



National
Qualifications
SPECIMEN ONLY

S813/76/02

Chemistry
Section 1 — Questions

Date — Not applicable

Duration — 2 hours 30 minutes

Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet S813/76/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

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

You must leave your answer booklet on your desk; if you do not, you could lose all the marks for this paper.



SECTION 1 — 20 marks

Attempt ALL questions

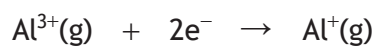
1. Which of the following elements, at room temperature, could be described as monatomic?

- A Argon
- B Boron
- C Iodine
- D Sulfur

2. The table shows the first three ionisation energies of aluminium.

Ionisation energy (kJ mol^{-1})		
1st	2nd	3rd
578	1817	2745

Using this information, what is the enthalpy change, in kJ mol^{-1} , for the following reaction?



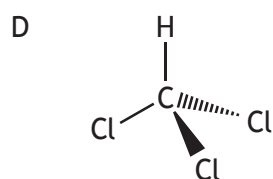
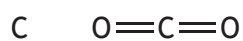
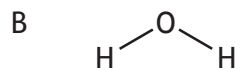
- A +2167
- B -2167
- C +4562
- D -4562

3. Which of the following chlorides is likely to have the most ionic character?

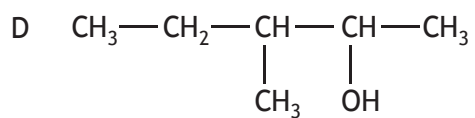
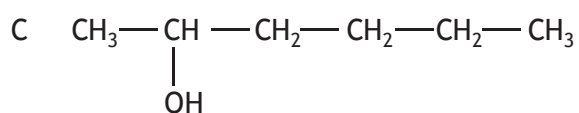
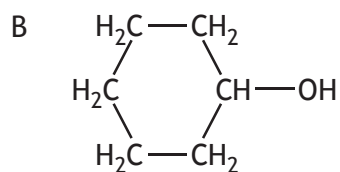
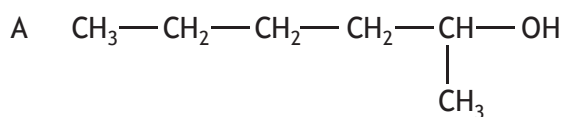
- A BeCl_2
- B CaCl_2
- C CsCl
- D LiCl

4. The shapes of some common molecules are shown below and each contains at least one polar bond.

Which molecule is non-polar?

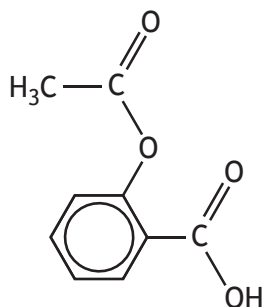


5. Which of the following is an isomer of hexan-2-ol?

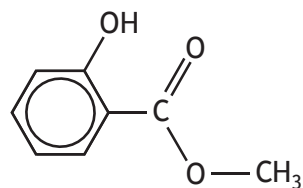


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6. Aspirin and oil of wintergreen are used in medicine. Their structures are shown below.



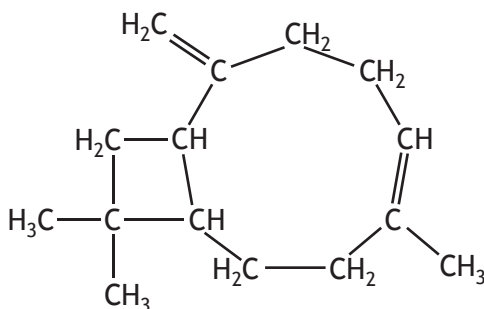
aspirin



oil of wintergreen

Identify the term which can be applied to aspirin but **not** to oil of wintergreen.

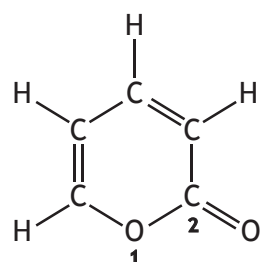
- A Aldehyde
 - B Ketone
 - C Ester
 - D Carboxylic acid
7. The structure of caryophyllene, which can be extracted from clove oil, is



Which of the following would be the best solvent for extracting caryophyllene?

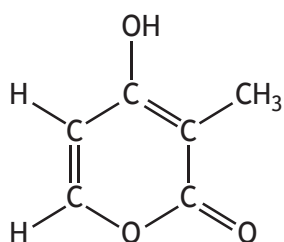
- A $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_3$
- B $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CHO}$
- C $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CO—CH}_2\text{—CH}_3$
- D $\text{HO—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_3$

8. 2-pyrones are esters used as flavourings. The name '2-pyrone' comes from the carbonyl group being in position 2 in the structure shown.

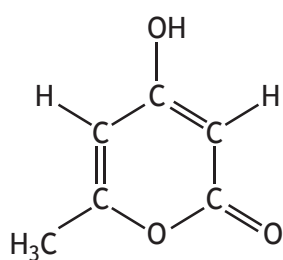


Which of the following structures is the pyrone, 4-hydroxy-6-methyl-2-pyrone?

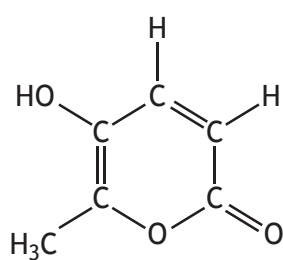
A



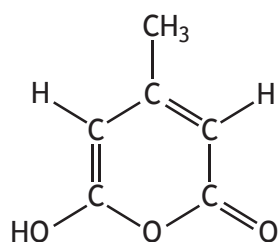
B



C



D

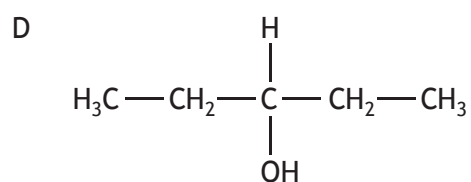
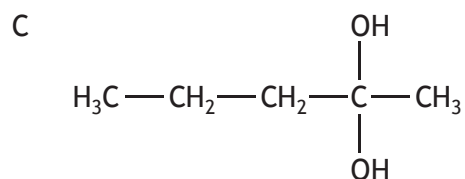
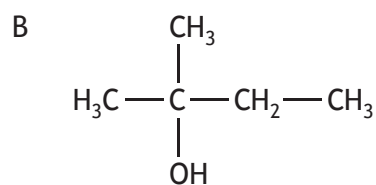
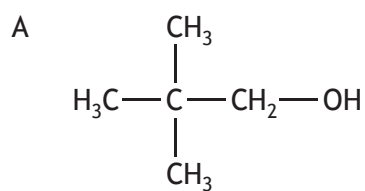


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9. Which of the following reactions can be classified as reduction?

- A $\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{COOH}$
B $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3 \rightarrow \text{CH}_3\text{COCH}_3$
C $\text{CH}_3\text{CH}_2\text{COCH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
D $\text{CH}_3\text{CH}_2\text{CHO} \rightarrow \text{CH}_3\text{CH}_2\text{COOH}$

10. Which of the following structural formulae represents a tertiary alcohol?



11. A mixture of sodium bromide and sodium sulfate is known to contain 10 moles of sodium ions and 4 moles of bromide ions.

How many moles of sulfate ions are present?

- A 3
- B 4
- C 5
- D 6

12. 4.6 g of sodium is added to 4.8 litres of oxygen to form sodium oxide.

When the reaction is complete, which of the following statements is true?

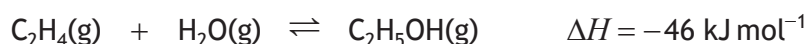
Take the volume of 1 mole of oxygen to be 24 litres.

- A 0.10 mol of oxygen will be left unreacted.
- B 0.10 mol of sodium will be left unreacted.
- C 0.15 mol of oxygen will be left unreacted.
- D 0.20 mol of sodium oxide will be formed.

13. In a reversible reaction, equilibrium is reached when

- A molecules of reactants stop changing into molecules of products
- B the concentrations of reactants and products are constant
- C the concentrations of reactants and products are equal
- D the activation energy of the forward reaction is equal to that of the reverse reaction.

14. Ethanol is manufactured by reacting ethene with steam.

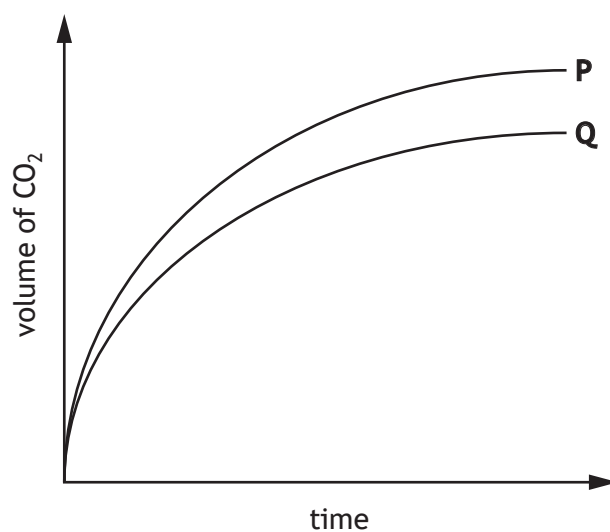


Which set of conditions would give the best yield of ethanol at equilibrium?

- A High temperature, low pressure
- B High temperature, high pressure
- C Low temperature, high pressure
- D Low temperature, low pressure

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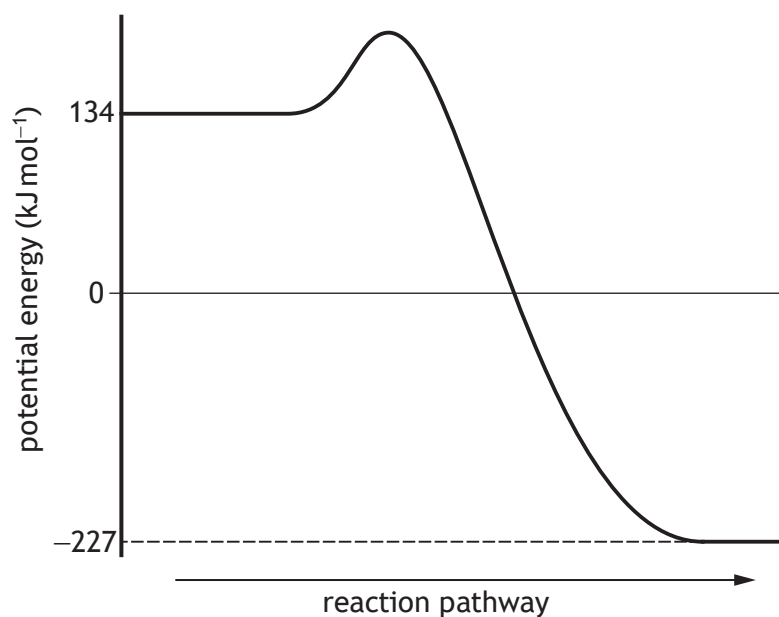
15. When copper carbonate is reacted with excess acid, carbon dioxide is produced. The curves shown were obtained under different conditions.



The change from **P** to **Q** could be brought about by

- A increasing the concentration of the acid
- B decreasing the mass of copper carbonate
- C decreasing the particle size of the copper carbonate
- D adding a catalyst.

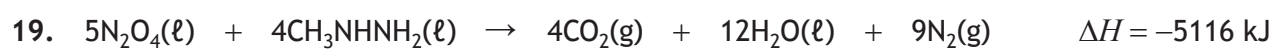
16. The potential energy diagram for a reaction is shown.



ΔH , in kJ mol^{-1} , for the forward reaction is

- A +361
B -93
C -227
D -361
17. Which of the following is **not** a correct statement about the effect of a catalyst?
The catalyst
- A provides energy so that more molecules have successful collisions
B lowers the energy that molecules need for successful collisions
C provides an alternative route to the products
D allows more molecules to have energies greater than the activation energy.
18. Which of the following equations represents an enthalpy of combustion?
- A $\text{C}_2\text{H}_6(\text{g}) + 3\frac{1}{2}\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\ell)$
B $\text{C}_2\text{H}_5\text{OH}(\ell) + \text{O}_2(\text{g}) \rightarrow \text{CH}_3\text{COOH}(\ell) + \text{H}_2\text{O}(\ell)$
C $\text{CH}_3\text{CHO}(\ell) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CH}_3\text{COOH}(\ell)$
D $\text{CH}_4(\text{g}) + 1\frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + 2\text{H}_2\text{O}(\ell)$

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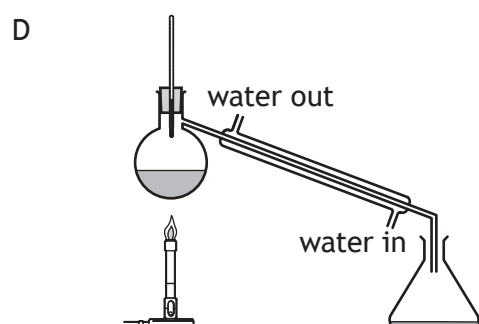
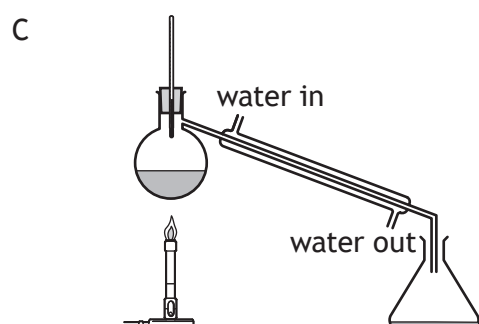
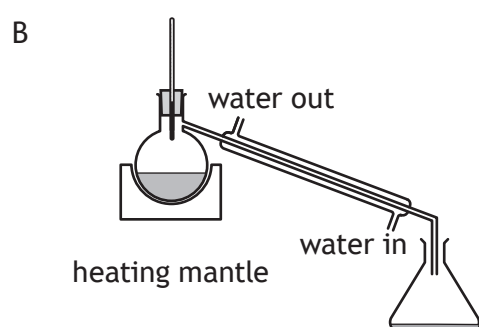
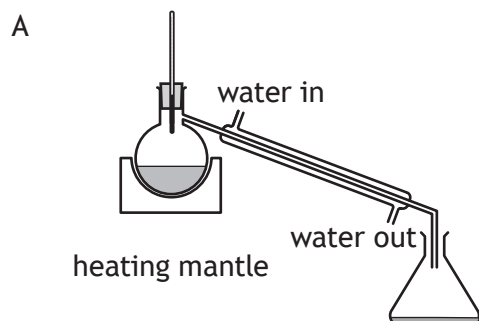


The energy released when 2 moles of each reactant are mixed and ignited is

- A 5116 kJ
- B 4093 kJ
- C 2558 kJ
- D 2046 kJ.

20. Ethanol and ethanoic acid are flammable liquids.

Which of the following diagrams shows the correct set up for the separation of ethanol from ethanoic acid?



[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF
YOUR QUESTION AND ANSWER BOOKLET]



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Mark

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S813/76/01**Chemistry
Section 1 — Answer grid
and Section 2**

Date — Not applicable

Duration — 2 hours 30 minutes



* S 8 1 3 7 6 0 1 *

Fill in these boxes and read what is printed below.

Full name of centre

--

Town

--

Forename(s)

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Surname

--

Number of seat

--

Date of birth

Day

--	--

Month

--	--

Year

--	--

Scottish candidate number

--	--	--	--	--	--	--	--	--

Total marks — 100**SECTION 1 — 20 marks**

Attempt ALL questions.

Instructions for the completion of Section 1 are given on *page 02*.**SECTION 2 — 80 marks**

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. You should score through your rough work when you have written your final copy.

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

Do not remove any exam materials. You must leave this booklet on your desk; if you do not, you could lose all the marks for this paper.



* S 8 1 3 7 6 0 1 0 1 *

The questions for Section 1 are contained in the question paper S813/76/02.

Read these and record your answers on the answer grid on *page 03*.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).
2. There is **only one correct** answer to each question.
3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample question

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

- A fractional distillation
- B chromatography
- C fractional crystallisation
- D filtration.

The correct answer is **B** — chromatography. The answer **B** bubble has been clearly filled in (see below).

A	B	C	D
☐	☒	☐	☐

Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.

A	B	C	D
☐	☒	☐	☐

If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:

A	B	C	D
☐	☒	☐	☒

or

A	B	C	D
☐	☒	☐	☐



* S 8 1 3 7 6 0 1 0 2 *



	A	B	C	D
1	☐	☐	☐	☐
2	☐	☐	☐	☐
3	☐	☐	☐	☐
4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐
11	☐	☐	☐	☐
12	☐	☐	☐	☐
13	☐	☐	☐	☐
14	☐	☐	☐	☐
15	☐	☐	☐	☐
16	☐	☐	☐	☐
17	☐	☐	☐	☐
18	☐	☐	☐	☐
19	☐	☐	☐	☐
20	☐	☐	☐	☐



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SECTION 2 — 80 marks

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.
- (ii) Explain why the atoms decrease in size from lithium to neon.
- (iii) Name the element that is the strongest reducing agent in the second period.

1

1

1

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* S 8 1 3 7 6 0 1 0 5 *

1. (continued)

MARKS

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- (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



* S 8 1 3 7 6 0 1 0 6 *

2. Chlorine is a reactive gas.

(a) The boiling point of chlorine is much higher than that of argon.

Explain **fully**, in terms of structure and the type of Van der Waals forces present, why the boiling point of chlorine is higher than that of argon.

3

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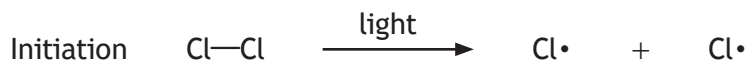
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2. (continued)

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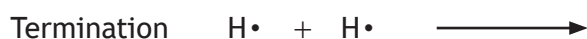
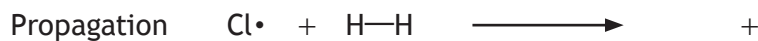
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A free radical chain reaction is initiated when ultraviolet light energy causes the bond in chlorine molecules to break.

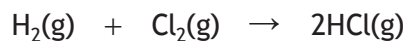


- (b) (i) Complete the equations below showing possible propagation and termination steps.

2



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



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



* S 8 1 3 7 6 0 1 0 8 *

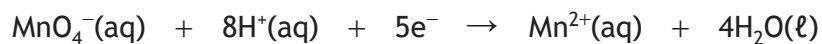
2. (continued)

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- (c) 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.



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

1

[Turn over



* S 8 1 3 7 6 0 1 0 9 *

3. A chemist was developing a new shower gel.
- (a) A suitable fragrance was needed for the shower gel.
- (i) Six isomeric esters were tested and given a rating out of one hundred depending on how fruity the smell is.

Structure	Fruit-smell rating
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} \\ \diagdown \\ \text{O} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \end{array}$	100
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} \\ \diagdown \\ \text{O} - \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \\ \\ \text{CH}_3 \end{array}$	34
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} \\ \diagdown \\ \text{O} - \text{C} - \text{CH}_2 - \text{CH}_3 \\ \\ \text{CH}_3 \end{array}$	0
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{CH}_2 - \text{C} \\ \diagdown \\ \text{O} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \end{array}$	92
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{CH} - \text{C} \\ \quad \diagdown \\ \text{CH}_3 \quad \text{O} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \end{array}$	44
$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{C} \\ \quad \parallel \\ \text{CH}_3 \quad \text{O} - \text{CH}_2 - \text{CH}_3 \end{array}$	32

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

1



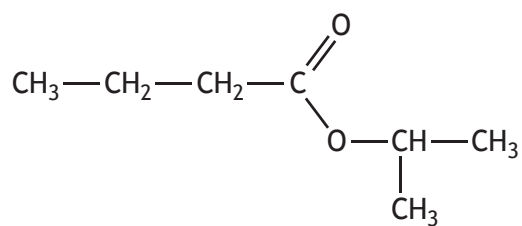
* S 8 1 3 7 6 0 1 1 0 *

3. (a) (i) (continued)

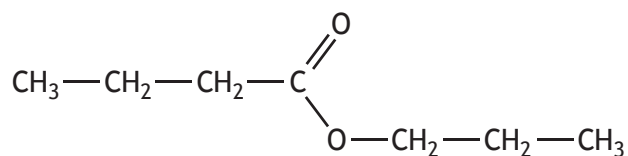
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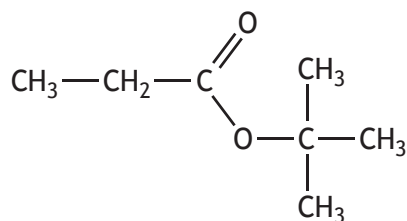
(B) The structures of three more isomers are shown.



Ester A



Ester B



Ester C

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

1

Ester > Ester > Ester

[Turn over

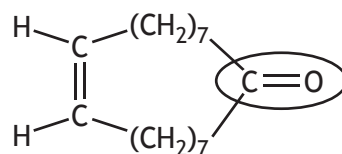


* S 8 1 3 7 6 0 1 1 1 *

3. (a) (continued)

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



civetone

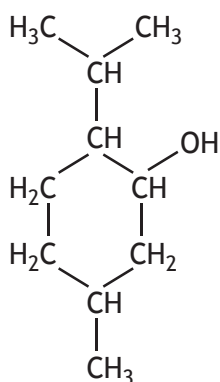
(A) Name the functional group circled in the structure above.

1

(B) Draw a structural formula for the alcohol that could be used 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*.)

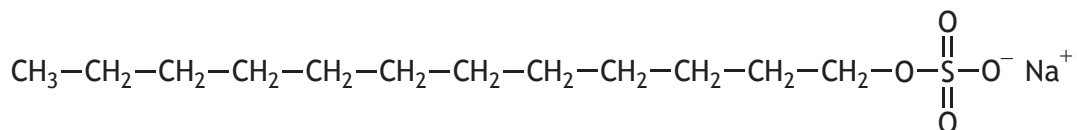


3. (continued)

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- (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.
You may wish to use diagrams to illustrate your answer.

3

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

1

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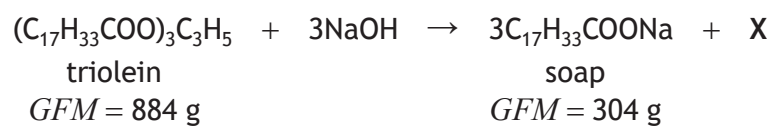
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3. (continued)

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- (d) A soap was made by heating triolein obtained from olive oil with sodium hydroxide solution.



- (i) Name product X.

1

- (ii) 5.00 g of triolein produced 1.28 g of soap.
Calculate the percentage yield.

2



* S 8 1 3 7 6 0 1 1 4 *

4. The properties of molecular compounds depends on the polarity of the bonds present.

Using your knowledge of chemistry, comment on this statement.

3

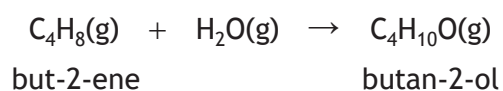
[Turn over



* S 8 1 3 7 6 0 1 1 5 *

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.



Calculate the enthalpy change, in kJ mol^{-1} , for this reaction using the following information.

2



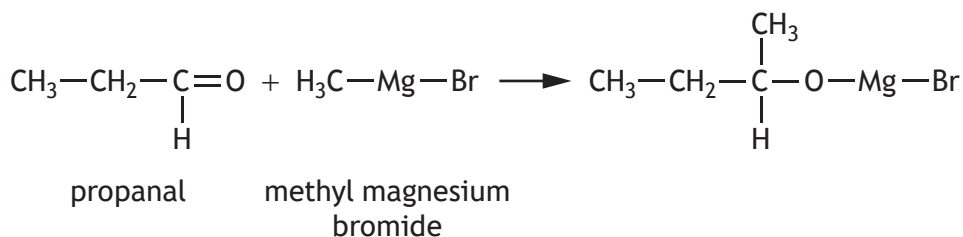
5. (continued)

MARKS

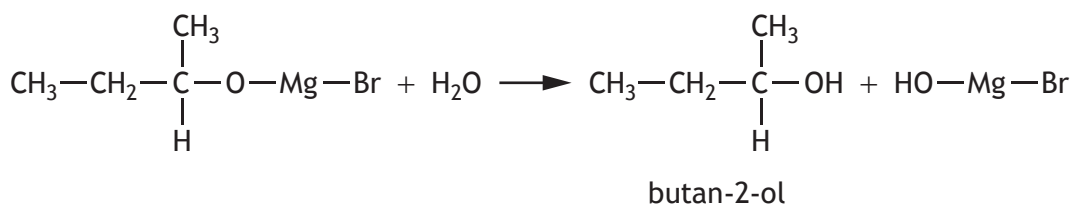
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(b) Butan-2-ol can be produced from propanal using a two-step process.

Step One



Step Two



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

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* S 8 1 3 7 6 0 1 1 7 *

5. (continued)

MARKS

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(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 = $(14 \times \text{number of carbon atoms}) - 59$

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

1

(d) Describe a chemical test, with the expected results for both compounds, that could be used to distinguish between butan-2-ol and 2-methylpropan-2-ol.

2



* S 8 1 3 7 6 0 1 1 8 *

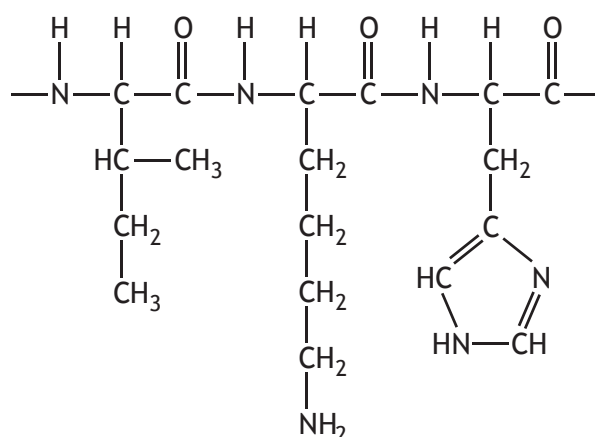
6. Cheese contains protein and fat.

- (a) When cheese is heated, the texture changes as the protein molecules denature.

Explain fully what is meant by denature.

2

- (b) A section of the structure of a protein found in cheese is shown.



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

1

[Turn over



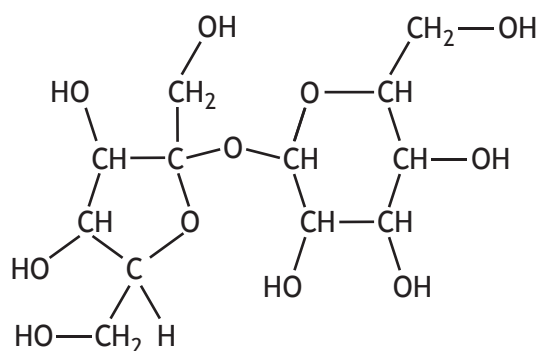
* S 8 1 3 7 6 0 1 1 9 *

6. (continued)

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- (c) (i) 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

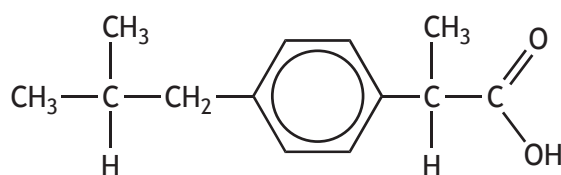
- (ii) Name the type of reaction that takes place when fatty acid molecules react with sucrose.

1



* S 8 1 3 7 6 0 1 2 0 *

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



ibuprofen

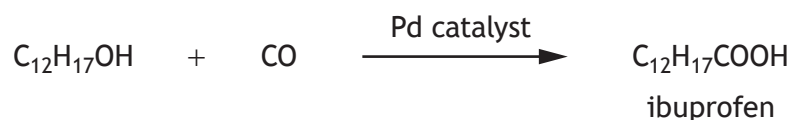
- (a) Ibuprofen tablets should not be taken by people who suffer from acid indigestion.

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

1

- (b) Ibuprofen is produced by a three step process.

The equation below shows the final step.



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

1

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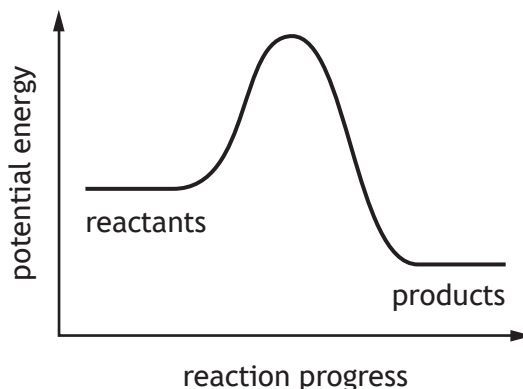


7. (b) (continued)

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



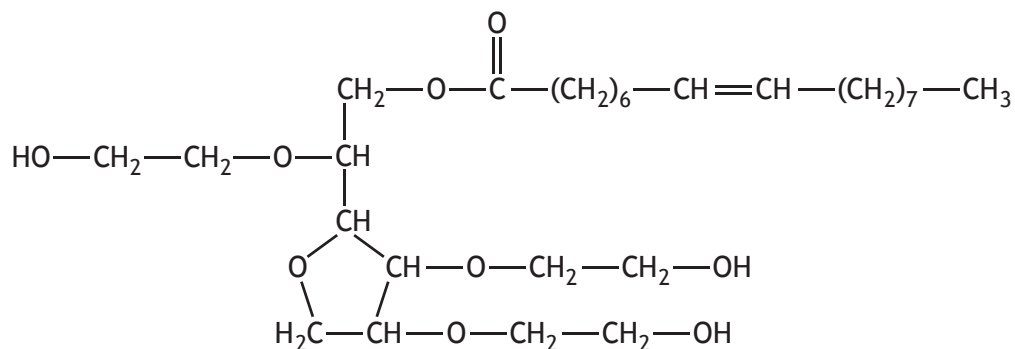
Add a line to the diagram showing the changing potential energy when the catalyst is used.

1

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

- (c) Ibuprofen can also be supplied in a liquid mixture.

- (i) The liquid mixture also contains polysorbate 80.



Suggest why polysorbate 80 is included in the mixture.

1



* S 8 1 3 7 6 0 1 2 2 *

7. (c) (continued)

MARKS

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- (ii) The liquid mixture contains 2.0 g of ibuprofen in every 100 cm³ of liquid.

The recommended dose for treating a 6-month-old baby is 0.050 g.

Calculate the volume, in cm³, of liquid mixture needed to treat a 6-month-old baby.

1

[Turn over



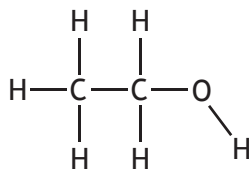
* S 8 1 3 7 6 0 1 2 3 *

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

- (a) Alcohols can absorb water from the air which causes problems in car 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)

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- (c) The enthalpy of combustion of 2-methylpropan-1-ol was determined experimentally.

Mass of 2-methylpropan-1-ol	1 g
<i>GFM</i> of 2-methylpropan-1-ol	74 g
Mass of water	2 kg
Temperature rise of water	4.3 °C

Use the data in the table to calculate the enthalpy of combustion of 2-methylpropan-1-ol.

3

[Turn over



* S 8 1 3 7 6 0 1 2 5 *

9. A student carried out an investigation to measure the ion levels in water.

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

(i) Calculate the mass, in mg, of sodium fluoride, NaF ($GFM = 42$ g), needed to make 1 litre of standard solution with a **fluoride ion** concentration of 100 mg l^{-1} .

1

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

3

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

1

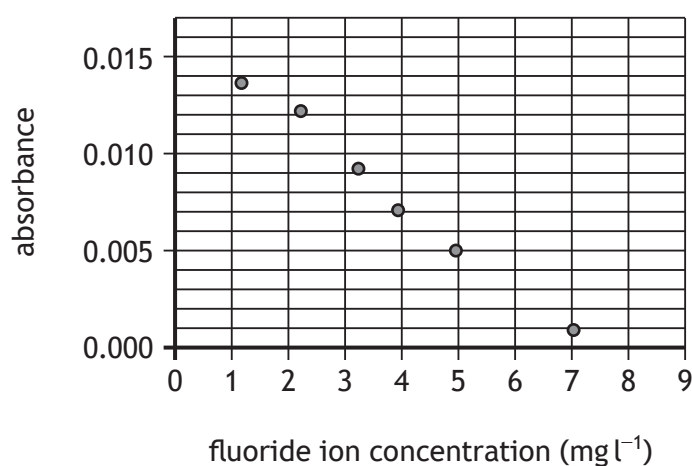


9. (a) (continued)

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- (iv) 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 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 0.010.

1

[Turn over



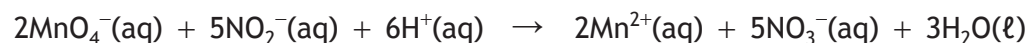
9. (continued)

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- (b) Nitrite ions, NO_2^- , are also present in water.

The concentration of nitrite ions in water was determined by titrating water samples with acidified permanganate solutions.

The reaction taking place is



- (i) 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.

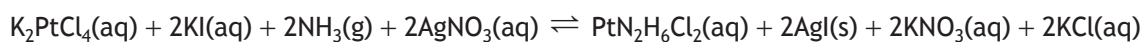
3

- (ii) Describe how a pipette should be prepared for use in this experiment.

2



10. Cis-platin, $\text{PtN}_2\text{H}_6\text{Cl}_2$, is a widely used anti-cancer drug.
It can be produced in the following **exothermic** reaction.



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

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

[Turn over



* S 8 1 3 7 6 0 1 2 9 *

11. Hypochlorite bleaches are cleaning products containing the hypochlorite ion, $\text{ClO}^-(\text{aq})$, 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.

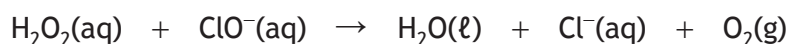
1

- (b) When $\text{ClO}^-(\text{aq})$ acts as a bleach, it is reduced to produce the $\text{Cl}^-(\text{aq})$ ion. Complete the ion-electron equation to show the reduction reaction.

1



- (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.

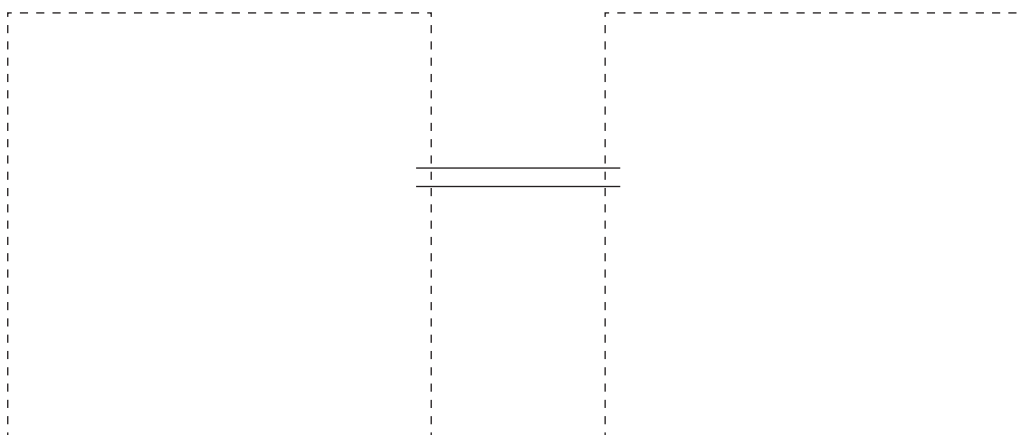


By measuring the volume of oxygen given off, the concentration of bleach can be calculated.

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

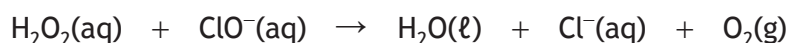
Your diagram should include labels showing the names and positions of the reacting chemicals and the collected product.

2



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

- (ii) 80 cm³ of oxygen gas was produced from 5.0 cm³ of bleach.



Calculate the concentration of hypochlorite ion, in mol l⁻¹, in bleach.

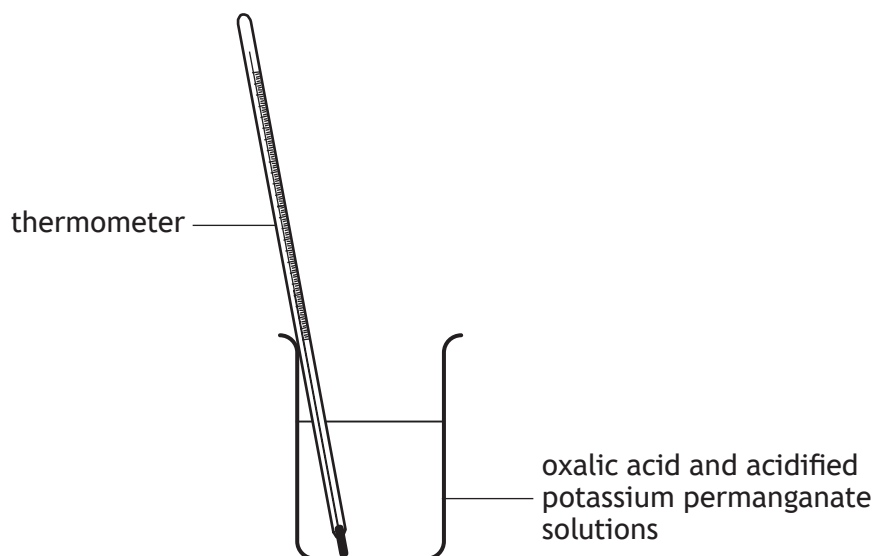
3

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.

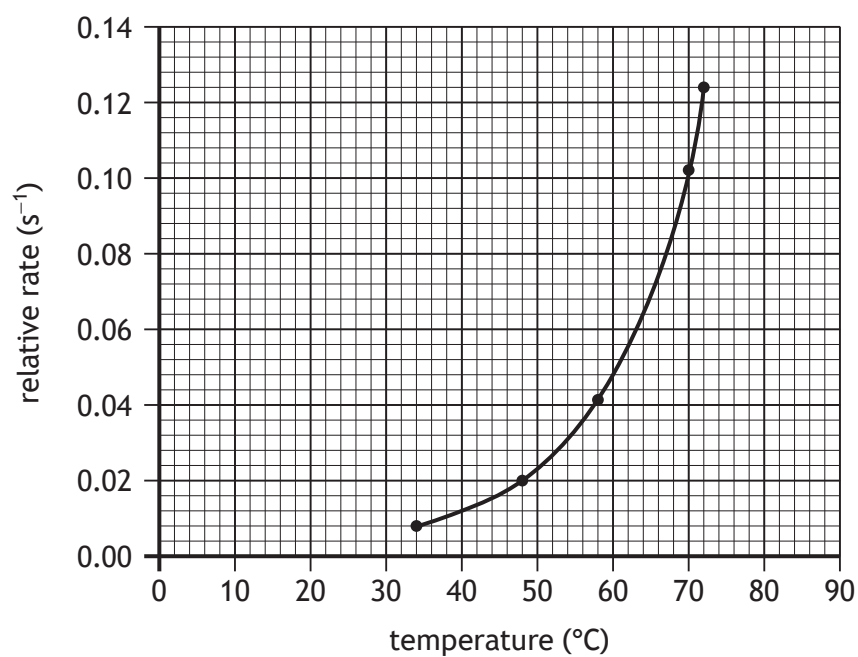
1

12. (a) (continued)

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



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

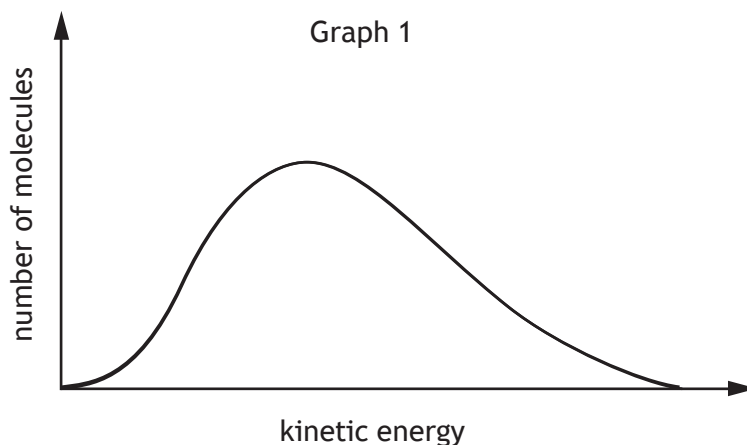
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* S 8 1 3 7 6 0 1 3 3 *

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

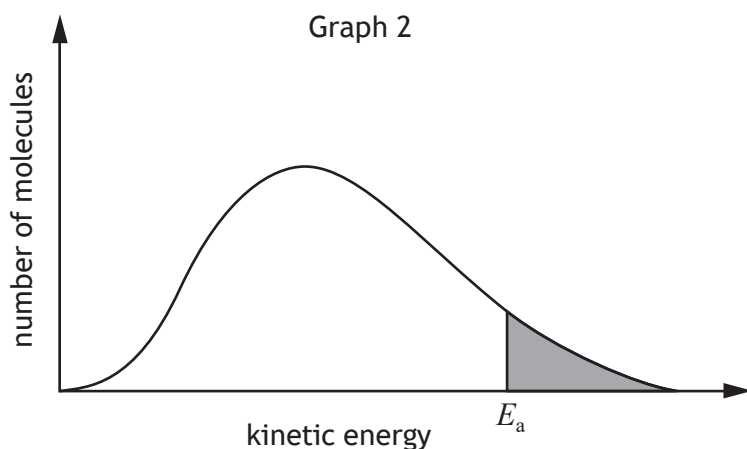


Add a second curve to Graph 1 to show the distribution of kinetic energies at 50 °C.

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 .



Add a line to Graph 2 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



12. (continued)

- (d) Changing concentration can also affect the rate of a reaction.

Explain **fully** why increasing the concentration causes an increase in reaction rate.

2

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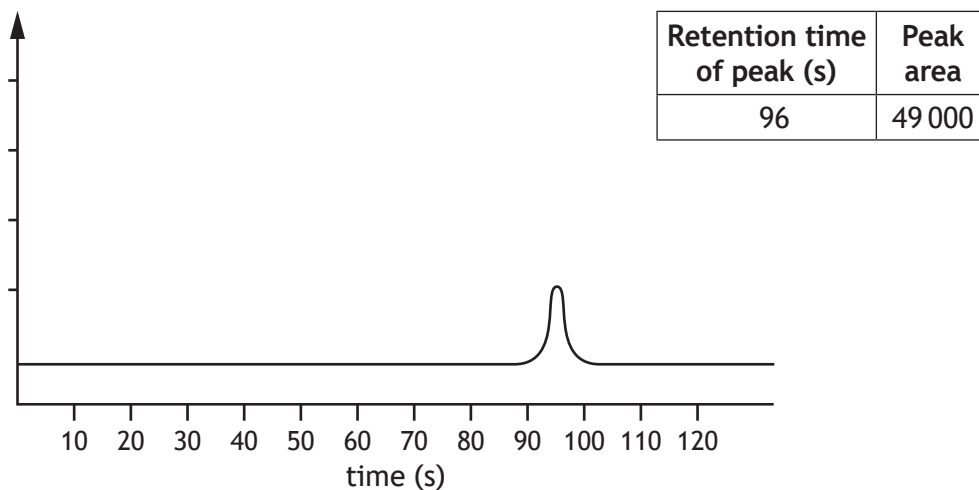


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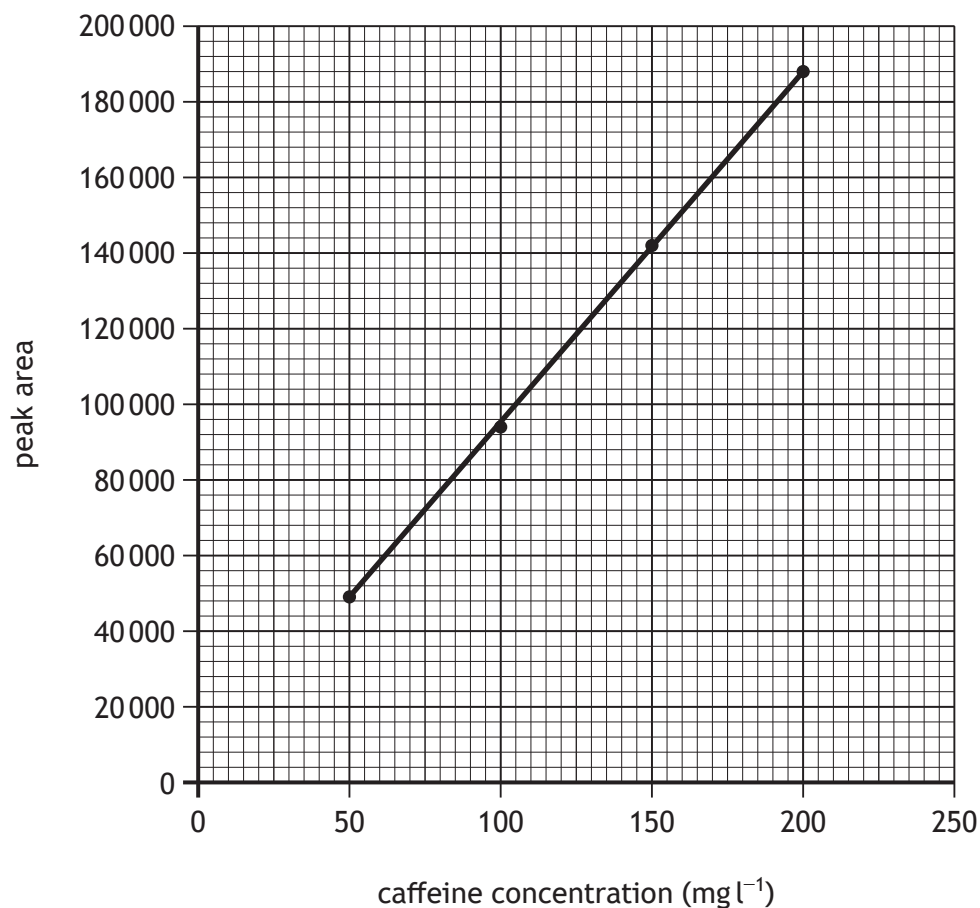
13. Some soft drinks contain caffeine.

The concentration of caffeine can be found using chromatography.

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



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

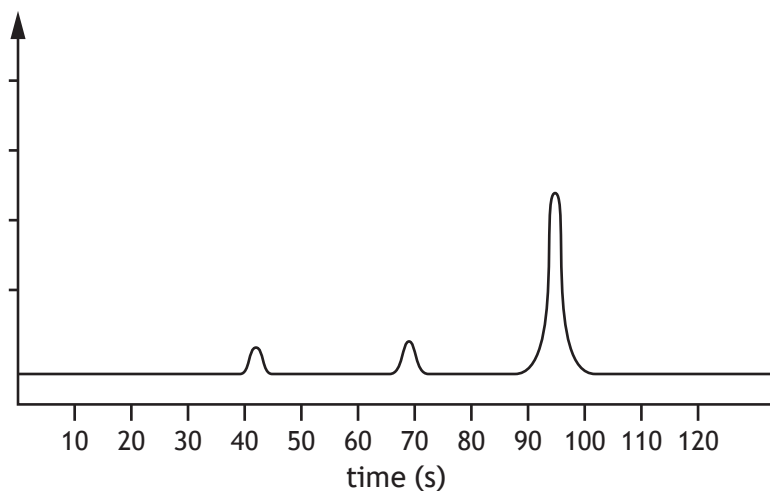


13. (continued)

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

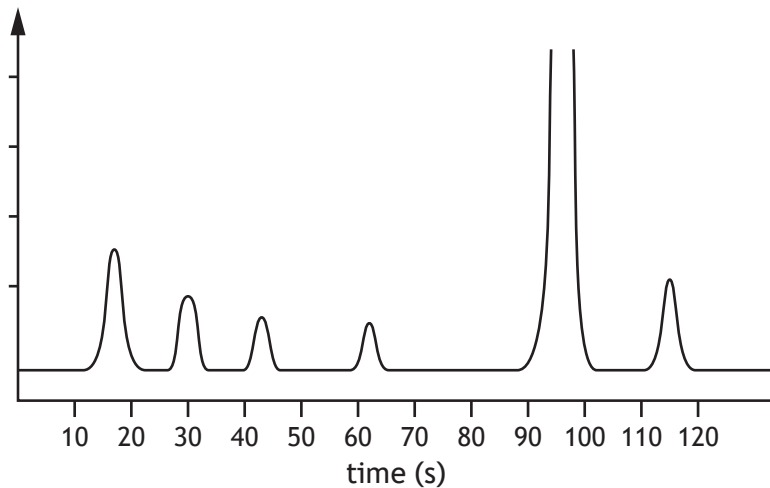


Retention time of peak (s)	Peak area
42	1000
69	1350
96	68 000

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

1

(b) 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.

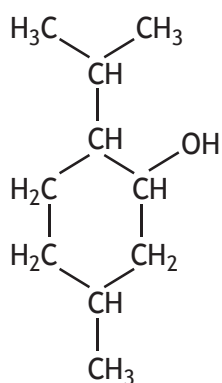
Suggest what could be done to the sample of soft drink Y so that the caffeine content could be reliably determined.

1

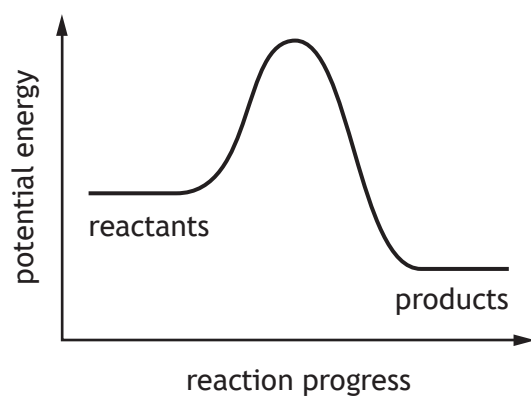
[END OF SPECIMEN QUESTION PAPER]



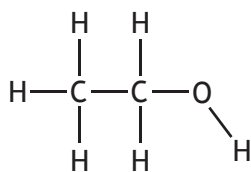
Additional diagram for question 3 (b)



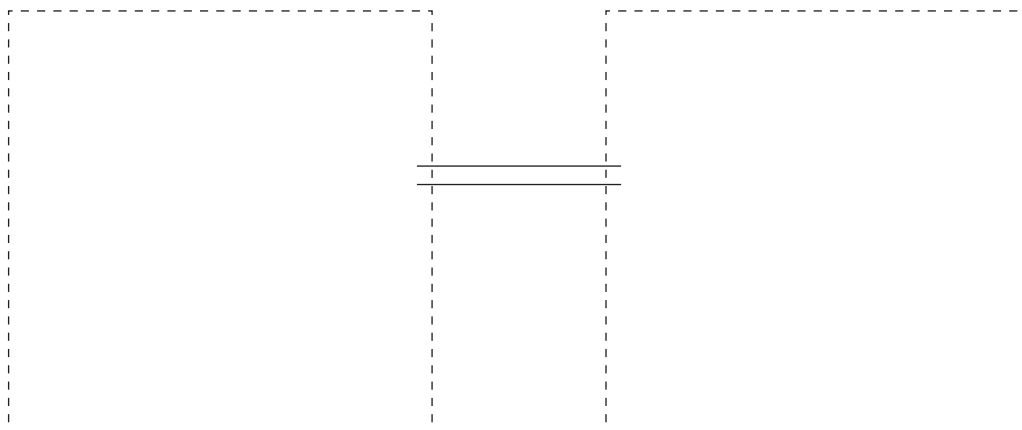
Additional diagram for question 7 (b) (ii)



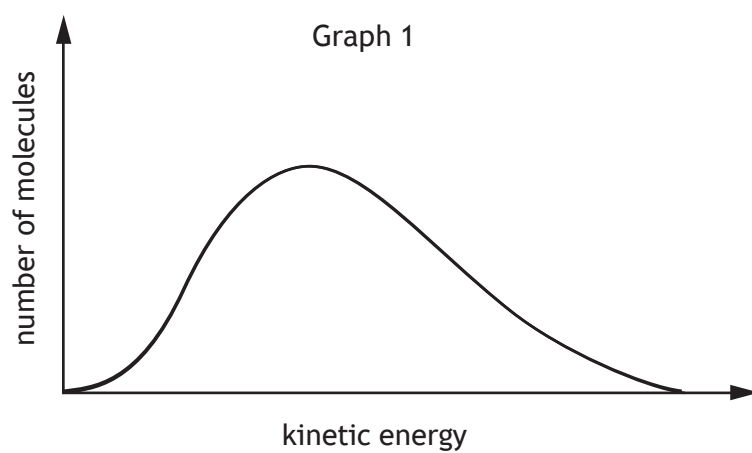
Additional diagram for question 8 (a)



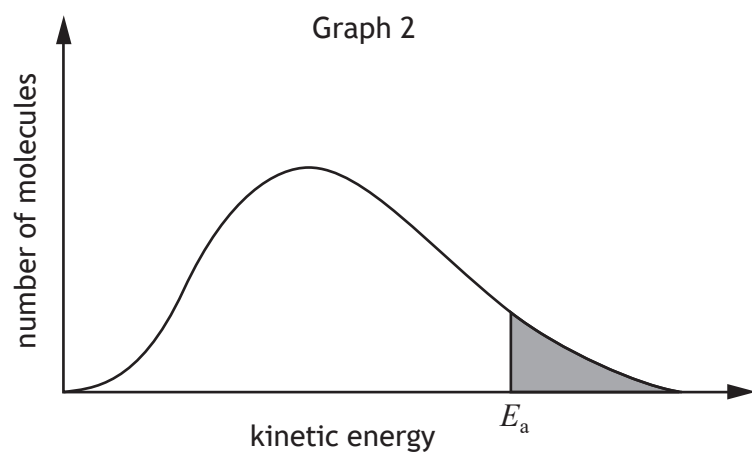
Additional diagram for question 11 (c) (i)



Additional graph for question 12 (b) (i)



Additional graph for question 12 (b) (ii)



ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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Chemistry

Marking Instructions

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

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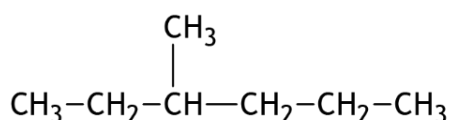
General marking principles for Higher Chemistry

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. $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\ell)$. 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.'

Section 1

Marking instructions for each question

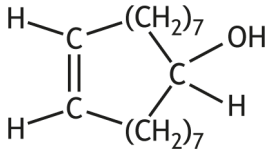
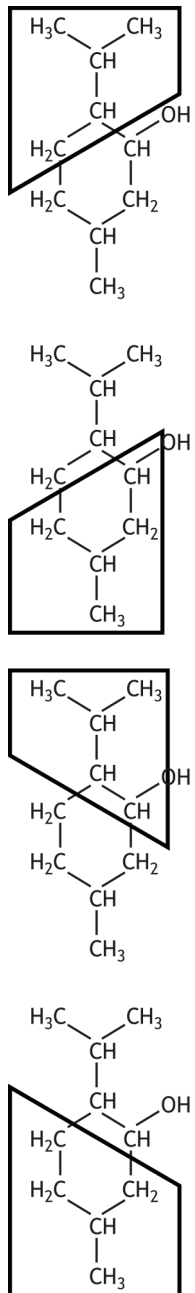
Question	Answer	Max mark
1.	A	1
2.	D	1
3.	C	1
4.	C	1
5.	D	1
6.	D	1
7.	A	1
8.	B	1
9.	C	1
10.	B	1
11.	A	1
12.	C	1
13.	B	1
14.	C	1
15.	B	1
16.	D	1
17.	A	1
18.	A	1
19.	D	1
20.	B	1

Section 2

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)		(More shells so) increased screening/ more screening. (1 mark) (Covalent radius increases/atom size increases/more shells so) attraction of the nucleus/protons for the (outer/shared) electron(s) decreases. (1 mark)	2	Shielding is acceptable in place of screening. Increased attraction of the electron for the nucleus would be considered cancelling.

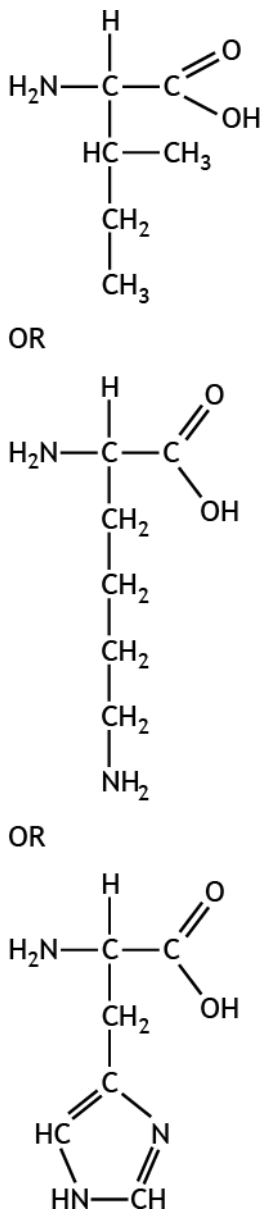
Question			Expected response	Max mark	Additional guidance
2.	(a)		Correctly identify that there are stronger/more (Van der Waals) forces between chlorine (molecules) than between the argon (atoms). (1 mark) Correctly identifying that the Van der Waals forces present in both these elements are London dispersion forces. (1 mark) Chlorine molecules (Cl₂) have more electrons than argon atoms (Ar). (1 mark)	3	This mark can only be awarded if no other forces are mentioned as being broken.
	(b)	(i)	HCl + H• (1 mark) H–H / H₂ (1 mark)	2	Both propagation products are required for first mark. Only one product must be shown for the termination reaction.
		(ii)	–183 (kJ mol⁻¹) (1 mark) For partial marking The three relevant bond enthalpy values are retrieved; 436, 243 and 431. (1 mark) OR If only two bond enthalpies are retrieved, and the candidate recognises that bond breaking is endothermic and bond making is exothermic and correctly manipulates the bond enthalpy values they have used to give their answer. (1 mark)	2	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).
	(c)		$10\text{Cl}^-(\text{aq}) + 2\text{MnO}_4^-(\text{aq}) + 16\text{H}^+(\text{aq})$ $\downarrow$ $5\text{Cl}_2(\text{g}) + 2\text{Mn}^{2+}(\text{aq}) + 8\text{H}_2\text{O}(\ell)$	1	State symbols are not required, but if shown must be correct.

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	

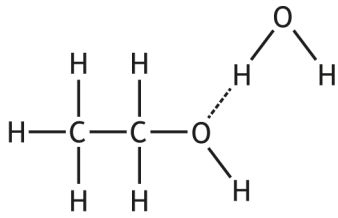
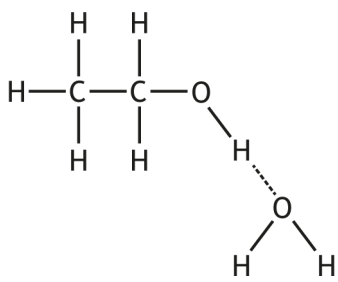
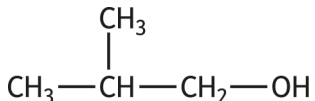
Question			Expected response	Max mark	Additional guidance
3.	(c)	(i)	Sodium lauryl sulfate/detergent has an ionic/hydrophilic part and a non polar/hydrophobic part (or alternative wording/diagram showing knowledge of these parts of the molecule). (1 mark) Correctly identifies the part of the molecule/head/SO_2O^- dissolves in water/is hydrophilic and the part of the molecule/tail/hydrocarbon chain dissolves in oil/hydrophobic. (1 mark) Agitation separates oil from the surface/cause small oil droplets to form. OR The (negatively-charged) ball-like structures repel each other (and the oil or grease is kept suspended in the water. OR Sodium lauryl sulfate/detergent break(s) oil into micelles. (1 mark)	3	
		(ii)	Do not form scum/precipitates (with hard water).	1	
	(d)	(i)	Glycerol/propane-1,2,3-triol	1	Accept propan-1,2,3-triol or glycerine.
		(ii)	24.8 or 25 (%) For partial marking Theoretical yield = 5.16 (g). (1 mark) OR Allow follow through from incorrect calculation of theoretical yield. (1 mark)	2	

Question				Expected response	Max mark	Additional guidance
4.				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
5.	(a)		–43.9 (kJ mol⁻¹) For partial marking Evidence of understanding of reversal of first and final equations, with second equation unchanged. (1 mark)	2	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).
	(b)		Hexan-2-ol	1	
	(c)	(i)	Oxidation	1	
		(ii)	–3 (°C)	1	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).
	(d)		Acidified dichromate changes from orange to green (blue-green/blue) with butan-2-ol AND no colour change would be observed with 2-methylpropan-2-ol. (2 marks) OR Using hot copper(II) oxide a brown solid forms/copper forms/colour change from black to brown would be observed with butan-2-ol AND no colour change would be observed with 2-methylpropan-2-ol. (2 marks)	2	Acidified dichromate (1 mark) Hot copper(II) oxide (1 mark)

Question			Expected response	Max mark	Additional guidance
6.	(a)		The protein changes shape/chains unwind. (1 mark) Intermolecular bonds/Van der Waals forces/Hydrogen bonds (within the protein) break. (1 mark)	2	
	(b)		 OR OR	1	Accept full or shortened structural formulae.
	(c)	(i)	Eight or 8	1	Do not award mark for circling hydroxyl groups without stating the number.
		(ii)	Condensation	1	Esterification is accepted.

Question			Expected response	Max mark	Additional guidance
7.	(a)		Carboxyl	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 below the existing maximum.	1	
	(c)	(i)	(It is an) emulsifier. OR To prevent non-polar and polar liquids separating into layers.	1	
		(ii)	2.5 (cm ³)	1	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).

Question			Expected response	Max mark	Additional guidance
8.	(a)		Any correctly drawn diagram showing an oxygen atom (in water or ethanol) attracted to a hydrogen atom (in the other molecule). eg  OR 	1	
	(b)			1	Accept full or shortened structural formulae.
	(c)		-2660.152 (kJ mol⁻¹) (3 marks) If final answer is wrong a maximum of 2 marks for the following concepts may be awarded: 1 mark for a demonstration of the correct use of the relationship $E_h = cm\Delta T$ as shown by $(4.18 \times (\text{an order of magnitude of } 2) \times 4.3)$ (ignore units for this mark). 1 mark for evidence of scaling up of a calculated value of energy released to 1 mole (74 g).	3	2660.152 (kJ mol⁻¹) (2 marks) Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper). kJ is acceptable in place of kJ mol⁻¹ (KJ or Kj or KJ mol⁻¹ or Kj mol⁻¹ accepted).

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	221 (mg)	1	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).
		(ii)	Dissolve (sample) in a small/minimum volume of (deionised) water. (1 mark) Transfer with rinsings to a volumetric/standard flask. (1 mark) Make up to the mark in a volumetric/standard flask. (1 mark)	3	
		(iii)	Chloride ions/magnesium ions/calcium ions/metal ions/metal salts may be present in tap water. OR (Tap water) might contain fluoride ions. OR (Tap water) might be coloured.	1	
		(iv)	2.7 – 2.9 (mg l ⁻¹)	1	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).

Question			Expected response	Max mark	Additional guidance
9.	(b)	(i)	0.0324 (mol l⁻¹) For 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 <i>c</i> and <i>v</i> concentrations and volumes into the formula $\frac{c_1 v_1}{n_1} = \frac{c_2 v_2}{n_2}$ (1 mark) For appreciation that this reaction demonstrates a 2:5 stoichiometry: eg by multiplying a number of moles by either $\frac{2}{5}$ or $\frac{5}{2}$ (2 marks) OR For substitution of the numbers 2 and 5 into as values for <i>n</i> in the formula $\frac{c_1 v_1}{n_1} = \frac{c_2 v_2}{n_2}$ (1 mark)	3	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper). 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.
		(ii)	Rinse with sample/solution (1 mark) Fill above the mark and allow liquid to drop down to the mark (and read from the bottom of the meniscus). (1 mark) OR Fill to mark, read from the bottom of the meniscus. (1 mark)	2	Accept either nitrite solution or acidified permanganate solution.

Question			Expected response	Max mark	Additional guidance
10.			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
11.	(a)		$2\text{NaOH} + \text{Cl}_2 \rightarrow \text{NaClO} + \text{NaCl} + \text{H}_2\text{O}$	1	State symbols are not required, but if shown must be correct.
	(b)		$\text{ClO}^- + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$	1	State symbols are not required, but if shown must be correct. Negative sign on electron not required.
	(c)	(i)	Diagram shows a workable method of generating gas with hydrogen peroxide and bleach labelled. (1 mark) Method for collecting and measuring the volume of gas produced with oxygen labelled. (1 mark)	2	
		(ii)	0.67 (mol l⁻¹) If incorrect answer is given, a maximum of two partial marks can be awarded for demonstration of two of the following concepts. Correct use of the relationship between volume of gas, molar volume and number of moles. (1 mark) Correct application of mole ratio. (1 mark) 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 mark)	3	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).

Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	Purple to colourless	1	
		(ii)	83 or 83.3 (s)	1	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).
	(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 E_a shown on graph.	1	
	(c)		Incorrect orientation/geometry. OR Activated complex breaks up to reform the reactants.	1	
	(d)		The more particles/molecules (in a given volume). (1 mark) More successful collisions (and the faster the reaction). (1 mark)	2	

Question			Expected response	Max mark	Additional guidance
13.	(a)		69 – 70 (mg)	1	Units are not required but must be correct if given. (Wrong units would only be penalised once in any paper).
	(b)		Sample of Y should be diluted. OR Less of sample Y should be used. OR Smaller sample of Y.	1	

[END OF SPECIMEN MARKING INSTRUCTIONS]

Published: August 2026

Change since last published:

We've replaced Question Paper 1 and Question Paper 2 with a single question paper that has two sections. The duration has been shortened and the number of marks reduced. Some questions have been removed from the previous specimen question papers, some have been edited or updated, and some have been replaced.