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Mark

S813/76/01

Chemistry
Paper 2

Date — Not applicable

Duration — 2 hours 20 minutes

S8137601

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

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Date of birth
Day Month Year

Scottish candidate number

Total marks — 95

Attempt ALL questions.

You may use a calculator.

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

S8137601

Total marks — 95

Attempt ALL questions

1. The periodic table allows chemists to make predictions about the properties of elements.

(a) The elements lithium to neon make up the second period of the periodic table.

Li	Be	B	C	N	O	F	Ne

(i) Name an element from the second period that can exist as a covalent network. **1**

(ii) Explain why the atoms decrease in size from lithium to neon. **1**

(iii) Name the element that is the strongest reducing agent in the second period. **1**

MARKS

DO NOT WRITE IN THIS MARGIN

(b) On descending group 1 from lithium to caesium, the electronegativity of the elements decreases.

Explain **fully** why the electronegativity of the elements decreases going down group 1. **2**

(c) Tin(IV) iodide is a compound formed from a metal element and a non-metal element.

Tin(IV) iodide is a bright orange powder that dissolves easily in non-polar solvents. It has a melting point of 143 °C and a boiling point of 340 °C.

Name the type of bonding **and** structure present in tin(IV) iodide. **1**

[Turn over

2. The table below contains information about some diatomic molecules.

	H—H	H—Cl	Cl—Cl	I—Cl	Br—Br
Boiling point (°C)	−253	−85	−34	97	59
Bond enthalpy (kJ mol^{-1})	436	432	243	211	194

(a) Boiling points can be used to show the effect of intermolecular forces.

Explain **fully** why ICl and Br_2 provide good evidence for a fair comparison of the relative strengths of different types of intermolecular force. **3**

(b) State which of the diatomic molecules listed in the table above has the strongest covalent bond. **1**

MARKS

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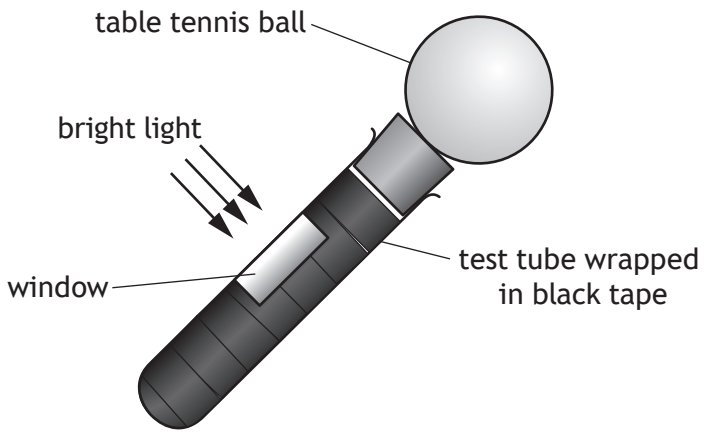
(c) Hydrogen and chlorine gases were used in an experiment to demonstrate a free radical reaction.

A test-tube was wrapped with black tape leaving a 'window' on one side. The tube was filled with a mixture of hydrogen and chlorine. When a bright light was directed at the tube, the gas mixture exploded and the ball was fired across the room.



A free radical chain reaction is initiated when light energy causes chlorine radicals to form as shown below.

Initiation $Cl—Cl \xrightarrow{light} Cl\bullet + Cl\bullet$

(i) Complete the equations below showing possible propagation and termination steps. **2**

Propagation $Cl\bullet + H—H \longrightarrow \quad +$

Termination $H\bullet + H\bullet \longrightarrow$

(ii) Suggest why the test tube was wrapped in black tape. **1**

[Turn over

MARKS

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(iii) When hydrogen gas and chlorine gas react hydrogen chloride gas is produced.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

Using bond enthalpy values, calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction of one mole of hydrogen with one mole of chlorine. **2**

(d) Chlorine can be made in a redox reaction between permanganate ions and chloride ions.

The ion-electron equations for the oxidation and reduction reactions are shown below.

$$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$$

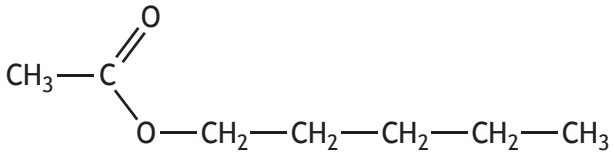
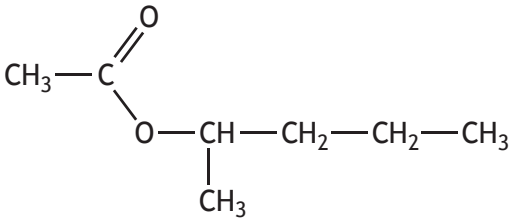
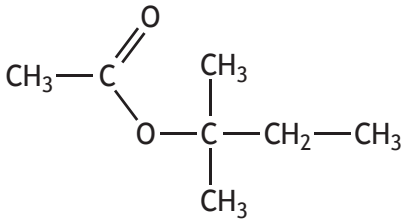
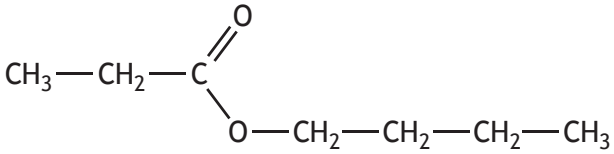
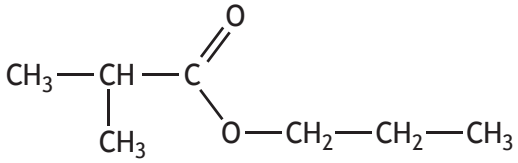
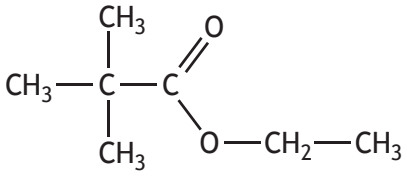
$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$$

Write a balanced equation for the reaction of permanganate ions with chloride ions to produce chlorine gas. **1**

3. A team of chemists are developing a shower gel. **MARKS** DO NOT WRITE IN THIS MARGIN

(a) A suitable fragrance must be created for the shower gel.

(i) To give the gel a fruity smell the chemists are considering adding an ester. They synthesise six isomeric esters. Volunteers smell each ester and give it a rating out of one hundred depending on how fruity the smell is.

Structure	*Fruit-smell rating*
	100
	34
	0
	92
	44
	32

(A) Name the ester with the fruit-smell rating of 92. **1**

[Turn over

MARKS

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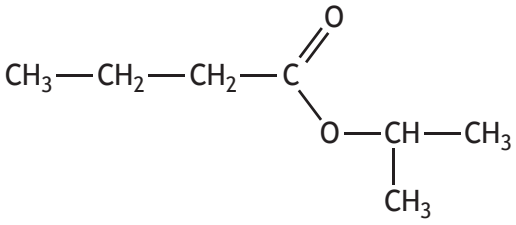
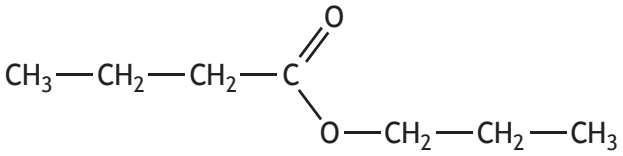
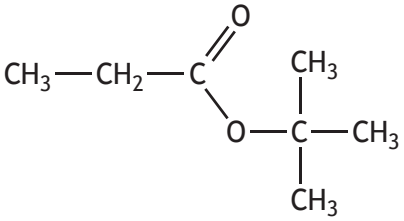
(B) Shown below are the structures of three more isomers.



Ester **A**



Ester **B**



Ester **C**

Arrange these esters in order of **decreasing** fruit-smell rating. **1**

Ester ☐ > Ester ☐ > Ester ☐

3. (a) (continued)

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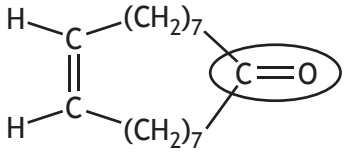
(ii) The compound civetone will also be used in the fragrance.

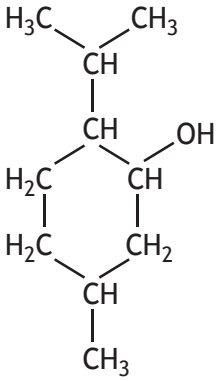


civetone

(A) Name the functional group circled in the structure above. **1**

(B) Draw a structural formula for the alcohol that can be oxidised to form civetone. **1**

(b) To make the shower gel produce a cold, tingling sensation when applied to the skin, menthol is added.



Menthol is based on two isoprene units.

Circle one of the isoprene units on the menthol structure above. **1**

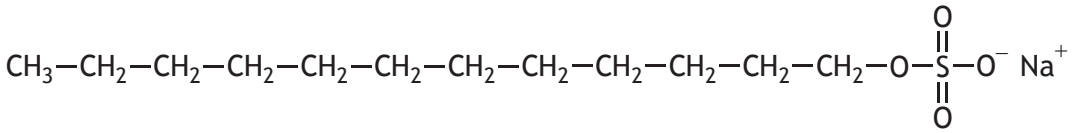
(An additional diagram, if required, can be found on *page 38*.)

[Turn over

3. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(c) Sodium lauryl sulfate, a detergent, is used in the shower gel to give the product cleaning properties.



(i) **Explain fully** the cleaning action of sodium lauryl sulfate. **3**
(You may wish to use diagrams to illustrate your answer.)

(ii) Explain why detergents, like sodium lauryl sulfate, are preferable to soap in hard water areas. **1**

MARKS

DO NOT WRITE IN THIS MARGIN

(d) Esters and terpenes have been used for thousands of years to create fragrances.

Traces of liquid were discovered in a perfume bottle that belonged to Queen Hatshepsut, ruler of Egypt, over 3500 years ago.

Egyptian perfumes were made by dissolving plant extracts containing pleasant-smelling terpenes and esters in an edible oil. A little ethanol and water may also have been added.

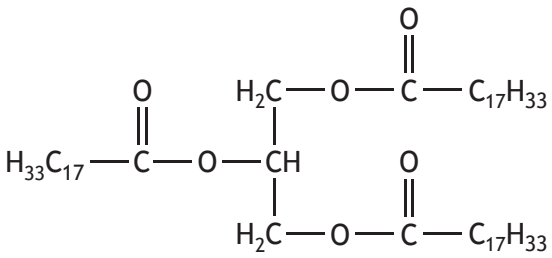
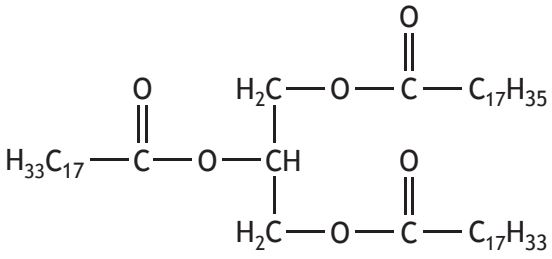
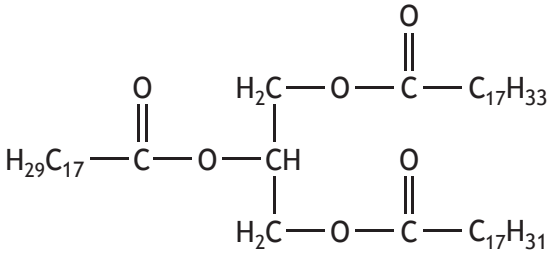
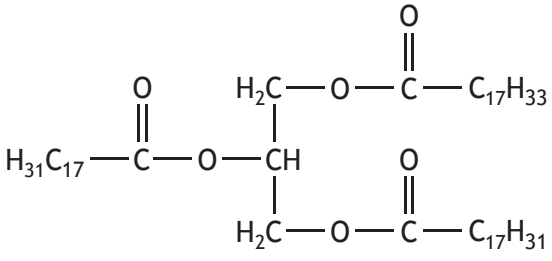
Using your knowledge of chemistry, comment on the possible smell(s) when such a bottle is opened after being stored for thousands of years. **3**

[Turn over

DO NOT WRITE IN THIS MARGIN

4. A student carried out some experiments using different edible fats and edible oils.

(a) The first experiment allowed the iodine number to be determined. The larger the iodine number, the greater the number of carbon-to-carbon double bonds present in the fat or oil.

Fat or oil	*Iodine number*	*Typical molecule found in fat or oil*
Olive oil	86	
Shea butter	57	
Linseed oil	173	
Sunflower oil		

4. (a) (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(i) Shea butter has the highest melting point of these substances.

Explain **fully** why the melting point of shea butter is higher than the edible oils. **3**

(ii) By considering the number of carbon-to-carbon double bonds in each structure, predict the iodine number of sunflower oil. **1**

[Turn over

4. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(b) In the second experiment, soap was made by heating triolein obtained from olive oil with sodium hydroxide solution.

$$\underset{\text{triolein}}{(C_{17}H_{33}COO)_3C_3H_5} + 3NaOH \rightarrow \underset{\text{soap}}{3C_{17}H_{33}COONa} + \mathbf{X}$$

GFM = 884 g GFM = 304 g

(i) Name product **X**. **1**

(ii) 5·00 g of triolein produced 1·28 g of soap.

Calculate the percentage yield. **3**

5. Butan-2-ol is widely used as a solvent.

(a) In industry butan-2-ol is produced by the hydration of but-2-ene.

$$\underset{\text{but-2-ene}}{C_4H_8(g)} + H_2O(g) \rightarrow \underset{\text{butan-2-ol}}{C_4H_{10}O(g)}$$

The enthalpy values for the following reactions are:

$$4C(s) + 4H_2(g) \rightarrow C_4H_8(g) \qquad \Delta H = -7{\cdot}1 \text{ kJ mol}^{-1}$$

$$4C(s) + 5H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow C_4H_{10}O(g) \qquad \Delta H = -292{\cdot}8 \text{ kJ mol}^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(g) \qquad \Delta H = -241{\cdot}8 \text{ kJ mol}^{-1}$$

Using the data above, calculate the enthalpy change, in kJ mol^{-1}, for the production of butan-2-ol by hydration of but-2-ene. **2**

[Turn over

MARKS

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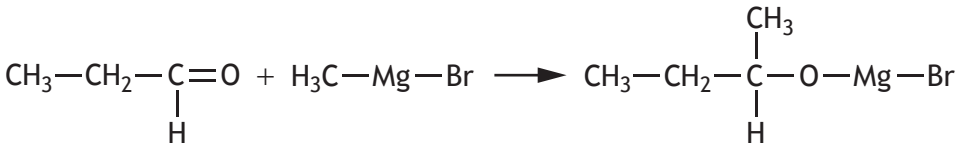
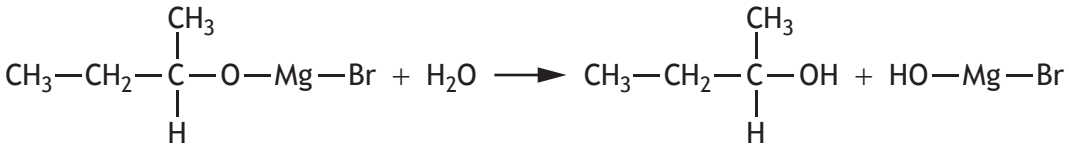
(b) A chemist investigated the costs involved in producing butan-2-ol from propanal using a two-step process.

Step One



propanal methyl magnesium bromide

Step Two



butan-2-ol

(i) The chemist made 5·75 g of butan-2-ol using 5·01 g of propanal and 20·0 g of methyl magnesium bromide.

The costs of the chemicals used are shown below.

Propanal	£22·10 for 1 kg
Methyl magnesium bromide	£75·00 for 25 g

Calculate the cost of the chemicals, in £, needed to produce 100 g of butan-2-ol using this method. **2**

(ii) This method can be used to produce different alcohols by using other aldehydes in place of propanal.

Name the alcohol produced if this method is repeated using pentanal. **1**

5. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(c) Butan-2-ol can be converted into butanone, another useful solvent.

(i) Name the type of reaction that takes place when butan-2-ol is converted into butanone. **1**

(ii) Care must be taken when using butanone as a solvent because it is highly flammable.

The lowest temperature at which butanone will ignite is called its flash point.

For the family of compounds containing butanone, the flash point can be predicted from the number of carbon atoms it contains using the formula:

flash point in °C $=$ (14 $\times$ number of carbon atoms) $-$ 59

Calculate the flash point, in °C, for butanone. **1**

[Turn over

6. Chemists have developed cheeses specifically for use in cheeseburgers.

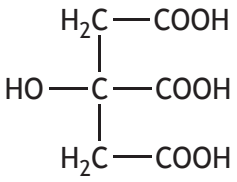
(a) When ordinary cheese is heated, the texture changes as the protein molecules change shape.

Explain fully why protein molecules change shape when they are heated. **2**

(b) To make cheese for burgers, ordinary cheese, soluble milk proteins and water are mixed and heated to no more than 82 °C. As the cheese begins to melt, trisodium citrate is added.

(i) Suggest why a water bath was used to heat the mixture. **1**

(ii) Trisodium citrate is the salt formed when citric acid is neutralised using a base.



citric acid

Suggest the name of a base that could be used to neutralise citric acid forming trisodium citrate. **1**

MARKS

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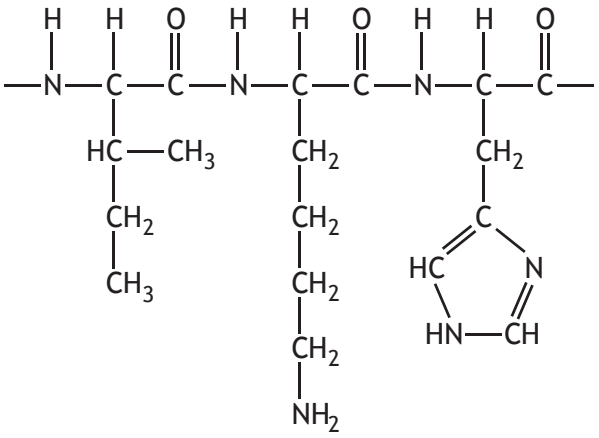
(iii) A section of the structure of a soluble milk protein is shown below.



Draw a structural formula for any **one** of the amino acids formed when this section of protein is hydrolysed. **1**

(c) Cheese is a source of zinc, an essential element for the body.

The mass of zinc in four 100 g samples taken from a burger cheese was measured.

Sample	*Mass of zinc* (mg)
1	4·0
2	21·7
3	3·9
4	4·1

Calculate the average mass of zinc, in mg, in 100 g of this burger cheese. **1**

MARKS

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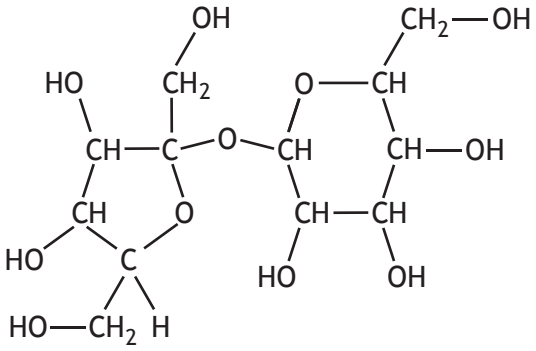
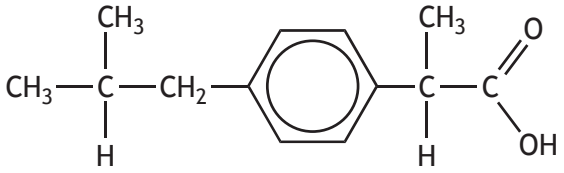
(d) A calorie-free replacement for the fat in cheese can be made by reacting fatty acids with the hydroxyl groups on a molecule of sucrose.



sucrose

State how many fatty acid molecules can react with one molecule of sucrose. **1**

7. Ibuprofen is one of the best-selling painkillers in the UK.



ibuprofen

(a) Ibuprofen tablets should not be taken by people who suffer from acid indigestion.

Name the functional group present in ibuprofen that makes this drug unsuitable for these people. **1**

(b) From the 1990s, ibuprofen has been synthesised by a three step process.

The equation below shows the final step of the synthesis.

$$C_{12}H_{17}OH + CO \xrightarrow{\text{Pd catalyst}} C_{12}H_{17}COOH$$

ibuprofen

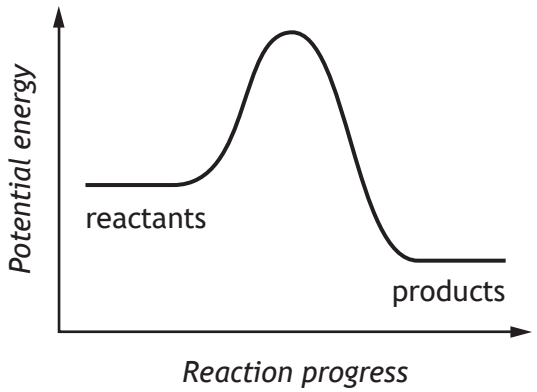
(i) State the percentage atom economy of this step. **1**

[Turn over

MARKS

DO NOT WRITE IN THIS MARGIN

(ii) The diagram below represents the changing potential energy during this reaction when it is carried out without the palladium catalyst.



Add a line to the diagram showing the changing potential energy when the catalyst is used. **1**

(An additional diagram, if required, can be found on *page 38*.)

(c) Ibuprofen, $C_{12}H_{17}COOH$, is taken for the relief of pain in the form of pills or tablets because it is only slightly soluble in water.

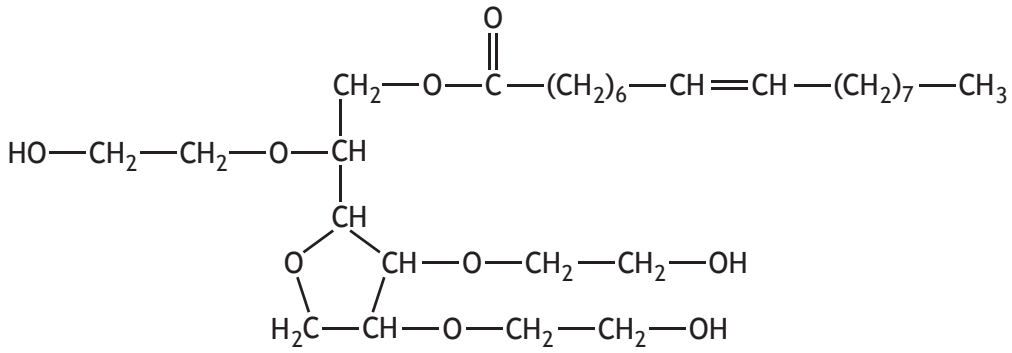
(i) Suggest why ibuprofen is only slightly soluble in water. **1**

MARKS

DO NOT WRITE IN THIS MARGIN

(ii) Small children can find it difficult to swallow tablets or pills so ibuprofen is supplied as an 'infant formula' liquid.

(A) The 'infant formula' also contains polysorbate 80. Its structure is shown below.



Suggest why polysorbate 80 is included in the 'infant formula'. **1**

(B) The 'infant formula' contains 2·0 g of ibuprofen in every 100 cm^3 of liquid.

The recommended dose for treating a 6-month-old baby is 0·050 g.

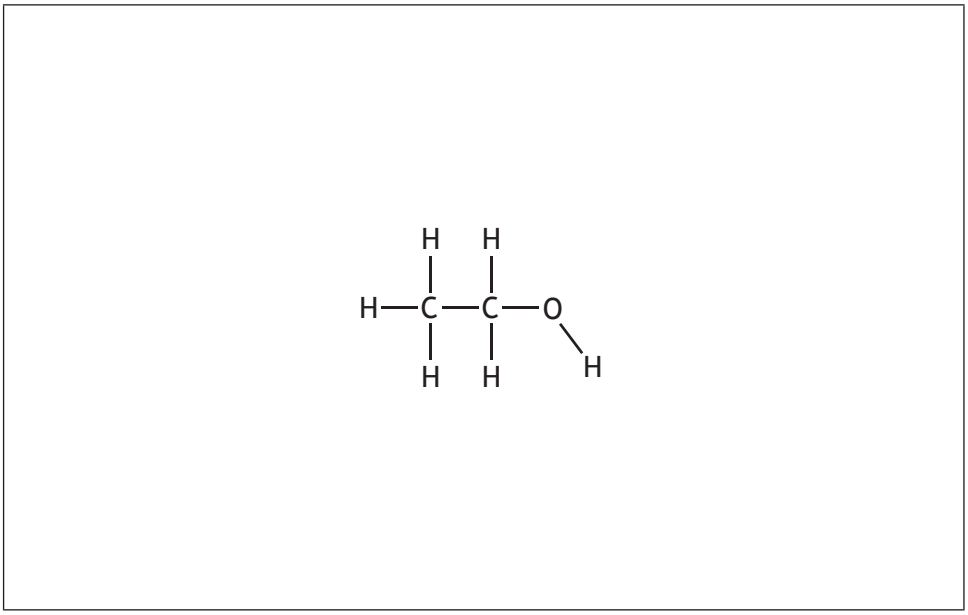
Calculate the volume, in cm^3, of 'infant formula' needed to treat a 6-month-old baby. **1**

[Turn over

8. Ethanol and 2-methylpropan-1-ol are alcohols that can be used as renewable fuels in car engines.

(a) Alcohols tends to absorb water from the air causing corrosion in fuel tanks and engines. Water is absorbed because alcohols can form hydrogen bonds with water molecules.

In the box below, showing a molecule of ethanol, draw a molecule of water and use a dotted line to show where a hydrogen bond exists between the two molecules. **1**



(An additional diagram, if required, can be found on *page 38*.)

(b) Draw a structural formula for 2-methylpropan-1-ol. **1**

8. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(c) A car was fuelled with 15 litres of ethanol. The ethanol burned releasing 351 000 kJ of energy.

Volume of 1 g of 2-methylpropan-1-ol	1·25 cm^3
Energy released when 1 g of 2-methylpropan-1-ol burns	36·1 kJ

Use the data in the table to calculate the volume of 2-methylpropan-1-ol that would burn to release the same quantity of energy. **3**

[Turn over

9. A student carried out an investigation to measure the fluoride and nitrite levels in a water supply.

(a) The student prepared a set of sodium fluoride solutions of known concentration by diluting a standard solution.

(i) State what is meant by the term **standard solution**. **1**

(ii) Calculate the mass, in mg, of sodium fluoride, NaF, needed to make 1 litre of standard solution with a **fluoride ion** concentration of 100 mg l^{-1}. **2**

(iii) Describe how the standard solution would be prepared from the weighed sample of sodium fluoride. **3**

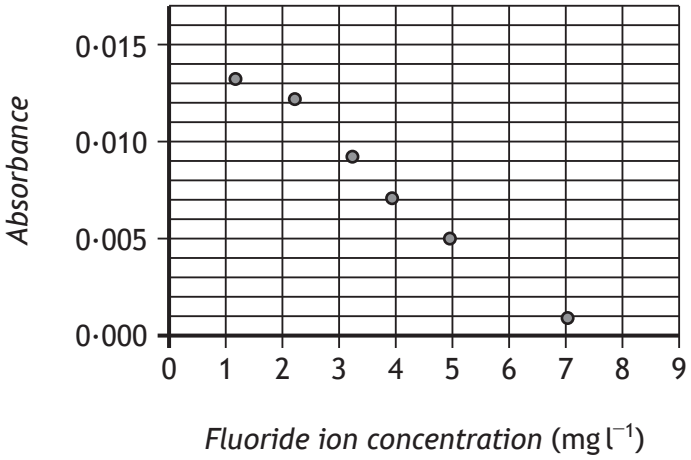
(iv) Suggest why the student should use distilled or deionised water rather than tap water when dissolving the sodium fluoride. **1**

MARKS

DO NOT WRITE IN THIS MARGIN

(v) The concentration of fluoride ions in a sample of water can be determined by adding the sample to a solution containing a coloured compound. The coloured compound reacts with fluoride ions turning colourless. The higher the concentration of fluoride ions present in a water sample, the paler the colour and the less light is absorbed by the solution.

The graph below shows results for six solutions of known fluoride ion concentration.



Determine the concentration, in mg l^{-1}, of fluoride ions in a water sample that reacted with the coloured compound to form a solution with an absorbance of 0·012. **1**

[Turn over

9. (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(b) The concentration of nitrite ions, NO_2^-, in the water supply was determined by titrating water samples with acidified permanganate solutions.

The reaction taking place is

$$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(\ell)$$

(i) Name the most appropriate piece of laboratory apparatus to measure out 25·0 cm^3 samples of water. **1**

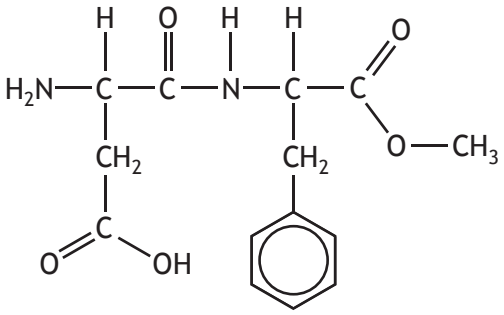
(ii) 21·6 cm^3 of 0·015 mol l^{-1} acidified permanganate solution was required to react completely with the nitrite ions in a 25·0 cm^3 sample of water.

Calculate the nitrite ion concentration, in mol l^{-1}, in the water.

Show your working clearly. **3**

10. Soft drinks can contain ingredients such as sweeteners and caffeine.

(a) Aspartame is a sweetener. Its structure is shown below.



(i) In the stomach, aspartame is hydrolysed by acid to produce two amino acids and an alcohol.

State what is meant by the term 'hydrolysed'. **1**

(ii) Name the alcohol produced in the hydrolysis reaction. **1**

(iii) The body cannot make all the amino acids it requires and is dependent on protein in the diet for the supply of certain amino acids.

State the term used to describe the amino acids the body cannot make. **1**

[Turn over

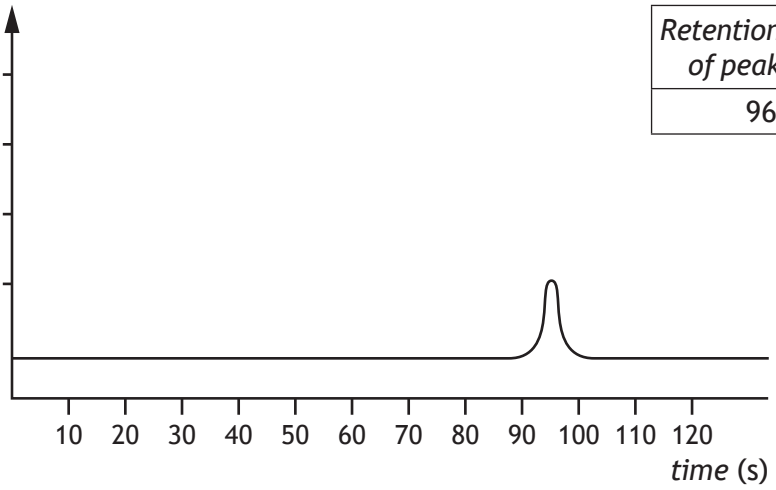
10. (continued)

DO NOT WRITE IN THIS MARGIN

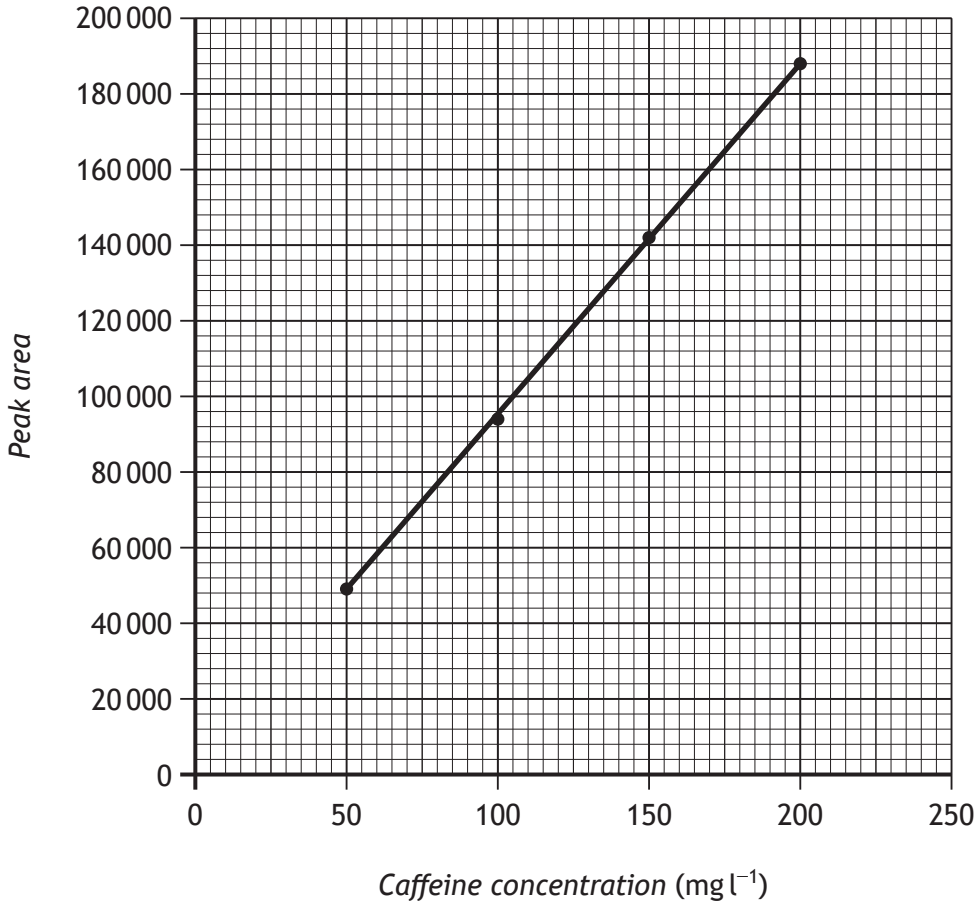
(b) The concentration of caffeine can be found using chromatography.

A chromatogram for a solution containing 50 mg l^{-1} of caffeine is shown below.

Retention time of peak (s)	*Peak area*
96	49 000



Results from four caffeine solutions were used to produce the calibration graph below.



MARKS

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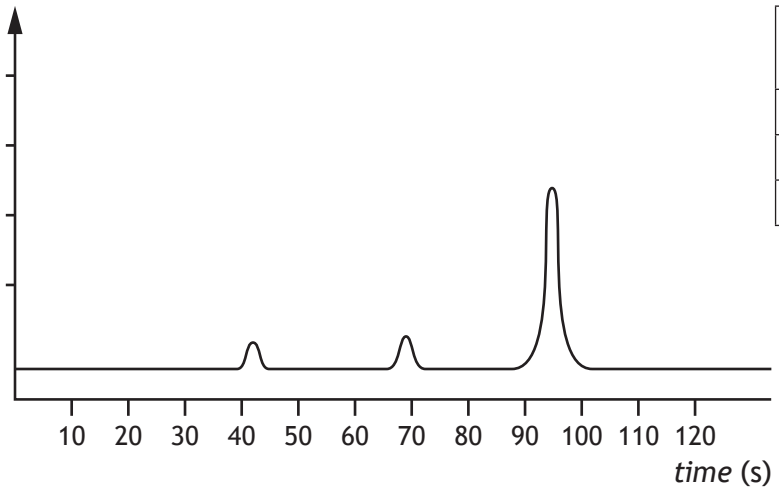
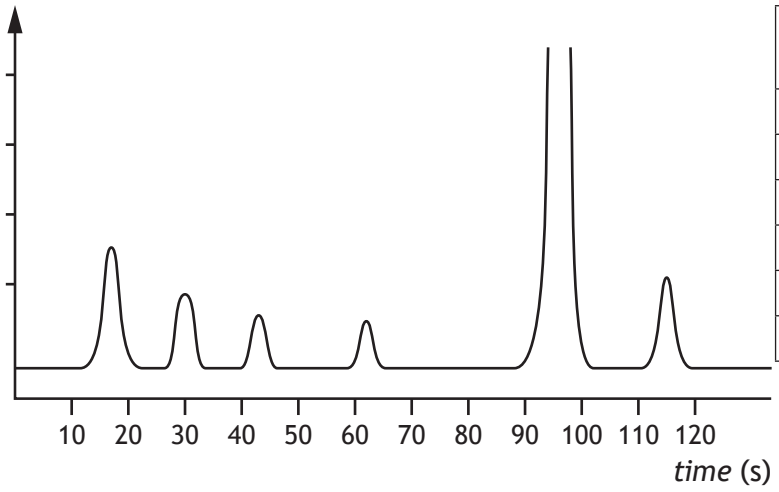
(i) The chromatogram for soft drink **X** is shown below.



Retention time of peak (s)	*Peak area*
42	1000
69	1350
96	68 000

Determine the caffeine content, in mg l^{-1}, of soft drink **X**. **1**

(ii) The chromatogram for soft drink **Y** is shown below.



Retention time of peak (s)	*Peak area*
17	7000
30	4600
43	3000
62	2500
96	- - - -
115	5000

The caffeine content of soft drink **Y** cannot be determined from its chromatogram.

Suggest what could be done to the sample of soft drink **Y** so that the caffeine content could be reliably determined. **1**

11. Hypochlorite bleaches are cleaning products containing the hypochlorite ion, $ClO^-(aq)$, a good oxidising agent.

(a) Hypochlorite bleaches can be made by reacting sodium hydroxide with chlorine. Sodium hypochlorite, NaClO, sodium chloride and water are formed.

Write a balanced equation for the reaction. **1**

(b) When $ClO^-(aq)$ acts as a bleach, it is reduced to produce the $Cl^-(aq)$ ion.

Complete the ion-electron equation to show the reduction reaction. **1**

$ClO^-(aq) \quad \rightarrow \quad Cl^-(aq)$

MARKS

DO NOT WRITE IN THIS MARGIN

(c) In one method that can be used to measure the concentration of hypochlorite ions in a sample of bleach, the bleach sample is reacted with excess hydrogen peroxide.

$$H_2O_2(aq) + ClO^-(aq) \rightarrow H_2O(\ell) + Cl^-(aq) + O_2(g)$$

By measuring the volume of oxygen given off, the concentration of bleach can be calculated.

(i) Draw a diagram showing an assembled apparatus that could be used to react hydrogen peroxide solution with bleach and measure the volume of oxygen gas released.

Your diagram should include labels showing the names and positions of the reacting chemicals and the collected product. **3**

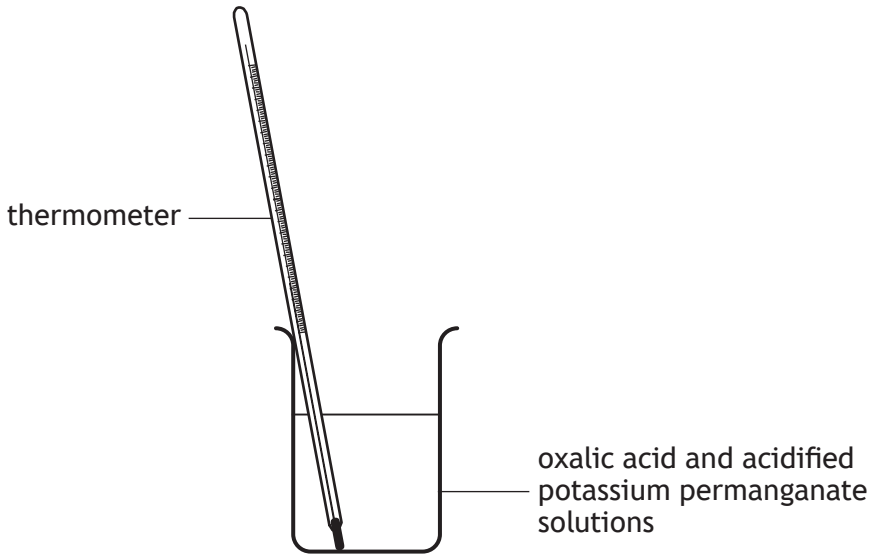
(ii) 80 cm^3 of oxygen gas was produced from 5·0 cm^3 of bleach.

Calculate the concentration, in mol l^{-1}, of the hypochlorite ions in the bleach. **3**

(Take the molar volume of one mole of oxygen to be 24 litres.)

12. Changing the temperature at which a redox reaction is carried out changes the rate of reaction.

(a) The effect of temperature on reaction rate can be studied using the rate at which acidified potassium permanganate is reduced by oxalic acid.

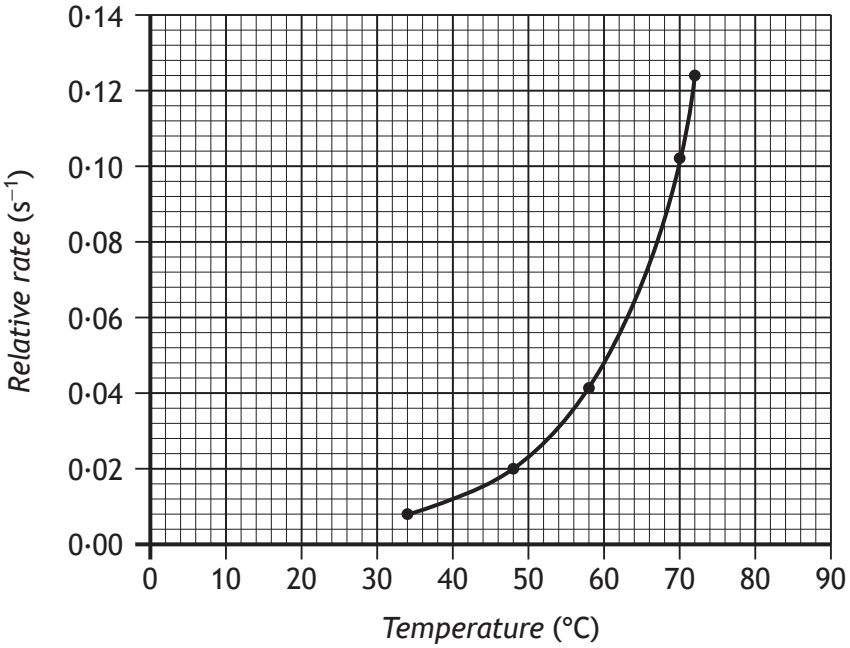


(i) State the colour change that takes place when acidified permanganate ions are reduced. **1**

12. (a) (continued)

MARKS DO NOT WRITE IN THIS MARGIN

(ii) A student's results are shown on the graph below.



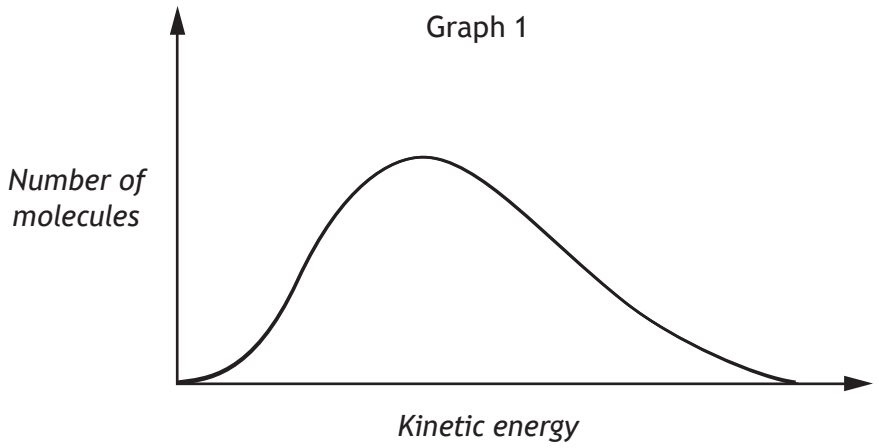
Calculate the time taken for the reaction, in s, when the reaction is carried out at 40 °C. **2**

[Turn over

MARKS

DO NOT WRITE IN THIS MARGIN

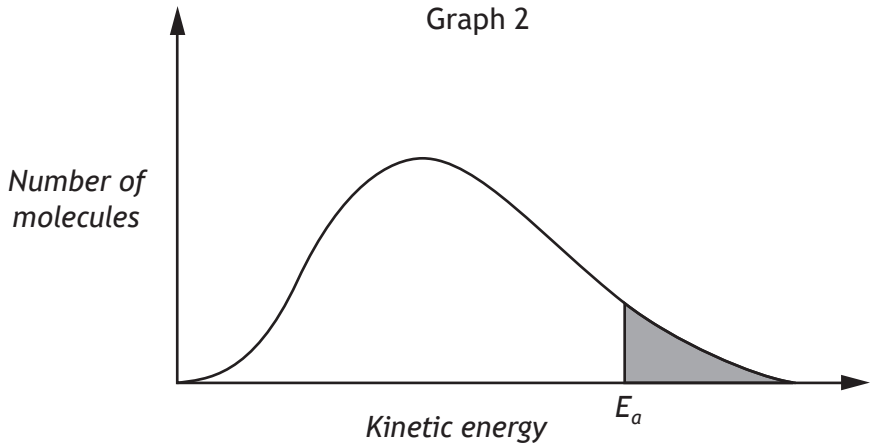
(b) (i) Graph 1 shows the distribution of kinetic energy of molecules in a gas at 100 °C.



Add a second curve to Graph 1 to show the distribution of kinetic energies at 50 °C. **1**

(An additional graph, if required, can be found on *page 39*.)

(ii) In Graph 2, the shaded area represents the number of molecules with the required activation energy, E_a.



Draw a line to show how a catalyst affects the activation energy. **1**

(An additional graph, if required, can be found on *page 39*.)

(c) A collision involving molecules with the required energy of activation may **not** result in a reaction.

State a reason for this. **1**

13. Cis-platin, $PtN_2H_6Cl_2$, is a widely used anti-cancer drug.

It can be produced in the following **exothermic** reaction.

$$K_2PtCl_4(aq) + 2KI(aq) + 2NH_3(g) + 2AgNO_3(aq) \rightleftharpoons PtN_2H_6Cl_2(aq) + 2AgI(s) + 2KNO_3(aq) + 2KCl(aq)$$

The cost of the chemicals used are shown in the table.

Chemical	*Cost per gram* (£)
K_2PtCl_4	65·00
KI	0·21
NH_3	0·02
$AgNO_3$	3·90

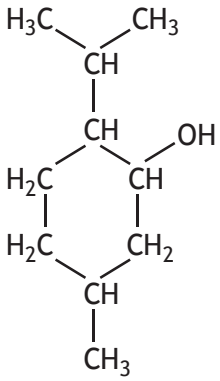
MARKS DO NOT WRITE IN THIS MARGIN

Using your knowledge of chemistry, comment on how this process could be carried out to make the production of cis-platin as profitable as possible. **3**

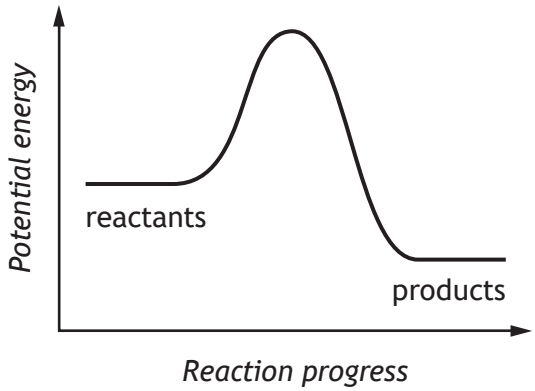
[END OF SPECIMEN QUESTION PAPER]

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

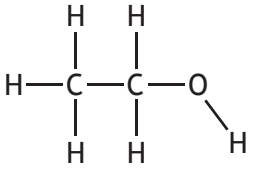
ADDITIONAL DIAGRAM FOR QUESTION 3 (b)



ADDITIONAL DIAGRAM FOR QUESTION 7 (b) (ii)



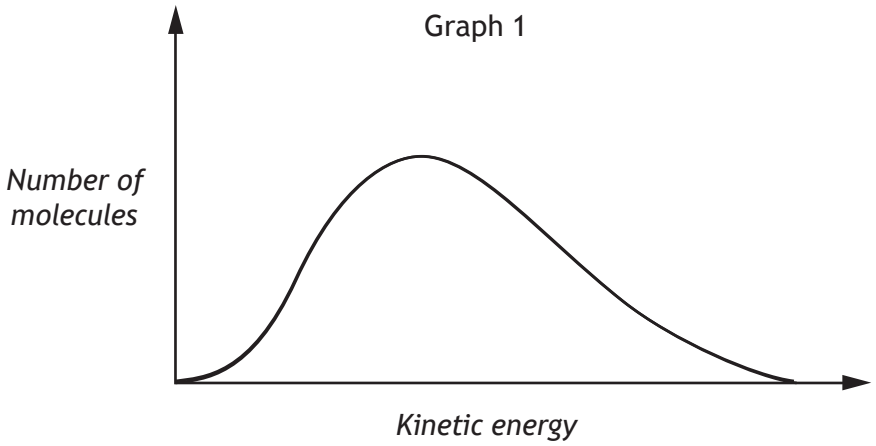
ADDITIONAL DIAGRAM FOR QUESTION 8 (a)



ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

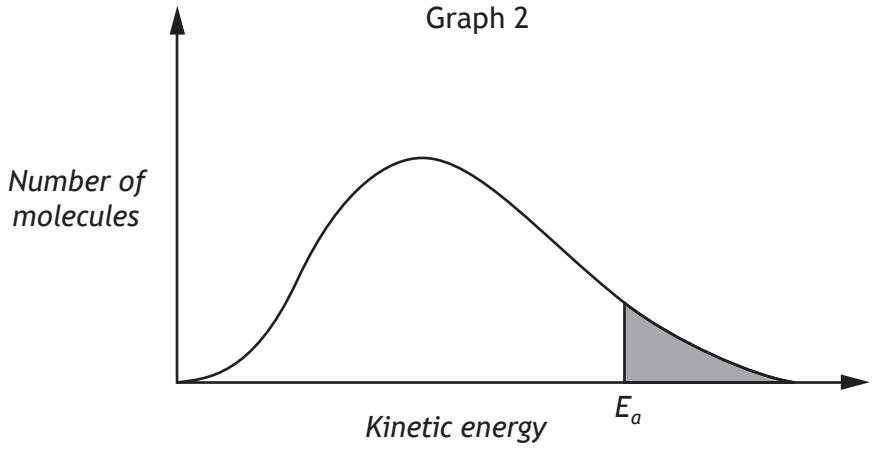
ADDITIONAL GRAPH FOR QUESTION 12 (b) (i)

Graph 1



ADDITIONAL GRAPH FOR QUESTION 12 (b) (ii)

Graph 2



ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

MARKS DO NOT WRITE IN THIS MARGIN

National
Qualifications
SPECIMEN ONLY

S813/76/01

Chemistry
Paper 2

Marking Instructions

These marking instructions have been provided to show how SQA would mark this specimen question paper.

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General marking principles for Higher Chemistry

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

(b) If a candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.

(c) Do not award half marks.

(d) Where a candidate makes an error at an early stage in a multi-stage calculation, award marks for correct follow-on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. Apply the same principle for questions that require several stages of non-mathematical reasoning. The exception to this rule is where the marking instructions for a numerical question assign separate 'concept marks' and an 'arithmetic mark'. In such situations, the marking instructions will give clear guidance on the assignment or partial marks.

(e) Unless a numerical question specifically requires evidence of working to be shown, award full marks for a correct final response (including units) on its own.

(f) Candidates may fully access larger mark allocations whether their responses are in continuous prose, linked statements, or a series of developed bullet points.

(g) Do not deduct marks for inaccurate or unconventional spelling or vocabulary as long as the meaning of the word(s) is conveyed. **For example**, responses that include 'distilling' for 'distillation', or 'it gets hotter' for 'the temperature rises', are acceptable.

(h) In many questions, the unit in which the answer is to be expressed is given. In these questions, the candidate does not need to state a unit in their answer; but if they do, the unit must be correct. The full mark allocation cannot be awarded if an incorrect unit is shown. In these questions, incorrect units would only be penalised once in any paper.

(i) If a correct response is followed by a wrong response, award no marks. **For example** in response to the question, 'State the colour seen when blue Fehling's solution is warmed with an aldehyde', do not award marks for the response 'red green'. However, if a correct response is followed by additional information which does not conflict with that, ignore the additional information, whether correct or not. **For example** in response to a question concerned with melting point, 'State why the tube should not be made of copper', the response 'Copper has a low melting point and is coloured grey' **would** gain marks.

(j) Award full marks for the correct response to a calculation without working. Award partial marks, as shown in the detailed marking instructions, when working is given but the final response is incorrect. An exception is when candidates are asked to 'Find, by calculation' - do not award full marks for the correct response without working.

(k) Ignore the omission of one H atom from a full structural formula provided the bond is shown.

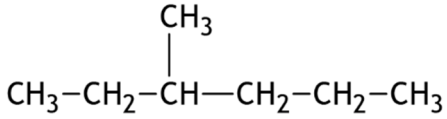
(l) Award marks for a symbol or correct formula in place of a name **unless stated otherwise in the detailed marking instructions.**

(m) When formulae of ionic compounds are given as responses, candidates only need to show ion charges if these have been specifically asked for. However, if ion charges are shown, they must be correct. If incorrect charges are shown, do not award marks.

(n) If an answer comes directly from the text of the question, do not award marks. **For example**, in response to the question, 'A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy. $C_3H_8(g) + 5O_2(g) = 3CO_2(g) + 4H_2O(\ell)$. Name the kind of enthalpy change that the student measured', do not award marks for 'burning' since the word 'burned' appears in the text.

(o) A guiding principle in marking is to give credit for correct elements of a response rather than to look for reasons not to give marks.

Example 1: The structure of a hydrocarbon found in petrol is shown below.



Name the hydrocarbon

- Award the full mark for '3, methyl-hexane', although the punctuation is not correct.

Example 2: A student measured the pH of four carboxylic acids to find out how their strength is related to the number of chlorine atoms in the molecule. The results are shown.

CH_3COOH	1·65
$CH_2ClCOOH$	1·27
$CHCl_2COOH$	0·90
CCl_3COOH	0·51

Describe the relationship between the number of chlorine atoms in the molecule and the strengths of the acids.

- Award the full mark for a response such as 'the more Cl_2, the stronger the acid', although not completely correct.

(p) Unless the question is clearly about a non-chemistry issue, for example costs in an industrial chemical process, do not award marks for a non-chemical response.
For example, in response to the question, 'Why does the (catalytic) converter have a honeycomb structure?', do not award a mark for 'To make it work'. This response may be correct but it is not a chemical response.

(q) Only award marks for a valid response to the question asked. Where candidates are asked to:

- **identify, name, give** or **state**, they must only name or present in brief form.
- **describe**, they must provide a statement or structure of characteristics and/or features.
- **explain**, they must relate cause and effect and/or make relationships between things clear.
- **compare**, they must demonstrate knowledge and understanding of the similarities and/or differences between things.
- **complete**, they must finish a chemical equation or fill in a table with information.

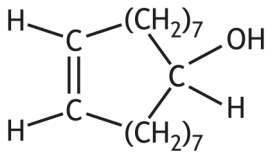
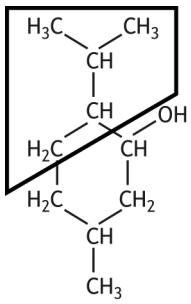
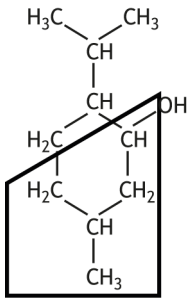
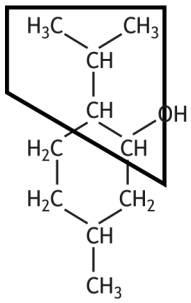
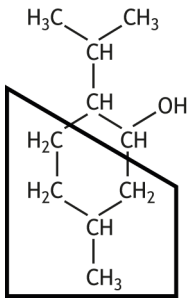
- **determine** or **calculate**, they must determine a number from given facts, figures or information.
- **draw**, they must draw a diagram or structural formula, for example 'Draw a diagram to show the part of a poly(propene) molecule formed from two propene molecules.'
- **estimate**, they must determine an approximate value for something.
- **predict**, they must suggest what may happen based on available information.
- **evaluate**, they must make a judgement based on criteria.
- **suggest**, they must apply their knowledge and understanding of chemistry to a new situation. A number of responses are acceptable: award marks for any suggestions that are supported by knowledge and understanding of chemistry.
- **use their knowledge of chemistry or aspect of chemistry to comment on**, they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented (for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation). Candidates gain marks for the breadth and/or depth of their conceptual understanding.
- **write**, they must complete a chemical or word equation, for example 'Write the word equation for the complete combustion of ethanol.'

Marking instructions for each question

Question				Expected response	Max mark	Additional guidance
1.	(a)	(i)		Boron OR Carbon OR B OR C	**1**	
		(ii)		Increasing/greater/stronger/higher nuclear charge OR Increasing/greater/higher number of protons	**1**	Do not accept increased nuclear pull on its own.
		(iii)		Lithium OR Li	**1**	
	(b)			Electrons are further from the nucleus OR Atomic size increases OR Extra energy level **(1)** Increased screening/shielding **(1)**	**2**	
	(c)			Covalent molecular	**1**	Must have both the type of bonding and structure.

Question				Expected response	Max mark	Additional guidance
2.	(a)			Award up to 3 marks for answers containing the following points: Br_2 non-polar/I-Cl polar OR ICl has permanent dipole-permanent dipole interactions **(1)** Br_2 and ICl have same number of electrons OR Strength of LDF Br_2 and ICl similar **(1)** Boiling point of ICl higher than boiling point of Br_2 OR Intermolecular forces are broken when a substance boils **(1)**	**3**	
	(b)			H_2/hydrogen	**1**	
	(c)	(i)		Cl—H + H· **(1)** H—H / H_2 **(1)**	**2**	Both propagation products are required for first mark. Only one product must be shown for the termination reaction.
		(ii)		To prevent light/UV shining on sample OR To prevent initiation OR To prevent radicals from forming OR To prevent (glass/tube) shattering	**1**	

Question				Expected response	Max mark	Additional guidance
2.	(c)	(iii)		−185 (kJ mol^{-1}) Partial marking: A single mark is available if either of the following operations is correctly executed. EITHER The three relevant bond enthalpy values are retrieved; 436, 243 and 432 OR Correct use of incorrect bond enthalpy values	**2**	No units are required, but award only 1 mark for the correct answer if an incorrect unit is given.
	(d)			$10Cl^-(aq) + 2MnO_4^-(aq) + 16H^+(aq)$ ↓ $5Cl_2(g) + 2Mn^{2+}(aq) + 8H_2O(\ell)$	**1**	State symbols not required.

Question				Expected response	Max mark	Additional guidance
3.	(a)	(i)	A	Butyl propanoate	**1**	
			B	B>A>C	**1**	
		(ii)	A	Carbonyl	**1**	
			B		**1**	Accept full or shortened structural formulae.
	(b)			Any one of the four following groups of atoms circled    	**1**	

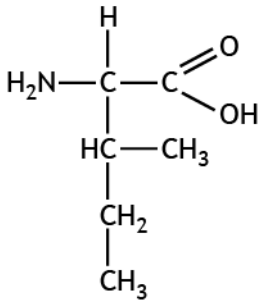
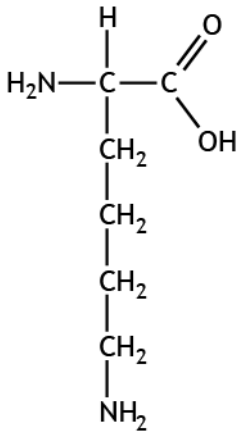
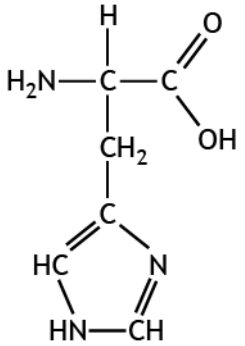
Question				Expected response	Max mark	Additional guidance
3.	(c)	(i)		Award up to 3 marks for the following points: Sodium lauryl sulfate has both hydrophobic/oil-soluble and hydrophilic/water-soluble parts OR Sodium lauryl sulfate has both ionic and non-polar parts **(1)** Correct identification of the parts of this molecule which dissolve in water and oil **(1)** Formation (by agitation) of a 'ball-like' structure/ globule (with the oil/grease held inside the ball) or micelle or mention of an emulsion **(1)** Repulsion of micelles (due to negatively charged heads) **(1)**	**3**	
		(ii)		Do not form scum/precipitates (with hard water)	**1**	

Question				Expected response	Max mark	Additional guidance
3.	(d)			**Award 1 mark** where the candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) which are relevant to the situation, showing that they have understood at least a little of the chemistry within the problem. **Award 2 marks** where the candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) which are relevant to the situation, showing that they have understood the problem. **Award 3 marks** where the candidate has demonstrated, at an appropriate level, a good understanding of the chemistry involved. They show a good comprehension of the chemistry of the situation and provide a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks. **Award 0 marks** where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award this mark also if the candidate merely restates the chemistry given in the question.	**3**	

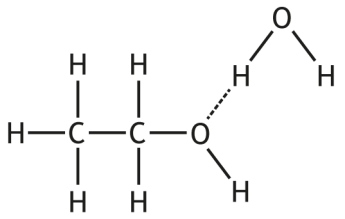
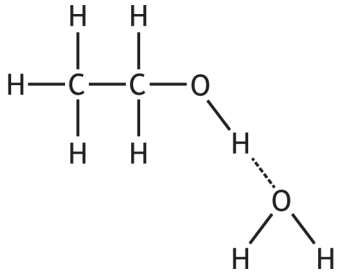
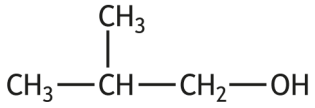
Question				Expected response	Max mark	Additional guidance
4.	(a)	(i)		Shea butter has fewer double bonds/is not very unsaturated **(1)** Unsaturated molecules cannot pack tightly OR Saturated molecules can pack tightly **(1)** The London dispersion forces/van der Waals' forces between its molecules are stronger (than in oils) **(1)**	**3**	
		(ii)		139 – 149	**1**	
	(b)	(i)		Glycerol / propane-1,2,3-triol	**1**	Accept propan-1,2,3-triol or glycerine.
		(ii)		24·8 or 25 (%) Partial marking: Calculation of theoretical yield of soap omitting mole ratio (1·72 (g)) OR Correctly calculated number of moles of reactant **and** product; 0·00566 and 0·00421 **(1)** Use of correct mole ratio 1:3 **(1)** Correctly calculated % yield using the actual mass and an incorrectly calculated theoretical mass OR Correctly calculated % yield using incorrectly calculated numbers of moles of product and reactant **(1)**	**3**	**Award 2 marks** for a theoretic mass of 5·16 (g) on its own. **Award 0 marks** for 1·28/5·00 or $3 \times 1{\cdot}28/5{\cdot}00$.

Question				Expected response	Max mark	Additional guidance
5.	(a)			−43·9 (kJ mol^{-1}) Partial marking: Evidence of understanding of reversal of first **and** final equations, with second equation unchanged **(1)**	**2**	No units are required but award only 1 mark for the correct answer, if an incorrect unit is given.
	(b)	(i)		(£) 1045 Partial marking: A single mark is available if any one of the following operations is correctly executed. Calculating the cost of the reactants required to prepare 5·75 g of butan-2-ol: £60·11 OR Calculating the mass of both reactants needed to produce 100 g of butan-2-ol: 87·1 g of propanal and 347·8 g of CH_3MgBr OR Having incorrectly calculated the cost of the reactants required to prepare 5·75 g of butan-2-ol, correctly scaling their calculated cost by 100/5·75 to obtain the cost to produce 100 g of butan-2-ol	**2**	Rounding at intermediate stages of the calculation may lead to variations of a few pence in the final answer. Accept answers correct to the nearest pound.
		(ii)		Hexan-2-ol	**1**	Accept 2-hexanol.
	(c)	(i)		Oxidation	**1**	
		(ii)		−3 (°C)	**1**	No units are required but award 0 marks for the correct answer if an incorrect unit is given.

Question				Expected response	Max mark	Additional guidance
6.	(a)			Shape maintained by intermolecular bonds (between side chains on protein) **(1)** These bonds broken when the protein is heated **(1)**	**2**	The first mark must not be awarded if there is any ambiguity over whether the bonds involved are van der Waals or covalent bonds.
	(b)	(i)		Gentle method of heating OR Can control temperature easily OR To prevent the protein structure changing/denaturing OR Mention of flammability	**1**	
		(ii)		Sodium oxide OR Sodium hydroxide OR Sodium carbonate OR Sodium hydrogen carbonate	**1**	Do not accept sodium.

Question				Expected response	Max mark	Additional guidance
6.	(b)	(iii)		 OR  OR 	**1**	Accept full or shortened structural formulae.
	(c)			4 or 4·0 (mg)	**1**	No units are required but award 0 marks for the correct answer if an incorrect unit is given.
	(d)			Eight or 8	**1**	Do not award mark for circling hydroxyl groups without stating the number.

Question				Expected response	Max mark	Additional guidance
7.	(a)			Carboxyl (group) OR Carboxylic acid (group)	**1**	
	(b)	(i)		100 (%)	**1**	
		(ii)		Curve starting at the level representing the reactants and finishing at the level representing the products but with a maximum, or maxima, below the existing maximum	**1**	
	(c)	(i)		Large hydrocarbon section/non-polar chain (attached to the carboxyl group)	**1**	
		(ii)	A	(It is an) emulsifier OR To stop layers forming	**1**	
			B	2·5 (cm^3)	**1**	No units are required but award 0 marks for the correct answer if an incorrect unit is given.

Question				Expected response	Max mark	Additional guidance
8.	(a)			Any correctly drawn diagram showing an oxygen atom attracted to a hydrogen atom within a hydroxyl group/water eg  OR 	**1**	
	(b)				**1**	Accept full or shortened structural formulae.

Question				Expected response	Max mark	Additional guidance
8.	(c)			12 200 cm^3 or 12·2 litres Partial marking: Where the correct value for the volume has not been calculated, one mark is available for either: The correct strategy to calculate the mass of 2-methylpropan-1-ol required: $\frac{351000}{36{\cdot}1}$ or 9720 OR The correct strategy to work out the volume of 2-methylpropan-1-ol required: $mass\ in\ g \times 1{\cdot}25$ or $\frac{351000}{28{\cdot}88}$ OR A correct strategy to work out the energy released per cm^3: $\frac{36{\cdot}1}{1{\cdot}25}$ or 28·88 One mark is also available where the candidate gives the correct unit for volume in their final answer.	**3**	To gain the full three marks the candidate must state the correct answer and give the appropriate units. No units are required but award a maximum of 2 marks for the correct answer if an incorrect unit is given. eg 12 154 or 12·15

Question				Expected response	Max mark	Additional guidance
9.	(a)	(i)		A solution of exactly/accurately/precisely known concentration	**1**	
		(ii)		221 (mg) Partial marking: A single mark is available if any one of the following operations is correctly executed. The GFM of NaF has been calculated correctly: 42 (g) OR The number of moles of fluoride ions has been calculated correctly: 0·00526	**2**	No units are required but award only 1 mark for the correct answer if an incorrect unit is given.
		(iii)		Dissolve (sample) in a small/minimum volume of (deionised) water **(1)** Transfer with rinsings **(1)** Make up to the mark in a **volumetric/standard** flask **(1)**	**3**	
		(iv)		(Tap water) might contain fluoride ions. OR (Tap water) might contain species that interfere with the reaction. OR (Tap water) might be coloured.	**1**	
		(v)		1·5 – 2·0 (mg l^{-1})	**1**	No units are required but award 0 marks for the correct answer if an incorrect unit is given.

Question				Expected response	Max mark	Additional guidance
9.	(b)	(i)		Pipette	**1**	
	(b)	(ii)		0·0324 (mol l^{-1}) Partial marking: Two 'concept' marks are available. For correct use of the relationship between concentration, number of moles and volume: eg by calculating a number of moles by multiplying a concentration by a volume and/or by calculating a concentration by dividing a number of moles by a volume, and/or calculating a number of moles OR For inserting correct pairings for c and v concentrations and volumes into the formula $\frac{c_1v_1}{n_1} = \frac{c_2v_2}{n_2}$ **(1)** For appreciation that this reaction demonstrates a 2:5 stoichiometry: eg by multiplying a number of moles by either $\frac{2}{5}$ or $\frac{5}{2}$ OR For substitution of the numbers 2 and 5 into as values for n in the formula $\frac{c_1v_1}{n_1} = \frac{c_2v_2}{n_2}$ **(1)**	**3**	No units are required but award a maximum of 2 marks for the correct answer if an incorrect unit is given. Where the candidate has used the relationship between concentration, number of moles and volume, the concept must be applied correctly on all occasions to gain the mark.

Question				Expected response	Max mark	Additional guidance
10.	(a)	(i)		When a molecule reacts with water to break down/apart (into smaller molecules)	**1**	
		(ii)		Methanol	**1**	
		(iii)		Essential (amino acids)	**1**	
	(b)	(i)		69 – 70 (mg)	**1**	No units are required but award 0 marks for the correct answer if an incorrect unit is given.
		(ii)		Sample of **Y** should be diluted OR Less of sample **Y** should be used OR Smaller sample of **Y**	**1**	

Question				Expected response	Max mark	Additional guidance
11.	(a)			$2NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$	**1**	State symbols are not required.
	(b)			$ClO^- + 2H^+ + 2e^- \rightarrow Cl^- + H_2O$	**1**	State symbols are not required. The negative charge can be omitted from the electrons, ie 2e.
	(c)	(i)		Gas-tight reaction vessel fitted with delivery tube **(1)** Method for collecting and measuring the volume of gas produced **(1)** Hydrogen peroxide, bleach and oxygen labelled in correct position **(1)**	**3**	Award a maximum of 2 marks if the diagram of apparatus shown would not work in practice.
		(ii)		0·67 (mol l^{-1}) Partial marking: Correct use of the relationship between volume of gas and number of moles, eg a volume of oxygen, in whatever unit, being divided by the molar volume, in whatever unit **(1)** Correct use of the relationship between the concentration of a solution, the number of moles of solute and the volume of solution, eg a value that the candidate believes to be the number of moles of ClO^- divided by the volume of the solution, in whatever unit. **(1)**	**3**	No units are required but award only 2 marks for correct answer if incorrect unit is given.

Question				Expected response	Max mark	Additional guidance
12.	(a)	(i)		Purple to colourless	**1**	
		(ii)		83 or 83·3 (s) Partial marking: A single mark is available if either of the following operations is correctly executed: Reading rate correctly from graph: 0·012 (s^{-1}) OR Correctly calculating the reaction time from an incorrect value for the relative rate.	**2**	No units required but award a maximum of 1 mark for correct answer if incorrect unit is given.
	(b)	(i)		The peak of the curve should be to the left and higher than the original peak.	**1**	
		(ii)		A vertical line should have been drawn at a lower kinetic energy than the original Ea shown on graph.	**1**	
	(c)			Incorrect orientation/geometry OR Activated complex breaks up to reform the reactants	**1**	

Question				Expected response	Max mark	Additional guidance
13.				**Award 1 mark** where the candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) which are relevant to the situation, showing that they have understood at least a little of the chemistry within the problem. **Award 2 marks** where the candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) which are relevant to the situation, showing that they have understood the problem. **Award 3 marks** where the candidate has demonstrated, at an appropriate level, a good understanding of the chemistry involved. They show a good comprehension of the chemistry of the situation and provide a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks. **Award 0 marks** where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award this mark also if the candidate merely restates the chemistry given in the question.	**3**	

[END OF SPECIMEN MARKING INSTRUCTIONS]