



CANDIDATE
NAME

--

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

0620/41

October/November 2021

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **12** pages.

- 1 Some elements are shown in the order they appear in the reactivity series. The most reactive element is at the top.

sodium
calcium
magnesium
aluminium
zinc
iron
hydrogen
copper

- (a) Answer the questions using the list of elements. Each element may be used once, more than once or not at all.

Identify:

- (i) a non-metal

..... [1]

- (ii) a metal which is stored under oil

..... [1]

- (iii) the main component of steel

..... [1]

- (iv) a metal with three electrons in the outer shell of its atoms

..... [1]

- (v) a metal found in brass

..... [1]

- (vi) a metal that forms chlorides of the type XCl_2 and XCl_3 .

..... [1]

- (b) Name the main ores of:

- (i) zinc [1]

- (ii) aluminium. [1]

- (c) In an experiment, a sample of aluminium appeared less reactive than expected.

Explain why.

.....
..... [1]

(d) Name **two** metals from the list which are extracted by reduction of their ores using carbon.

1

2 [2]

(e) When zinc granules are added to aqueous copper(II) sulfate, a reaction occurs. During the reaction, a red-pink solid is formed and the solution becomes colourless.

(i) Name the red-pink solid.

..... [1]

(ii) Name the colourless solution.

..... [1]

(iii) Explain, in terms of particles, why the rate of this reaction increases when the temperature is increased.

.....

.....

.....

.....

.....

..... [3]

(iv) Suggest two **other** ways of increasing the rate of this reaction.

1

2 [2]

[Total: 18]

2 This question is about copper and its compounds.

(a) Copper has two different naturally occurring atoms, ^{63}Cu and ^{65}Cu .

(i) State the term used for atoms of the same element with different nucleon numbers.

..... [1]

(ii) The atomic number of copper is 29.

Complete the table to show the number of protons, neutrons and electrons in the particles of copper shown.

	^{63}Cu	$^{65}\text{Cu}^{2+}$
protons		
neutrons		
electrons		

[3]

(iii) Relative atomic mass is the average mass of naturally occurring atoms of an element.

The percentage of the naturally occurring atoms in a sample of copper is shown.

^{63}Cu	^{65}Cu
70%	30%

Deduce the relative atomic mass of copper in this sample.

Give your answer to **one** decimal place.

relative atomic mass = ... [2]

(b) Anhydrous copper(II) sulfate is used to test for the presence of water. When this test is positive, hydrated copper(II) sulfate is formed.

(i) State the colour change seen during this test.

from to [2]

(ii) Complete the chemical equation to show the reaction that takes place.



(iii) State how hydrated copper(II) sulfate can be turned back into anhydrous copper(II) sulfate.

..... [1]

(iv) Describe a test for pure water.

.....

..... [2]

(c) Aqueous copper(II) sulfate contains $\text{Cu}^{2+}(\text{aq})$ ions.

(i) Describe what is seen when aqueous copper(II) sulfate is added to aqueous sodium hydroxide, $\text{NaOH}(\text{aq})$.

..... [1]

(ii) Write the ionic equation for the reaction between aqueous copper(II) sulfate and aqueous sodium hydroxide.

Include state symbols.

..... [3]

- (d) When solid copper(II) nitrate is heated copper(II) oxide, nitrogen dioxide and oxygen are formed.



Calculate the volume of nitrogen dioxide formed at room temperature and pressure when 4.7 g of $\text{Cu}(\text{NO}_3)_2$ is heated.

Use the following steps:

- calculate the mass of one mole of $\text{Cu}(\text{NO}_3)_2$

..... g

- calculate the number of moles of $\text{Cu}(\text{NO}_3)_2$ used

..... moles

- determine the number of moles of nitrogen dioxide formed

..... moles

- calculate the volume of nitrogen dioxide formed at room temperature and pressure.

..... dm^3
[4]

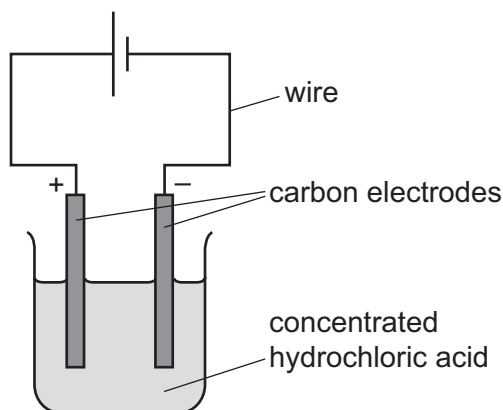
- (e) Write the chemical equation to show the action of heat on sodium nitrate, NaNO_3 .

..... [2]

[Total: 22]

3 This question is about electrolysis.

Concentrated hydrochloric acid is electrolysed using the apparatus shown.



(a) Chloride ions are discharged at the anode.

(i) Complete the ionic half-equation for this reaction.



(ii) State whether oxidation or reduction takes place. Explain your answer.

.....
 [1]

(b) Describe what is seen at the cathode.

..... [1]

(c) Write the ionic half-equation for the reaction at the cathode.

..... [2]

(d) The pH of the electrolyte is measured throughout the experiment.

(i) Suggest the pH of the electrolyte at the beginning of the experiment.

..... [1]

(ii) State how the pH changes, if at all, during the experiment.

Explain your answer.

.....
 [2]

(e) The electrolysis is repeated using molten lead(II) bromide.

Describe what is seen at the:

- cathode
- anode.

[2]

(f) State **two** properties of graphite (carbon) which make it suitable for use as an electrode.

1

2

[2]

[Total: 13]

4 Chalcopyrite, FeCuS_2 , is used in the manufacture of sulfuric acid in the Contact process.

- (a) In the first stage of the process, chalcopyrite reacts with oxygen in the air to produce sulfur dioxide, SO_2 , iron(III) oxide and copper(II) oxide.

Complete the chemical equation for the reaction of FeCuS_2 with oxygen.



- (b) Sulfur dioxide is then converted to sulfur trioxide.



The reaction is exothermic. It is also an equilibrium.

- (i) State **two** features of an equilibrium.

1

2 [2]

- (ii) State the temperature and pressure used in this reaction.
Include units.

• temperature

• pressure [2]

- (iii) Name the catalyst used.

..... [1]

- (iv) Explain why a catalyst is used.

..... [1]

- (v) Describe and explain, in terms of equilibrium, what happens when the temperature is increased.

.....

..... [2]

- (c) Concentrated sulfuric acid is a dehydrating agent.

When glucose is dehydrated, carbon and one other product are formed.

Complete the equation to show the dehydration of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$.



[Total: 12]

- 5 Alkenes and carboxylic acids are both families of similar compounds with similar chemical properties. Alkenes and carboxylic acids have different reactions.

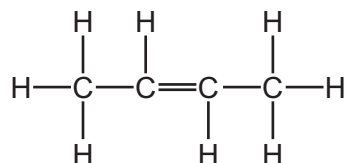
(a) State the term used for a 'family' of similar compounds.

..... [1]

(b) State the general formula of alkenes.

..... [1]

(c) The structure of but-2-ene is shown.



(i) But-2-ene reacts with aqueous bromine in an addition reaction.

Describe the colour change seen when but-2-ene is added to aqueous bromine.

from to [1]

(ii) State what is meant by the term *addition reaction*.

..... [1]

(iii) Write the chemical equation for the reaction between but-2-ene and bromine.

..... [2]

(iv) But-2-ene forms a polymer.

Suggest the name of the polymer formed from but-2-ene.

..... [1]

(v) Name and draw a structural isomer of but-2-ene.

Show all of the atoms and all of the bonds.

name

structure

[2]

(d) Butanoic acid, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$, is a carboxylic acid.

(i) Deduce the empirical formula of butanoic acid.

..... [1]

(ii) Complete the chemical equation for the reaction of butanoic acid and sodium carbonate, Na_2CO_3 .

$2\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{Na}_2\text{CO}_3 \rightarrow \dots + \dots + \dots$ [2]

(iii) Butanoic acid reacts with methanol to form an organic compound and water.

- Name the organic compound formed.

..... [1]

- Draw the structure of the organic compound formed.

Show all of the atoms and all of the bonds.

[2]

[Total: 15]

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.

The Periodic Table of Elements

Group																			
I	II	1 Hhydrogen1												III	IV	V	VI	VII	VIII
3 Li lithium 7	4 Be beryllium 9	Key atomic number atomic symbol name relative atomic mass												5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40												
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84	37 Rb rubidium 85	
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids		72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —	87 Fr francium —
87 Fr francium —	88 Ra radium —	89–103 actinoids		104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Lv livermorium —	116 Lv livermorium —	117 Ts tennessine —	118 Og oganeson —	119 Uue unbinilium —

lanthanoids

actinoids

57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).



CANDIDATE
NAME

--

--	--	--	--	--

--	--	--	--

0620/43

October/November 2021

1 hour 15 minutes

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

IB21 11_0620_43/3RP
© UCLES 2021

[Turn over

1 A list of substances is shown.

ammonia
bauxite
carbon dioxide
carbon monoxide
ethanol
hematite
oxygen
sodium chloride
sulfur dioxide

Answer the questions using the list of substances.

Each substance may be used once, more than once or not at all.

State which substance is:

- (a) an element [1]
- (b) an ore of aluminium [1]
- (c) a gas that causes acid rain [1]
- (d) used as a fuel [1]
- (e) an ionic compound [1]
- (f) produced in the Haber process [1]
- (g) a product of respiration [1]
- (h) a toxic product of the incomplete combustion of hydrocarbons
..... [1]
- (i) a gas produced in the test for nitrate ions. [1]

[Total: 9]

2 This question is about electrolysis.

(a) State the meaning of the term *electrolyte*.

.....
 [2]

(b) The table gives information about the electrolysis of two electrolytes. Carbon (graphite) electrodes are used in each experiment.

(i) Complete the table to show the observations and products of electrolysis.

	positive electrode (anode)		negative electrode (cathode)	
electrolyte	observations	name of product	observations	name of product
aqueous copper(II) sulfate	colourless bubbles			
concentrated aqueous sodium bromide			colourless bubbles	hydrogen

[5]

(ii) Hydrogen is produced at the negative electrode (cathode) during the electrolysis of concentrated aqueous sodium bromide.

Write the ionic half-equation for this reaction.

..... [2]

(iii) State **two** reasons why carbon (graphite) is suitable to use as an electrode.

1

2 [2]

(iv) Name the particle responsible for the conduction of electricity in the metal wires used in a circuit.

..... [1]

[Total: 12]

- 3 Lead is a metallic element in Group IV. One of the ores of lead is galena, which is an impure form of lead(II) sulfide, PbS .

Lead also occurs in the ore cerussite, which contains lead(II) carbonate, PbCO_3 .

- (a) Calculate the relative formula mass, M_r , of PbCO_3 .

M_r of PbCO_3 = ... [1]

- (b) The M_r of PbS is 239.

Calculate the percentage of lead by mass in PbS .

percentage of lead by mass in PbS = ... [1]

- (c) The percentage of lead by mass in PbCO_3 is 77.5%.

Use this information and your answer to (b) to suggest whether it would be better to extract lead from PbCO_3 or PbS .

Give a reason for your answer.

.....
 [1]

- (d) When lead(II) carbonate is heated it decomposes into lead(II) oxide, PbO , and carbon dioxide.

Write a chemical equation for this reaction.

..... [1]

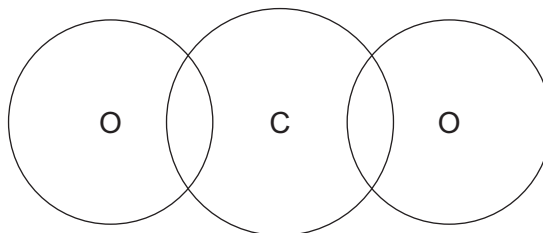
- (e) Lead(II) carbonate reacts with dilute nitric acid. One of the products is aqueous lead(II) nitrate, $\text{Pb}(\text{NO}_3)_2$.

Write a chemical equation for this reaction.

..... [2]

(f) Lead(II) oxide and carbon dioxide are oxides of Group IV elements.

- (i) Complete the diagram to show the electron arrangement in one molecule of CO_2 . Show only the outer electrons.



[2]

- (ii) The melting points of lead(II) oxide and carbon dioxide are shown.

	melting point/ $^{\circ}\text{C}$
lead(II) oxide	886
carbon dioxide	-56

Use your knowledge of structure and bonding to explain why lead(II) oxide has a much higher melting point than carbon dioxide.

Your answer should refer to:

- the types of particles involved
- the relative strength of the forces of attraction between the particles.

.....

.....

.....

..... [3]

(g) Part of the reactivity series is shown.

magnesium	most reactive
lead	↑
copper	least reactive

Aqueous lead(II) nitrate contains Pb^{2+} ions.

Two experiments are carried out.

In Experiment 1, magnesium is added to aqueous lead(II) nitrate.

In Experiment 2, copper is added to aqueous lead(II) nitrate.

Write an ionic equation for any reaction that occurs in each experiment. If no reaction occurs write 'no reaction'.

Experiment 1

Experiment 2 [2]

(h) When lead(II) nitrate is heated it decomposes to produce the same gaseous products as when copper(II) nitrate is heated.

(i) One of the gaseous products is oxygen.

Describe a test for oxygen.

test

observations [2]

(ii) Name the other gaseous product.

..... [1]

[Total: 16]

4 Carbon is an important element.

(a) Carbon exists as the isotopes $^{12}_6\text{C}$ and $^{13}_6\text{C}$.

Complete the table.

isotope	number of protons in one atom	number of electrons in one atom	number of neutrons in one atom
$^{12}_6\text{C}$			
$^{13}_6\text{C}$			

[2]

(b) Name **two** forms of the element carbon which have giant covalent structures.

..... and [1]

(c) The Avogadro constant is the number of particles in 1 mole.

The numerical value of the Avogadro constant is 6.02×10^{23} .

(i) Calculate the number of molecules in 22.0 g of carbon dioxide, CO_2 .

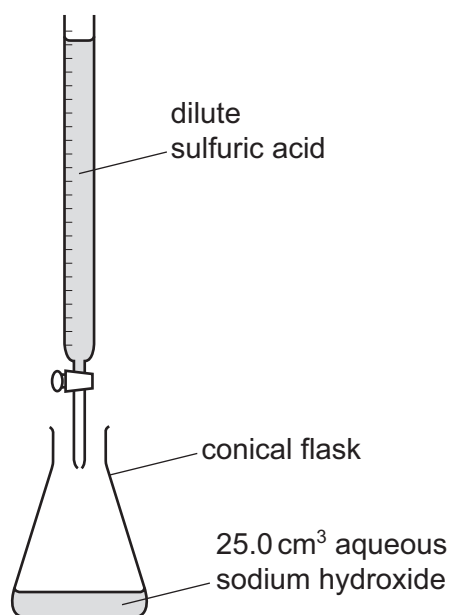
..... molecules [2]

(ii) Calculate the number of molecules in 6.00 dm^3 of carbon dioxide gas at room temperature and pressure.

..... molecules [1]

[Total: 6]

- 5 (a) Dilute sulfuric acid and aqueous sodium hydroxide can be used to prepare sodium sulfate crystals using a method that involves titration.



- (i) Suggest why universal indicator is **not** suitable for this titration.

..... [1]

- (ii) Name an indicator that can be used in this titration.

..... [1]

20.0 cm³ of dilute sulfuric acid neutralises 25.0 cm³ of 1.00 mol/dm³ aqueous sodium hydroxide. At the end of the titration the conical flask contains aqueous sodium sulfate with the dissolved indicator as an impurity.

- (b) Describe how to prepare a **pure** sample of sodium sulfate crystals from the original solutions of dilute sulfuric acid and aqueous sodium hydroxide of the same concentrations.

You are not required to give details of how to carry out the titration.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

- (c) Sodium hydrogensulfate, NaHSO_4 , dissolves in water to produce an aqueous solution, **X**, containing Na^+ , H^+ and SO_4^{2-} ions.

State the observations when the following tests are done.

- (i) A flame test is carried out on **X**.

..... [1]

- (ii) Copper(II) oxide is warmed with an excess of **X**.

.....

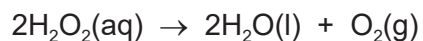
..... [2]

- (iii) Acidified aqueous barium nitrate is added to **X**.

..... [1]

[Total: 11]

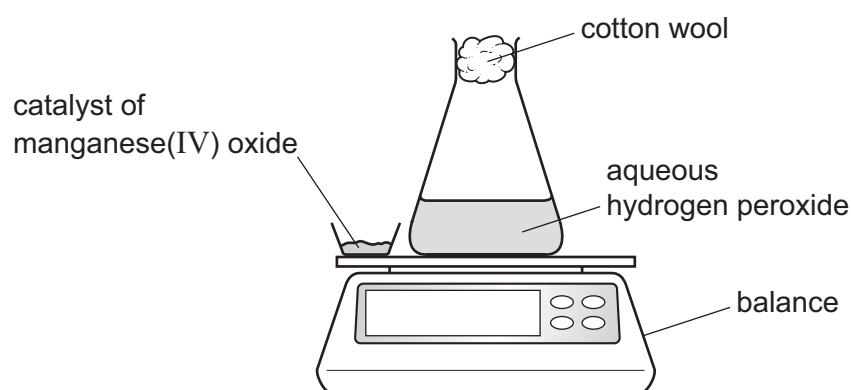
- 6 A student investigates the decomposition of hydrogen peroxide in the presence of a catalyst of manganese(IV) oxide.



- (a) State the meaning of the term *catalyst*.

.....
..... [2]

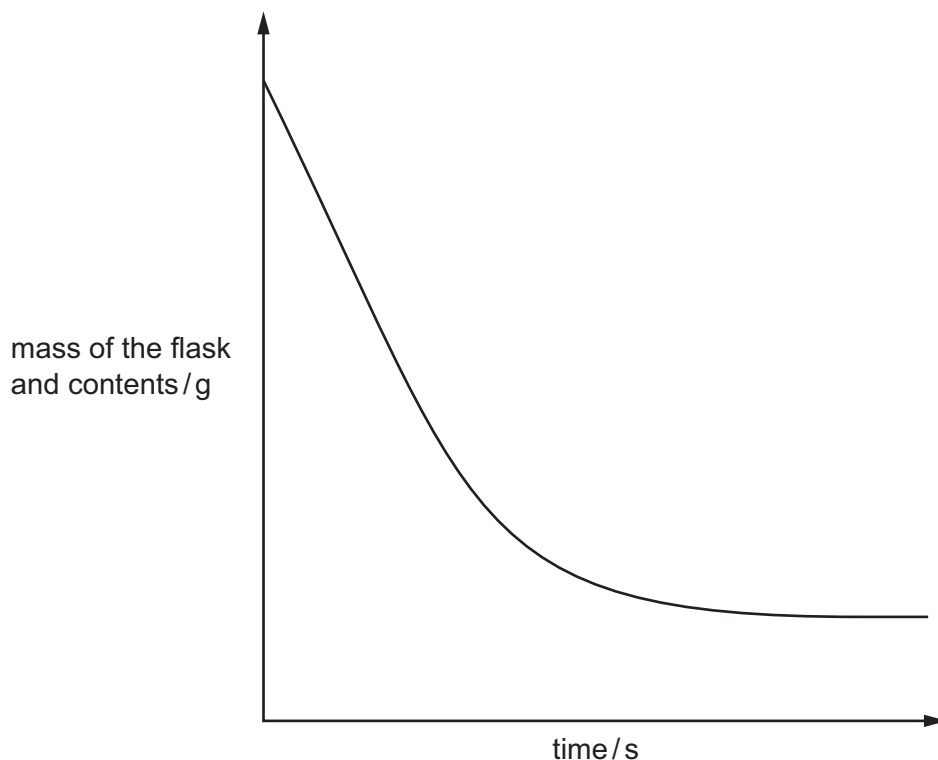
- (b) The diagram shows the equipment the student uses.



The student uses this method:

- the catalyst is added to the aqueous hydrogen peroxide
- the stop-clock is started
- the mass of the flask and contents is recorded at regular time intervals.

A graph of the mass of the flask and contents against time is shown.



- (i) Suggest why the mass of the flask and contents decreases as time increases.

..... [1]

- (ii) Describe what happens to the rate of the reaction as time increases.

.....

..... [2]

- (c) The student repeats the experiment at a higher temperature. All other conditions stay the same. The rate of reaction increases.

- (i) Explain, in terms of collisions between particles, why the rate of reaction increases at a higher temperature.

.....

.....

.....

..... [3]

- (ii) Draw a line on the graph in (b) for the experiment at a higher temperature. [2]

[Total: 10]

- 7 (a) Ethanol is a member of the homologous series of alcohols.

Give **two** characteristics of members of a homologous series.

1

2 [2]

- (b) Ethanol can be manufactured from ethene.

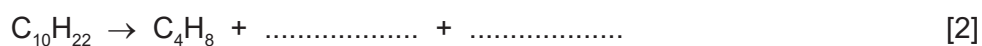
Ethene can be made from long chain hydrocarbons such as decane, $C_{10}H_{22}$.

Ethene is then converted into ethanol.

- (i) Name the process used to obtain ethene from long chain hydrocarbons such as decane, $C_{10}H_{22}$.

..... [1]

- (ii) Complete the chemical equation to show the formation of ethene from decane, $C_{10}H_{22}$.



- (iii) Write the chemical equation for the conversion of ethene into ethanol.

..... [1]

- (iv) Name the type of reaction occurring when ethene is converted into ethanol.

..... [1]

- (v) Give **one** condition for the reaction in which ethene is converted into ethanol.

..... [1]

- (c) Ethanol can also be produced by fermentation of carbohydrates such as glucose.

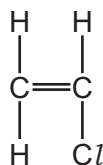
Give **two** advantages of manufacturing ethanol by fermentation compared to manufacturing ethanol from ethene.

1

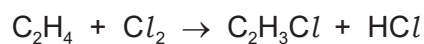
2 [2]

- (d) (i) Under certain conditions ethene can react with chlorine to produce chloroethene.

The structure of chloroethene is shown.



The equation for the chemical reaction is shown.



State the type of chemical reaction between ethene and chlorine that this equation shows.

..... [1]

- (ii) Chloroethene monomers can be converted into a polymer called poly(chloroethene).

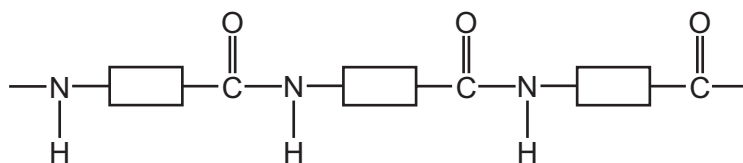
State the type of polymerisation that produces poly(chloroethene) from chloroethene.

..... [1]

- (iii) Draw a section of the poly(chloroethene) molecule made from **two** monomer molecules.

[2]

(e) The structure of part of a polymer is shown.



This polymer is made from one type of monomer only.

Complete the diagram to show the structure of the monomer used to produce this polymer. Show all of the atoms and all of the bonds in the functional groups.



[2]

[Total: 16]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.

The Periodic Table of Elements

Group																	
I	II	1 H hydrogen 1										III	IV	V	VI	VII	VIII
3 Li lithium 7	4 Be beryllium 9	Key atomic number atomic symbol name relative atomic mass										5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	2 He helium 4
	11 Na sodium 23												12 Mg magnesium 24	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium —	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —
87 Fr francium —	88 Ra radium —	89–103 actinoids	104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	114 Fl flerovium —	116 Lv livermorium —				

lanthanoids

57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).