5 (a) Which of the following substances will be a solid at 20 °C and will melt when placed in a beaker of hot water at 80 °C?

(1)

	melting point in °C	boiling point in °C
☒ **A**	122	249
☒ **B**	–7	59
☒ **C**	30	2403
☒ **D**	–32	27

(b) A student set up the apparatus shown in Figure 4 to obtain pure water from sea water by distillation.

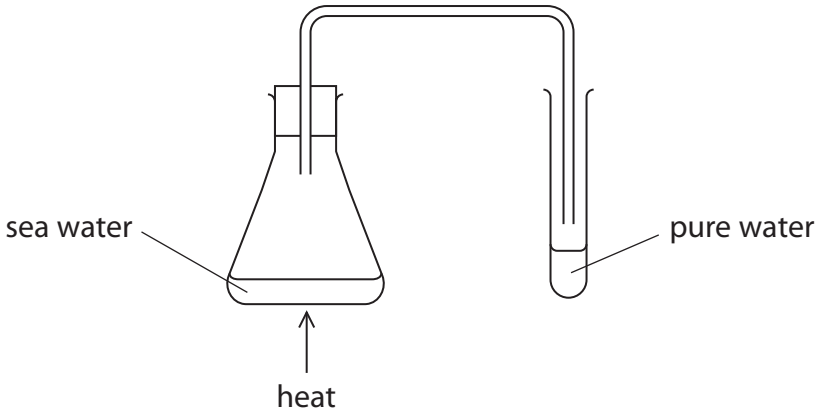


Figure 4

(i) Explain how the water in sea water separates to produce the pure water in this apparatus.

(2)

(ii) Explain how the apparatus could be improved to increase the amount of pure water collected from the same volume of sea water.

(2)

(c) A substance is heated at a constant rate and its temperature is taken every minute. During the heating, the substance undergoes one change of state.

The results are shown on the graph in Figure 5.

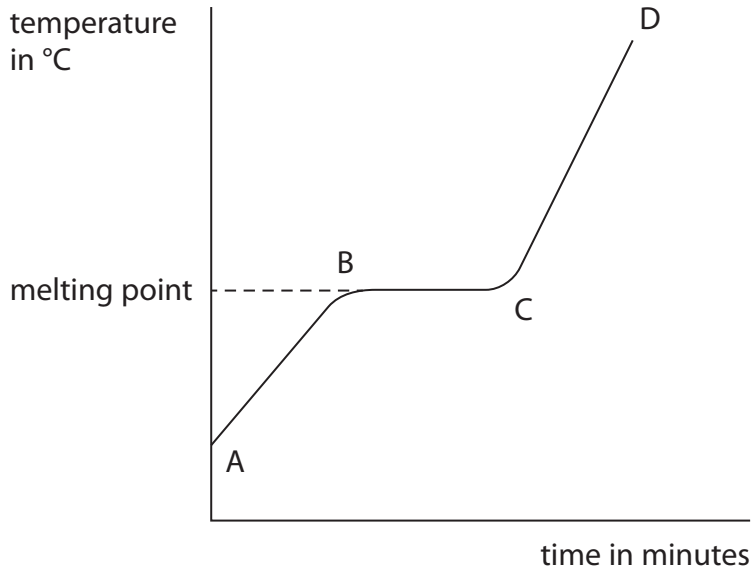


Figure 5

Explain the shape of the graph in terms of the changes in the movement and arrangement of the particles as the substance is heated.

(4)

(Total for Question 5 = 9 marks)

9 (a) A student placed a piece of metal **P** in a test tube containing excess dilute sulfuric acid.
The student repeated this with three other metals, **Q**, **R** and **S**.
All the pieces of all four metals were the same size.

(i) The student recorded the observations until each metal had reacted with the acid for two minutes.
The observations are shown in Figure 9.

metal	observations
P	bubbles produced very slowly some metal remained
Q	bubbles produced quickly no metal remained
R	bubbles produced slowly no metal remained
S	bubbles produced very quickly no metal remained

Figure 9

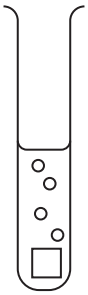
Use this information to put the four metals in order of reactivity from the least reactive to the most reactive.

(2)

least reactive | | | | | **most reactive**

(ii) Complete the diagram below to show how the student could add to the apparatus to measure the volume of gas produced in the two minutes.

(2)



(b) When iron reacts with copper sulfate solution, solid copper is formed.

Two possible equations for this reaction are

A $CuSO_4 + Fe \rightarrow Cu + FeSO_4$
B $3CuSO_4 + 2Fe \rightarrow 3Cu + Fe_2(SO_4)_3$

It was found that 10.00 g of iron powder reacted with excess copper sulfate solution to produce 11.34 g of copper.

Carry out a calculation to decide which equation, **A** or **B**, represents the reaction taking place.
(relative atomic masses: Fe = 56.0, Cu = 63.5)

(2)

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7 (a) Describe what is **seen** when chlorine water is added to potassium bromide solution and the mixture shaken.

(2)

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(b) Chlorine reacts with potassium bromide to form potassium chloride and bromine. In this reaction chlorine forms chloride ions

$$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$$

(i) In this reaction, chlorine has been reduced.

Explain, using the equation, how you know that chlorine has been reduced.

(2)

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.....

.....

(ii) Write the half equation for the formation of bromine from bromide ions.

(2)

.....

.....

(c) Aluminium reacts with chlorine to form aluminium chloride.

Write the balanced equation for this reaction.

(3)

(d) A solid ionic compound is dissolved in water to form a solution.

Describe a simple experiment to show that charged particles are present in this solution.

(3)

(Total for Question 7 = 12 marks)

9 (a) The rate of reaction between magnesium ribbon and dilute hydrochloric acid at room temperature is investigated.

The apparatus used is shown in Figure 11.

The volume of hydrogen gas given off was measured at regular intervals during the reaction.

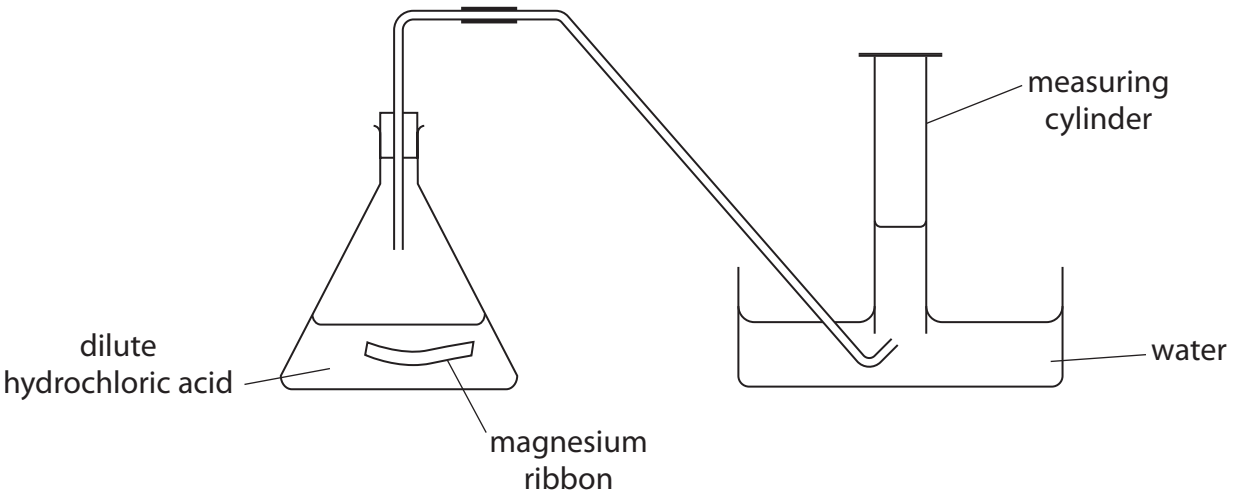

Figure 11

The graph in Figure 12 shows the results of this experiment.

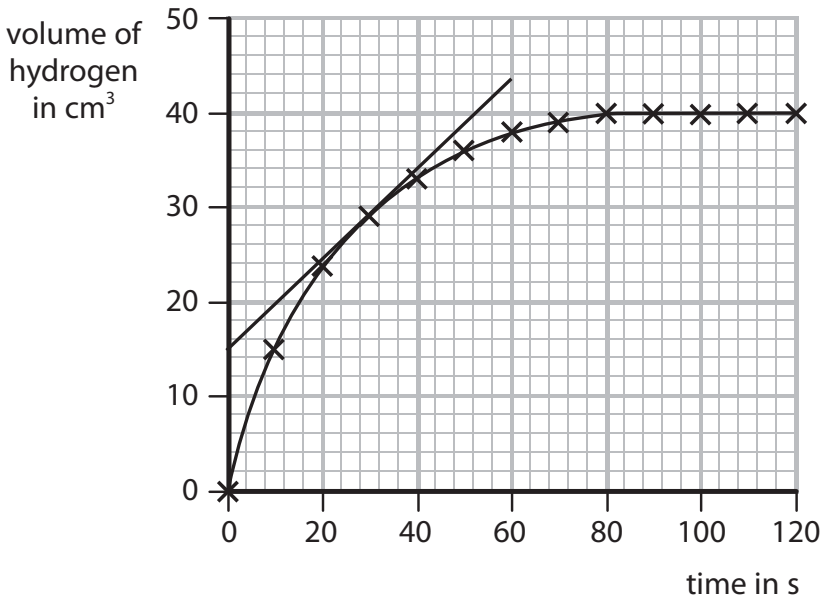

Figure 12

(i) State a change that can be made to the apparatus in Figure 11 to measure the volumes of gas more accurately.

(1)

.....

.....

(ii) A tangent has been drawn to the line on the graph in Figure 12.

Calculate the rate of reaction at this point.

(2)

rate of reaction = ... $cm^3\ s^{-1}$

(iii) On the graph in Figure 12, draw the line you would expect to obtain if the magnesium ribbon in this experiment was replaced with an equal mass of powdered magnesium. All other conditions are kept the same.

(1)

(b) The balanced equation for this reaction is

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

(i) In another experiment, 0.1 moles of hydrochloric acid, HCl, were reacted with 0.1 g of magnesium ribbon.

Calculate the number of moles of magnesium, Mg, in the 0.1 g sample of magnesium ribbon.
(relative atomic mass: Mg = 24)

(1)

number of moles = ...

(ii) In a further experiment, 0.5 mol of hydrochloric acid, HCl, were mixed with 0.5 mol of magnesium, Mg.

Use the equation to show that, in this experiment, the magnesium is in excess.

(1)

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*(c) Two substances, **A** and **B**, each form a colourless solution.
If the solutions are mixed in a beaker, **A** and **B** react to form a coloured product.
The rate of the reaction between **A** and **B** can be investigated by placing the beaker containing the mixture on a cross on a piece of paper and timing how long it takes for enough coloured product to be produced to make the cross invisible when viewed from above, through the solution.

	experiment 1	**experiment 2**	**experiment 3**
concentration of **A in solution** in g dm^{-3}	10	10	40
temperature in °C	20	40	40
time for cross to become invisible in s	320	80	20

Figure 13

Use the results of these experiments to explain, in terms of the behaviour of particles, the effect of changing temperature and the effect of changing the concentration of **A** in solution on the rate of this reaction.

(6)

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒.
If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Mixtures of coloured substances can be separated by paper chromatography.

(a) Paper chromatography was used to separate a mixture of blue and red inks.
A spot of the mixture was placed on chromatography paper as shown in Figure 1.

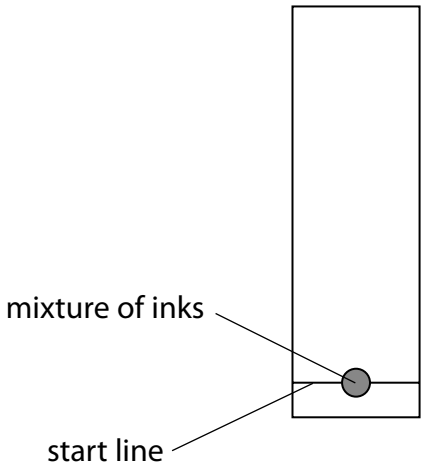

Figure 1

(i) Give a reason why the start line is drawn in pencil rather than in ink.

(1)

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(ii) The chromatography paper, with the spot of mixture on it, was placed in a beaker with the bottom of the paper in water.

On Figure 2, complete the diagram showing the position of the chromatography paper with the spot of mixture at the start of the experiment.

(1)

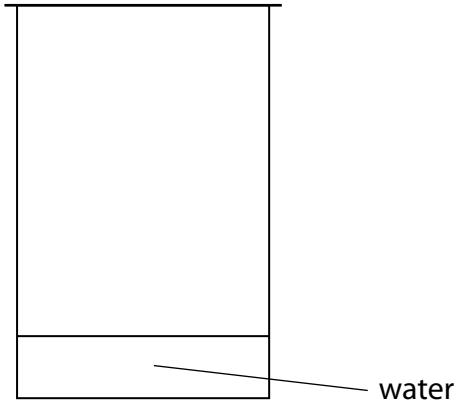

Figure 2

(iii) The chromatography was carried out and the result is shown in Figure 3.

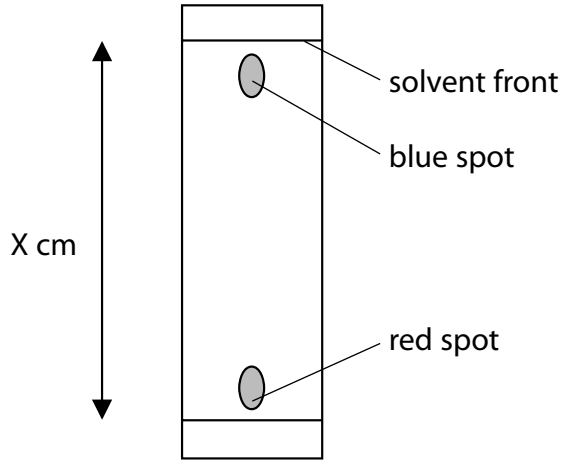

Figure 3

The blue spot had moved 14.5 cm and the solvent front had moved 15.3 cm.

Calculate the R_f value of the substance in the blue spot, giving your answer to 2 significant figures.

$$R_f \text{ value} = \frac{\text{distance travelled by a dye}}{\text{distance travelled by solvent front}}$$

(2)

R_f value = ...

(b) **P**, **Q**, **R** and **S** are mixtures of food colourings.
They are investigated using paper chromatography.
Figure 4 shows the chromatogram at the end of the experiment.

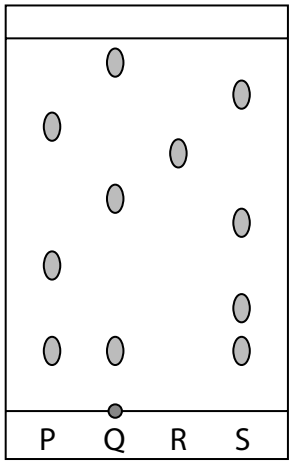

Figure 4

(i) Which mixture contains an insoluble food colouring?

(1)

☒ **A** mixture **P**

☒ **B** mixture **Q**

☒ **C** mixture **R**

☒ **D** mixture **S**

(ii) Give a change that could be made to the experiment to obtain an R_f value for the insoluble colouring.

(1)

.....

.....

(iii) Explain, by referring to Figure 4, which mixture is separated into the greatest number of soluble food colourings by this chromatography experiment.

(2)

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.....

.....

.....

(Total for Question 1 = 8 marks)

4 The method used to prepare a salt depends on its solubility in water.

(a) Complete Figure 9 by placing one tick in each row to show whether the salt is soluble or insoluble.

(2)

salt	soluble	insoluble
ammonium chloride		
lithium sulfate		
magnesium carbonate		

Figure 9

(b) Lead nitrate solution mixed with sodium sulfate solution forms lead sulfate as a precipitate.

$$Pb(NO_3)_2 + Na_2SO_4 \rightarrow PbSO_4 + 2NaNO_3$$

The theoretical yield of lead sulfate for this reaction was 2.85 g.
The actual yield of lead sulfate obtained was 2.53 g.

Calculate the percentage yield of lead sulfate in this experiment.

Give your answer to two significant figures.

(3)

percentage yield = ...%

(c) The method used to make the lead sulfate is:

- pour 100 cm^3 lead nitrate solution into a beaker
- add drops of sodium sulfate solution until a precipitate is seen
- allow the precipitate to settle to the bottom of the beaker
- pour off the liquid
- use a spatula to transfer the solid lead sulfate onto a filter paper

Explain **two** ways of improving this experimental method to increase the amount and quality of lead sulfate obtained from the same volume of lead nitrate solution.

(4)

(d) Ammonium nitrate is produced from ammonia and nitric acid on a large scale in industry.

Ammonium nitrate can also be made in the laboratory by titrating ammonia solution with dilute nitric acid.

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

Ammonium nitrate crystals can then be obtained by evaporating off some of the water from the solution.

Give **two** reasons why this laboratory method is not suitable for use on a large scale in industry.

(2)

(Total for Question 4 = 11 marks)

9 Some acids such as hydrochloric acid are described as strong acids.
Some acids such as ethanoic acid are described as weak acids.

(a) (i) Explain the difference between a strong acid and a weak acid.

(2)

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(ii) Give a reason why adding hydroxide ions to an acid solution leads to an increase in pH.

(1)

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.....

(b) The salt zinc nitrate can be made by reacting zinc oxide, ZnO, with dilute nitric acid, HNO_3.

Write the balanced equation for this reaction.

(2)

.....

(c) 50 cm^3 of potassium hydroxide solution of concentration 40 g dm^{-3} is needed for an experiment.

Calculate the mass of potassium hydroxide that must be dissolved in water to make 50 cm^3 of solution of this concentration.

(2)

mass of potassium hydroxide = ... g

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*(d) Salts of metals can be made by reacting one of the metal's compounds with the appropriate acid.

Plan an experiment to prepare pure, dry crystals of magnesium sulfate, $MgSO_4$, by reacting a suitable magnesium compound with a suitable acid.

You may use equations if you wish.

(6)

(Total for Question 9 = 13 marks)

7 A student investigated the rate of reaction between dilute hydrochloric acid and marble chips (calcium carbonate).

Calcium chloride, carbon dioxide and water are formed.

(a) Complete and balance the equation for the reaction.

(2)

$CaCO_3 + HCl \rightarrow$ ..... + ... + ...

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(b) The student investigated the rate by using different sizes of marble chips. In their investigation, the same mass of marble chips was used in each experiment.

The volume of gas given off was measured.

The graph in Figure 8 shows the results.

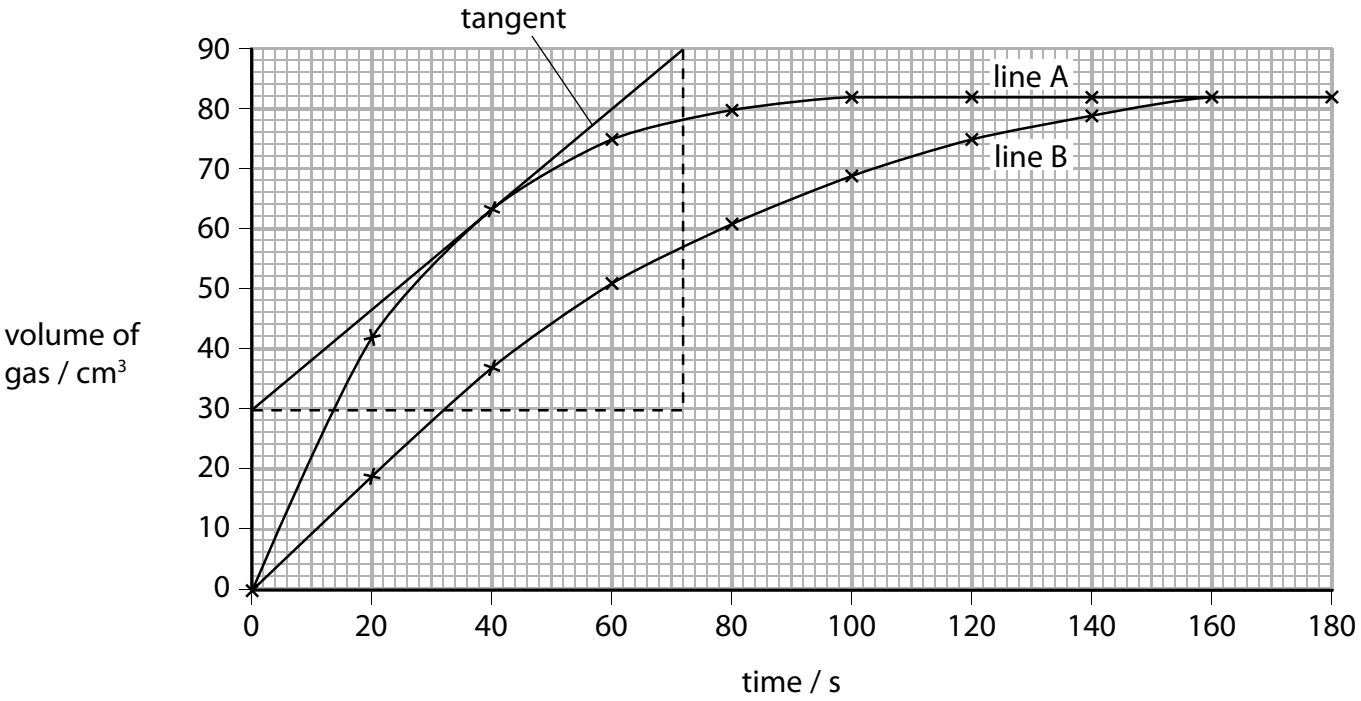


Figure 8

(i) State how the graph shows that line B gives the results for the larger marble chips.

(1)

.....

.....

(ii) A tangent has been drawn on line A.

Calculate the rate of reaction at this point.

(2)

rate of reaction = ... $cm^3 s^{-1}$

(c) During any reaction, reactants are used up and the rate of reaction decreases.

Explain, in terms of particles, why the rate of reaction decreases.

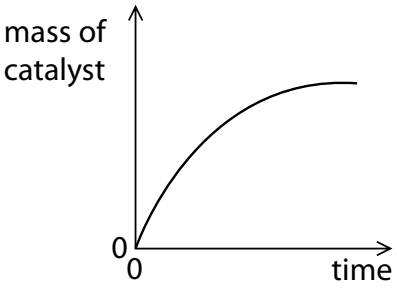
(2)

(d) The decomposition of hydrogen peroxide is catalysed by adding a small amount of manganese(IV) oxide.

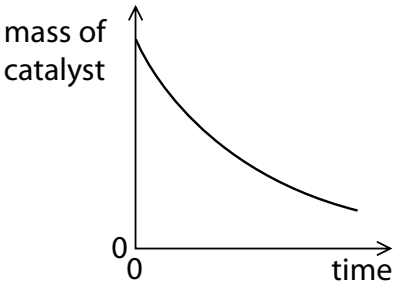
Which of these graphs shows the mass of the catalyst as the reaction takes place?

(1)

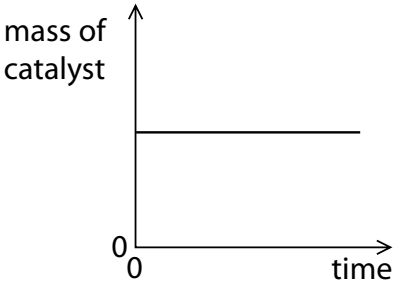
☒ **A**



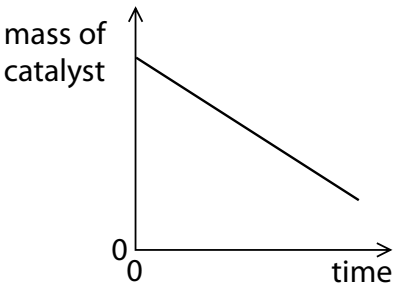
☒ **B**



☒ **C**



☒ **D**



(e) Two gases, **X** and **Y**, react to give a gaseous product **Z**.

The reaction is carried out under two different sets of conditions in experiments 1 and 2 as shown in Figure 9.

condition	experiment 1	experiment 2
temperature / °C	30	20
pressure / atm	1	2

Figure 9

Explain why it is not possible to predict what the rate of Experiment 2 will be compared with Experiment 1.

(3)

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(Total for Question 7 = 11 marks)

8 The elements chlorine, bromine and iodine are part of group 7 in the periodic table.

(a) The appearances of chlorine, bromine and iodine at room temperature are shown in Figure 10.

halogen	appearance
chlorine	green gas
bromine	red-brown liquid
iodine	grey solid

Figure 10

Astatine is the element below iodine in group 7.

Predict the appearance of astatine.

(1)

.....

*(b) The order of reactivity of chlorine, bromine and iodine can be determined by carrying out displacement reactions.

Explain how displacement reactions can be used to show the reactivity of these three elements.

(6)

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(c) When iron wool is heated in bromine vapour, it reacts to form iron bromide.

(i) In an experiment, 5.60 g of iron reacted exactly with 24.0 g of bromine, Br_2.

[relative atomic masses: Fe = 56.0, Br = 80.0]

Determine, using this information, the balanced equation for the reaction between iron and bromine.
You must show your working.

(4)

(ii) When iron reacts with bromine, bromide ions are formed.

Explain the type of reaction bromine atoms undergo when they are converted to bromide ions.

(2)

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(Total for Question 8 = 13 marks)

9 (a) A student carried out an experiment to prove that candle wax, a hydrocarbon, produces carbon dioxide and water vapour when it burns.

The equipment used is shown in Figure 11.

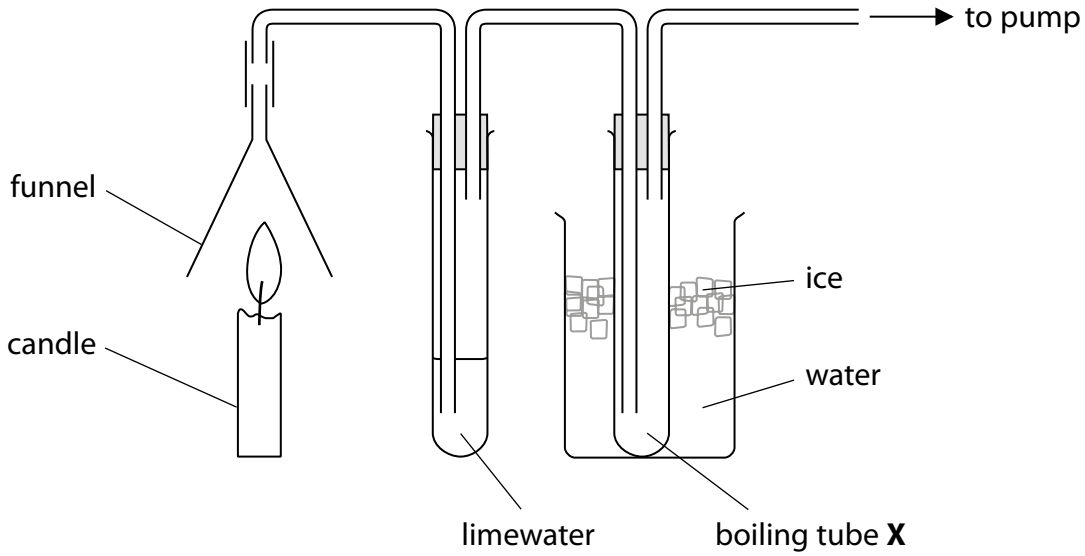

Figure 11

The gas produced from the burning candle is drawn through the apparatus.
The limewater turned milky showing that carbon dioxide had been formed.

A small amount of a colourless liquid condensed in boiling tube **X**.
The student claimed that this proved that burning candle wax produced water.
The teacher said the apparatus had been set up incorrectly and therefore this conclusion about water was not valid.

Explain how the student could modify the equipment to prove that water is produced by burning candle wax.

(2)

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*(b) Polymers are addition or condensation polymers.

Polymers can be formed by using the monomers shown in Figure 12.

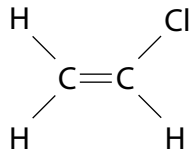
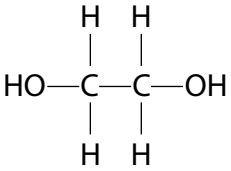
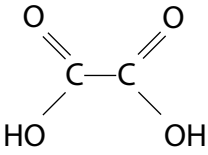
monomer	structure
chloroethene	
ethane-1,2-diol	
ethanedioic acid	

Figure 12

Explain, using appropriate monomers from Figure 12, how different polymers can be formed.

(6)

(c) An alcohol **A**, with molecular formula C_2H_5OH is oxidised to a compound **B** with molecular formula $C_2H_4O_2$.

(i) Compound **B** is not an alcohol and is a member of another homologous series.

State the name of this homologous series.

(1)

.....

(ii) Draw the structure of a molecule of compound **A** and a molecule of compound **B**, showing all covalent bonds.

(2)

Compound **A**

Compound **B**

(Total for Question 9 = 11 marks)

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Question Number	Answer	Mark
5(a)	**C** 30 2403 **The only correct answer is C** ***A*** *is not correct because it will be a solid above 80 ^{o}C* ***B*** *is not correct because it will be a liquid at 20 ^{o}C and gas at 80 ^{o}C* ***D*** *is not correct because it will be a liquid at 20 ^{o}C and gas at 80 ^{o}C*	**(1)** AO 1 1

Question Number	Answer	Additional guidance	Mark
5(b)(i)	An explanation linking • water {boils / evaporates} (to form steam / water vapour / leaving salt behind) (1) • (steam / water vapour) condenses (to form pure water) (1) allow alternative wording for evaporate and condense	ignore sea water evaporates sea water evaporates and condenses scores 1 overall mark independently	**(2)** AO 1 1

Question Number	Answer	Additional guidance	Mark
5(b)(ii)	An explanation linking • use a (Liebig) condenser / surround test tube with (beaker of) {iced/cold} water / wrap delivery tube with cold cloth (1) • to increase effectiveness of cooling / amount of condensation / remove the heat energy more effectively / ensure all the water vapour condenses (1)	ignore anti bumping granules / fractionating column allow alternative suitably described methods / prevent water vapour escaping / cools water vapour faster ignore sea water vapours a closed system scores 0 overall mark independently	**(2)** AO 3 3b

Question Number	Answer	Additional guidance	Mark
5(c)	An explanation linking from B to C: graph flat because • particles in solid use energy to {break out of lattice / break (intermolecular) bonds (between particles) / particles becoming randomly arranged / turn solid to liquid} (1) and any three from from A to B: graph rises because • particles in solid in a lattice / fixed (mean) positions (1) • vibrate more (rapidly) (as temperature increases) (1) from C to D: graph rises because • particles in liquid move past one another / randomly (1) • particles move more (rapidly) (as temperature increases) (1)	may be shown as a diagram / on graph may be shown as a diagram / on graph ignore references to gas / evaporation / boil	**(4)** AO 3 2a AO 3 2b

Total for question 5 = 9 marks

Question Number	Answer	Additional guidance	Mark
9(a)(i)	P R Q S (2)	two in correct order (1)	**(2)** AO 3 2a AO 3 2b

Question Number	Answer		Mark
9(a)(ii)	A workable diagram showing a method to measure the volume of the gas • delivery tube between test-tube and (1) • gas syringe / (graduated tube / inverted burette / measuring cylinder) over water bath (1)	if diagram is not workable (eg no bung at top of test tube), max 1 mark allow connection shown as  if collection vessel not labelled, graduations must be shown for the second mark	**(2)** AO 3 3a AO 3 3b

Question Number	Answer	Additional guidance	Mark
9(b)	iron $\frac{10.00}{56}$ = 0.179 / 0.18 / 0.2 and copper $\frac{11.34}{63.5}$ = 0.179 / 0.18 / 0.2 (1) (ratio 1:1) so reaction A (1)	allow max 1 mark for Fe : $\frac{56}{10.00}$ = 5.6 Cu : $\frac{63.5}{11.34}$ = 5.6 so reaction A other methods of calculation include 10.00 g Fe forms $\frac{10.00}{56}$ x 63.5 (1) g copper = 11.34 g copper so reaction A (1) second mark dependent on first	**(2)** AO 3 2a AO 3 2b

Question Number	Answer	Additional guidance	Mark
9(c)	$2Al + 6H^+ \rightarrow 2Al^{3+} + 3H_2$ (2)	Al and H_2 (1) balancing of correct species (1) allow multiples	**(2)** AO 2 1

Question Number	Answer	Additional guidance	Mark
9(d)	pH {increases / goes up} by <u>one</u> / moves <u>1</u> closer to neutral	ignore {increases / goes up} alone	**(1)** AO 1 1

Question Number	Answer	Additional guidance	Mark
9(e)	1 mol of hydrogen atoms = a mass of 1.00 g = 6.02×10^{23} atoms 6.02×10^{23} H atoms has mass = 1.00 g (1) mass of 1 H atom = $\frac{1.00}{6.02 \times 10^{23}}$ (1) $= 1.66 \times 10^{-24}$ (g) (1)	correct answer alone (3) if $1 \times 6.02 \times 10^{23}$ is followed by atoms or particles, then award 1st marking point on answer line 3.32×10^{-24} (g) (2) ignore sig figs except for one	**(3)** AO 2 1

Total for question 9 = 12 marks

(Total for Question 6 = 11 marks)

Question Number	Answer	Additional guidance	Mark
7(a)	A description including the following points : • (potassium bromide solution) colourless (1) • (mixture) turns yellow / brown / orange / red (1)	 ignore clear ignore reference to colour of chlorine water /change in colour allow colour combinations *e.g.* yellow-orange reject additional incorrect observations for MP2 but ignore yellow/orange/red/brown vapours	**(2)** AO 1 2

Question Number	Answer	Additional guidance	Mark
7(b)(i)	An explanation linking • (chlorine) gains (an) electron(s) (1) • to form {a chloride (ion) / Cl^- / negative ion} (1) MP2 dependent on MP1	 reject chlorine gains an electron from potassium reject sharing of electrons allow $Cl_2 + 2e \rightarrow 2Cl^-$ even if unbalanced (2) ignore chlorine ion	**(2)** AO 1 1

Question Number	Answer	Additional guidance	Mark
7(b)(ii)	$2Br^- \rightarrow Br_2 + 2e$ (2) correct species (in correct place) (1) balancing of correct species (1)	allow $2Br^- - 2e \rightarrow Br_2$ (2) unbalanced 1 max allow multiples	**(2)** AO 2 1

Question Number	Answer	Additional guidance	Mark
7(c)	$2Al + 3Cl_2 \rightarrow 2AlCl_3$ (3) LHS (1) RHS (1) balancing of correct formulae (1)	penalise the use of 'CL' or 'AL' once only ignore state symbols allow multiples ignore use of capital L for MP3	**(3)** AO 2 1

Question Number	Answer	Additional guidance	Mark
7(d)	A description to include the following points • insert electrodes (into aqueous solution)(1) • connect to electrical supply /powerpack /battery/cell (1) • bulb lights / ammeter shows current / electrolyte decomposes (1)	first two marks can be given for a suitable diagram allow anode **and** cathode allow carry out an electrolysis experiment alone / see if solution conducts electricity (1) allow pass an electric current through (the solution) (1) ignore electricity alone allow correct observation at one electrode (1)	**(3)** AO 3 3a

(Total for Question 7 = 12 marks)

Question Number	Answer	Additional guidance	Mark
9(a)(i)	(gas) syringe / graduated tube / burette (instead of measuring cylinder)		**(1)** AO 3 3b

Question Number	Answer	Additional guidance	Mark
9(a)(ii)	final answer in range 0.44 – 0.52 inclusive with or without working (2) If answer not in range: $\frac{\text{difference in volume}}{\text{difference in time}} = \frac{(43 - 15)}{(60 - 0)}$ (1) = 0.47 / 0.467 (1)	 allow ecf throughout where values are less than 1 (1 max) use of inverted gradient expression giving 2.27 – 1.92 scores 1 mark (evidence of working required)	**(2)** AO 2 1

Question Number	Answer	Additional guidance	Mark
9(a)(iii)	steeper **curve** to the left of printed curve and same final volume	line must not go above 40 cm^3 and curve back down	**(1)** AO 2 2

Question Number	Answer	Additional guidance	Mark
9(b)(i)	number of moles = 0.1 /24 = 0.0042 or 4.2 x 10^{-3} (1)	ignore answer left as fraction 1/240 rounding must be correct: reject 0.00416 (no dot) allow 0.00416̇ (with dot above the 6) allow 0.004	**(1)** AO 2 1

Question Number	Answer	Additional guidance	Mark
9(b)(ii)	the equation shows two HCl reacting with one Mg	allow ratio is 2:1 allow 1 mol HCl reacts with 0.5 mol of Mg allow 0.5 mol HCl reacts with 0.25 mol Mg	**(1)** AO 2 1

Question Number	Indicative content	Mark
*9(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • reactions occur when particle collisions have sufficient energy (activation energy) • reaction rates are increased when the energy collisions is increased • and / or the frequency of collisions is increased • two factors in the reaction have been changed (temperature and concentration of one of the reactants) • experiment 2 was carried out at a higher temperature than experiment 1 • concentrations of reactant are the same in experiment 1 and 2 • particles have more (kinetic energy), so move faster • so there are more frequent collisions between particles in solution **A** solution and solution **B** • collisions will also occur with greater energy • so more collisions will have the minimum activation energy to react when they collide • so greater frequency of successful collisions (so decreased reaction time/increased rate in experiment 2 compared to experiment 1) • experiment 3 was carried out at a higher concentration than experiment 2/ a fourfold increase • temperatures of the reactants are the same in experiment 2 and 3 • there are more reacting particles in the same volume of reaction mixture • so there are more frequent collisions between particles in solution **A** and solution **B** • so greater frequency of successful collisions (so decreased reaction time/increased rate in experiment 3 compared to experiment 2) • reaction rate in experiment 3 is greatest due to combined effects of increased temperature and increased concentration	**(6)** AO 2 2 AO 3 2a

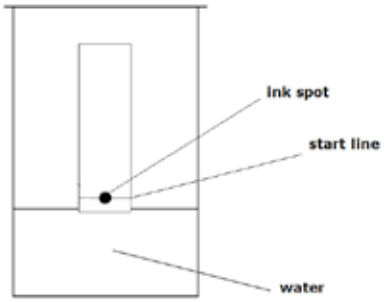
Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	• Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3)

		• The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Total for Question 9 = 12 marks)

Paper 1 Higher

Question number	Answer	Mark
1(a)(i)	Pencil is insoluble in the solvent (but chromatography would separate the ink in an ink line).	(1)

Question number	Answer	Mark
1(a)(ii)	Correct position of chromatography paper with start line and ink spot above surface of water.  	(1)

Question number	Answer	Additional guidance	Mark
1(a)(iii)	• R_f = 14.5 / 15.3= 0.9477 (1) • = 0.95 (answer to 2 significant figures) (1)	Award full marks for correct numerical answer without working.	(2)

Question number	Answer	Mark
1(b)(i)	B	(1)

Question number	Answer	Mark
1(b)(ii)	use a different solvent.	(1)

Question number	Answer	Mark
1(b)(iii)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • mixture S (1) • because it gives the greatest number of spots/gives four spots (1)	(2)

Question number	Answer	Mark
3(d)	$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ • Correct formulae (1) • Balancing of correct formulae (1)	**(2)**

Question number	Answer	Mark
4(a)	<table><tr><th>salt</th><th>soluble</th><th>insoluble</th></tr><tr><td>ammonium chloride</td><td>✓</td><td></td></tr><tr><td>lithium sulfate</td><td>✓</td><td></td></tr><tr><td>magnesium carbonate</td><td></td><td>✓</td></tr></table> • All three correct (2) • Any two correct (1)	**(2)**

Question number	Answer	Additional guidance	Mark
4(b)	• mass values in correct places (1) • multiplication by 100 (1) • correct final answer to two significant figures (1)	$\frac{2.53}{2.85} \times 100 = 88.8\%$ 89% (to 2 s.f.) Award full marks for correct numerical answer without working.	**(3)**

Question number	Answer	Mark
4(c)	An explanation that combines identification – improvement of the experimental procedure (maximum 2 marks) and justification/reasoning, which must be linked to the improvement (maximum 2 marks): • add excess sodium sulfate solution rather than a few drops (1) • so more reaction occurs to form more lead sulfate (1) • filter the reaction mixture rather than pour off the liquid(1) • so none of the lead sulfate is lost on separation(1) • wash the lead sulfate (1) • so the impurities are removed (1) • place the lead sulfate in an oven/warm place (1) • so the lead sulfate is dry (1)	**(4)**

Question number	Answer	Mark
4(d)	• volumes of solution too large for titration method (1) • large volumes of liquid need to be heated and then allowed to crystallise (1)	**(2)**

Question number	Answer	Mark
5(a)(i)	C	**(1)**

Question number	Answer	Additional guidance	Mark
8(c)	2.4/24 moles Mg = 0.1 mol (1) and 0.2 moles H_2O has mass 0.2 × formula mass H_2O = 3.6 g (1) total mass reactants = 2.4 + 3.6 = 6.0 g is the same as total mass products = 5.8 + 0.2 = 6.0 g (1)	Award full marks for correct numerical answer without working.	**(3)**

Question number	Answer	Mark
9(a)(i)	An explanation that makes reference to: identification – knowledge (1 mark) and reasoning /justification – knowledge (1 mark): • a strong acid is completely ionised in solution/exists completely as ions (1) • but a weak acid is only partly ionised/exists mainly as molecules with very few ions present (1)	**(2)**

Question number	Answer	Mark
9(a)(ii)	hydroxide ions react with hydrogen ions and reduce the hydrogen ion concentration therefore increase pH (1)	**(1)**

Question number	Answer	Mark
9(b)	$ZnO + 2HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O$ • zinc nitrate formula (1) • full, balanced equation (1)	**(2)**

Question number	Answer	Additional guidance	Mark
9(c)	mass = $50 \times \frac{40}{1000}$ (1) = 2 (g) (1)	Award full marks for correct numerical answer without working.	**(2)**

Question Number	Indicative content
9(d)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO2 (3 marks)** • suitable acid: sulfuric acid • suitable substance : magnesium oxide / magnesium carbonate / magnesium hydroxide / magnesium • equation for reaction: $MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$/ $Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$/ $MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$/ $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$ **AO3 (3 marks)** • add solid to warmed acid until in excess solid remains (oxide and hydroxide) / add solid a little at a time until no more bubbles (carbonate/metal) • filter off the excess solid, pour remaining solution into an evaporating basin • {heat solution / leave the water to evaporate} • until pure salt crystals form and then dry salt crystals with absorbent paper/leave to dry.

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• The plan attempts to link and apply knowledge and understanding of scientific enquiry, techniques and procedures, flawed or simplistic connections made between elements in the context of the question. (AO2) • Analyses the scientific information but understanding and connections are flawed. An incomplete plan that provides limited synthesis of understanding. (AO3)
Level 2	3–4	• The explanation is mostly supported through linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, some logical connections made between elements in the context of the question. (AO2) • Analyses the scientific information and provides some logical connections between scientific enquiry, techniques and procedures. A partially completed plan that synthesises mostly relevant understanding, but not entirely coherently. (AO3)
Level 3	5–6	• The explanation is supported throughout by linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, logical connections made between elements in the context of the question. (AO2) • Analyses the scientific information and provide logical connections between scientific concepts throughout. A well-developed plan that synthesises relevant understanding coherently. (AO3)

Question number	Answer	Additional guidance	Mark
7(a)	$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$ • LHS (1) • RHS (1)	Allow products in any order	**(2)**

Question number	Answer	Mark
7(b)(i)	(line B) less steep/(line B) flattens later (1)	**(1)**

Question number	Answer	Mark
7(b)(ii)	• Slope = 60 ÷ 72 (1) • = 0.83(3) (cm^3 s^{-1}) (1)	**(2)**

Question number	Answer	Mark
7(c)	An explanation that makes reference to: identification – knowledge (1 mark) and reasoning/justification – knowledge (1 mark): • fewer particles/as the reactants are used up there will be fewer particles to react/lower concentration of particles (1) • this will result in a lower frequency of collisions so fewer particles reacting in a given time (1)	**(2)**

Question number	Answer	Mark
7(d)	C	**(1)**

Question number	Answer	Mark
7(e)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): • the decrease in temperature will cause a decrease in rate of reaction (1) • and the increase in pressure will cause an increase in rate of reaction (1) • because the changes have opposite effects on the rate it is not possible which has the greater effect (1)	**(3)**

Question number	Answer	Mark
8(a)	Candidates relate information given to order of elements in the periodic table to predict: dark grey/black **and** solid/crystals	**(1)**

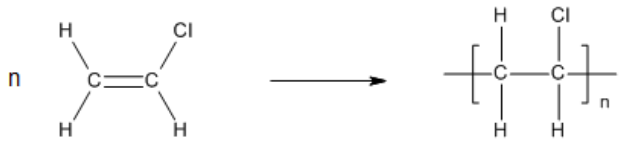
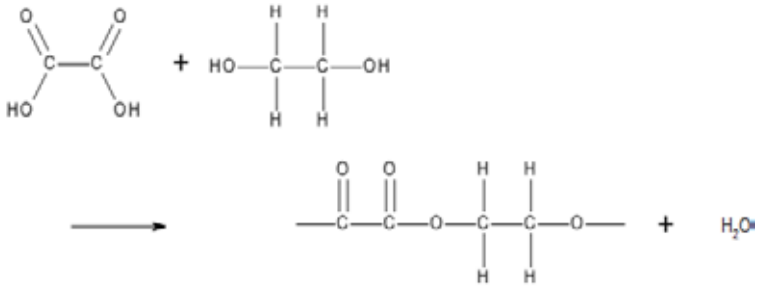
Question number	Indicative content	Mark
*8(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • order of reactivity: chlorine > bromine > iodine The order of reactivity supported by suitable experiments from: • add (aqueous) chlorine to a solution of potassium bromide • the solution turns orange/yellow • bromine is produced / $Cl_2 + 2KBr \rightarrow Br_2 + 2KCl$ / $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ • (so) chlorine is more reactive than/displaces bromine /oxidises bromide ions • add (aqueous) bromine to a solution of potassium iodide • the solution turns yellow/red/ brown • iodine is produced / $Br_2 + 2KI \rightarrow I_2 + 2KBr$ / $Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ • (so) bromine is more reactive than/displaces iodine/ oxidises iodide ions • add (aqueous) chlorine to a solution of potassium iodide • the solution turns yellow/red/ brown • iodine is produced / $Cl_2 + 2KI \rightarrow I_2 + 2KCl$ / $Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$ • (so) chlorine is more reactive than/displaces iodine/oxidises iodide ions Allow use of suggested reactions which do not produce a displacement reaction, e.g. add (aqueous) bromine to a solution of a potassium chloride with suitable conclusion/explanation	**(6)**

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas, enquiry, techniques and procedures lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure, which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Question number	Answer	Additional guidance	Mark
8(c)(i)	• calculates mol of Fe (1) • calculates mol of Br^2 (1) • determines simplest ratio/LHS of equation (1) • deduces formula of iron bromide produced/RHS of equation (1) OR • divides mass by relative atomic mass (1) • simplest ratio (1) • empirical formula (1) • deduces LHS to obtain balanced equation (1)	<u>Example of calculation</u> mol Fe = $\frac{5.6}{56}$ = 0.1 mol Br_2 = $\frac{24}{(2\times80)}$ = 0.15 ratio Fe:Br_2 = 2 : 3/ 2Fe + 3Br_2 2$FeBr_3$/Fe_2Br_6 Fe : Br $\frac{5.6}{56}$: $\frac{24}{80}$ 0.1 : 0.3 1 : 3 $FeBr_3$ 2Fe + 3Br_2 → 2$FeBr_3$	**(4)**

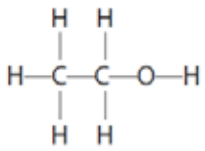
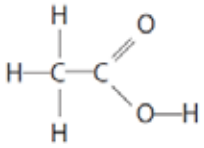
Question number	Answer	Mark
8(c)(ii)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • bromine atoms are reduced (1) • because electrons are gained to form bromide ions (1)	**(2)**

Question number	Answer	Mark
9(a)	An explanation that combines identification – improvement of the experimental procedure (1 mark) and justification/reasoning which must be linked to the improvement (1 mark): • reverse the boiling tubes/pass gas through the tube in ice water first (1) • so that if any liquid condenses in the tube it must have come from the burning wax (and not from the limewater) (1)	**(2)**

Question number	Indicative content	Mark
*9(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Candidates choose appropriate monomers to illustrate the formation of different polymers. • polymer molecules are long chains • made up of simple repeating units • use chloroethene (only) • to form poly(chloroethene) • which is addition polymerisation • use ethane-1,2-diol and ethanedioic acid • to form a polyester • which is condensation polymerisation • one of the bonds in the double bond in chloroethene molecule breaks • and chloroethene molecules join together to form a long chain molecule • equation  • identification of repeat unit • alcohol group combines with a carboxylic acid group • and an ester (link) formed • with a water (molecule) eliminated • equation  • ester link shown • identification of repeat unit	**(6)**

Level	Mark	Descriptor
	0	No awardable content.
Level 1	1–2	• The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2) • Lines of reasoning are unsupported or unclear. (AO2)
Level 2	3–4	• The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2) • Lines of reasoning mostly supported through the application of relevant evidence. (AO2)
Level 3	5–6	• The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2) • Lines of reasoning are supported by sustained application of relevant evidence. (AO2)

Question number	Answer	Marks
9(c)(i)	carboxylic acids	**(1)**

Question number	Answer	Marks
9(c)(ii)	A is  (1) B is  (1)	**(2)**

Question number	Answer	Mark
10(a)	B	**(1)**

Question number	Answer	Marks
10(b)	An answer that combines the following points to provide a plan: • measure known volume of sodium hydroxide solution (1) • add same volume of each of the acids (1) • stir the mixture (1) • record the initial and final temperatures/temperature change (1)	**(4)**