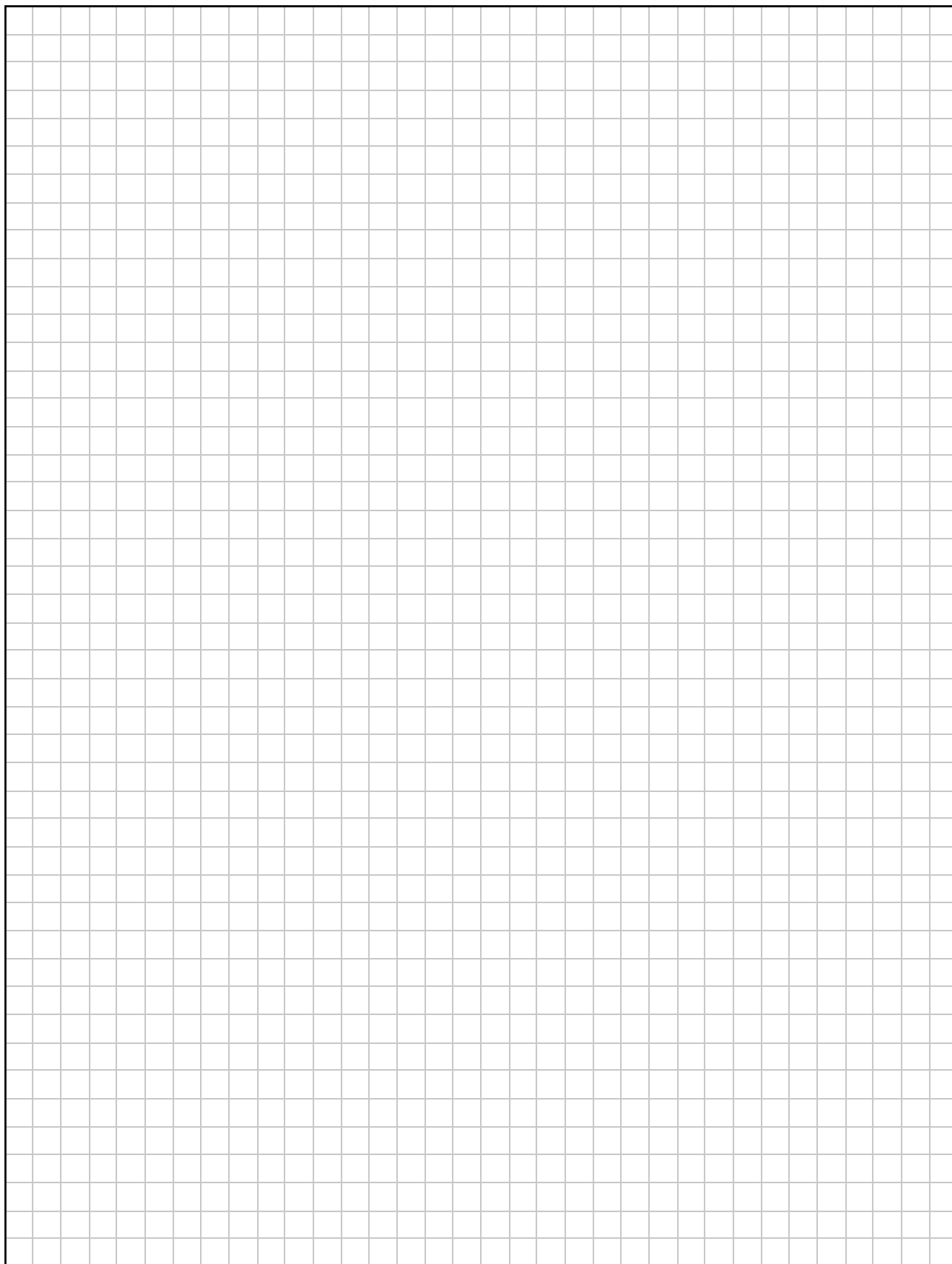
[illegible]

- (iii) Describe a test to distinguish between propanone and propanal. Your answer should identify all chemicals used and observations made.

[illegible]

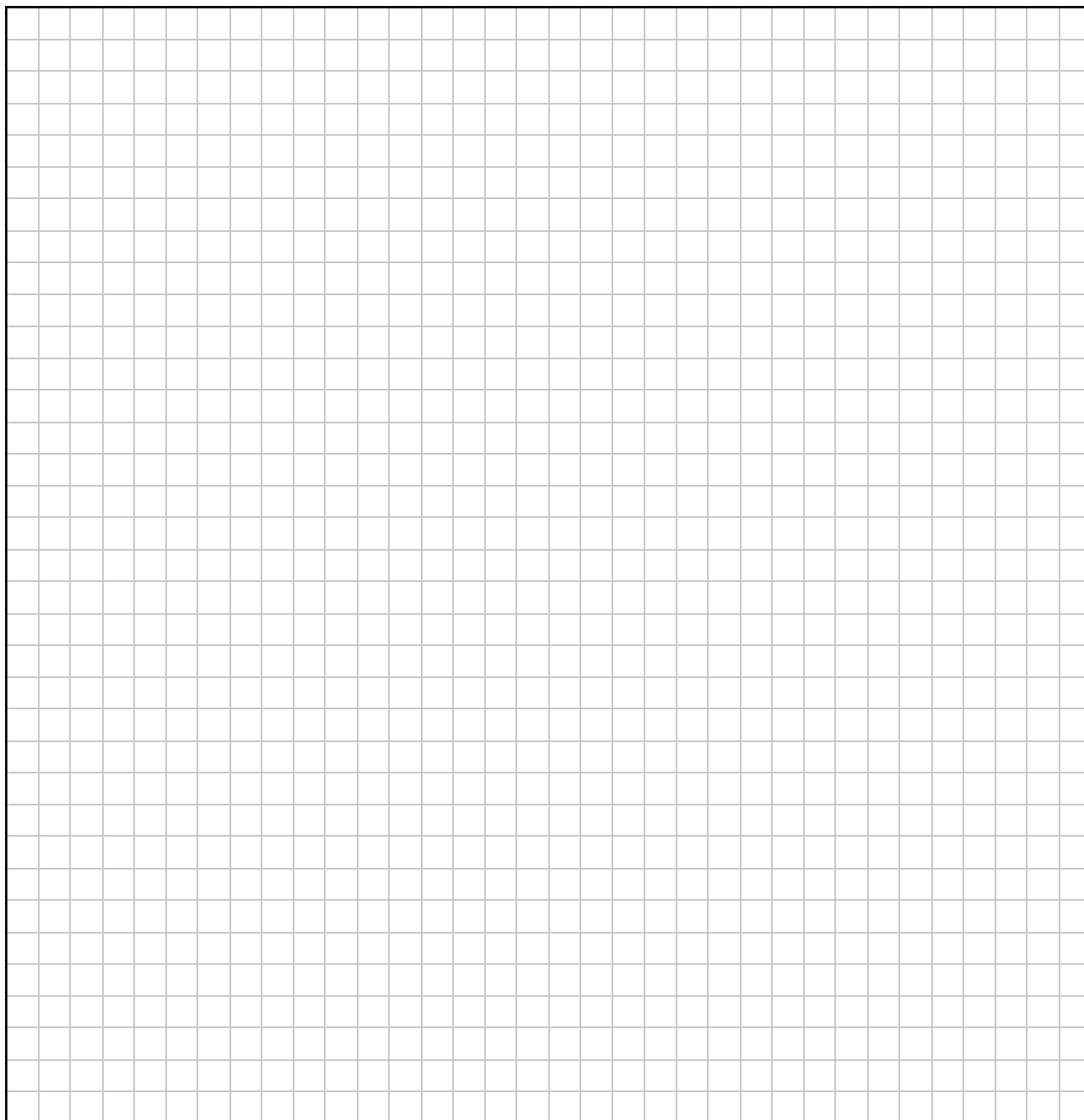
Page for extra work.

Label any extra work clearly with the question number and part.



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Leaving Certificate Examination – Ordinary Level

Chemistry

Sample 2

2 hours 30 minutes

