FOR OFFICIAL USE

National Qualifications 2017

Mark

X713/76/01

Chemistry
Section 1 — Answer Grid and Section 2

MONDAY, 8 MAY

9:00 AM – 11:30 AM

X7137601

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

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 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.

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 ©

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SECTION 1 — 20 marks

The questions for Section 1 are contained in the question paper X713/76/02.

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

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:

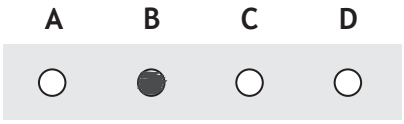
A fractional distillation

B chromatography

C fractional crystallisation

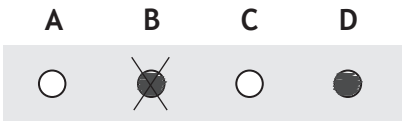
D filtration.

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

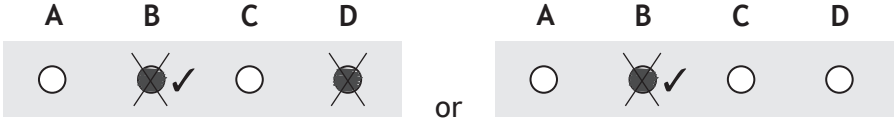


Changing an answer

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**.



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:



SECTION 1 — Answer Grid

OBJ20AD1

	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 elements sodium to argon make up the third period of the Periodic Table.

Na	Mg	Al	Si	P	S	Cl	Ar

(a) Name the element from the third period that exists as a covalent network. **1**

(b) Ionisation energy changes across the period.

(i) Explain why the first ionisation energy increases across the period. **1**

(ii) Write an equation, including state symbols, for the **second** ionisation energy of magnesium. **1**

(iii) The table shows the values for the first four ionisation energies of aluminium.

Ionisation energies (kJ mol^{-1})			
First	Second	Third	Fourth
578	1817	2745	11 577

Explain why there is a large difference between the third and fourth ionisation energies. **1**

1. (continued)

(c) 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**

2. Reactions involving iodine are commonly used to investigate rates of reaction.

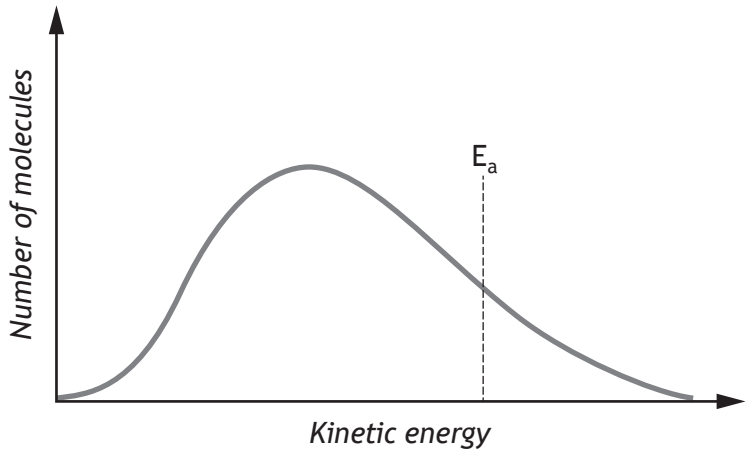
(a) One reaction involves hydrogen and iodine reacting together to form hydrogen iodide.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(i) This reaction is thought to occur by initially breaking bonds in one of the reactants.

Explain, using bond enthalpies, which bond is more likely to break first during this reaction. **1**

(ii) The graph shows the distribution of kinetic energies of reactant molecules in the gas mixture at 300 °C.



Add a second curve to the graph to show the distribution of kinetic energies at 400 °C. **1**

(An additional graph, if required, can be found on *Page 35*)

2. (a) (continued)

(iii) The reaction to produce hydrogen iodide is exothermic.

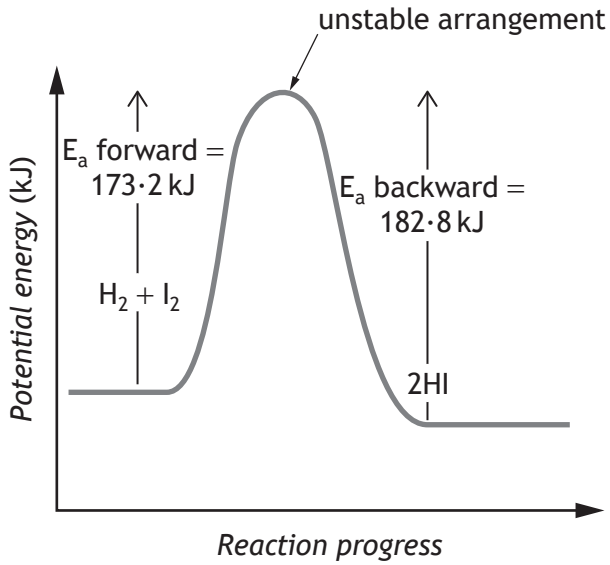
$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(A) State the effect of increasing temperature on the position of equilibrium. **1**

(B) State why changing the pressure has no effect on this equilibrium reaction. **1**

2. (a) (continued)

(iv) The potential energy diagram for the reaction between hydrogen and iodine is shown.



(A) State the term for the unstable arrangement of atoms. **1**

(B) Calculate the enthalpy change, in kJ, for the forward reaction. **1**

(C) Platinum can be used as a catalyst for this reaction.

State the effect that platinum would have on the activation energy for the reaction. **1**

2. (continued)

(b) The reaction between iodide ions, $I^-(aq)$, and persulfate ions, $S_2O_8^{2-}(aq)$, is used to investigate the effect of changing concentration on rate of reaction. The relative rate of the reaction is determined by mixing the reactants in a beaker and recording the time taken for the mixture to change colour.

The results of the investigation are shown in the table.

Experiment	*Concentration of $I^-(aq)$* (mol l^{-1})	*Concentration of $S_2O_8^{2-}(aq)$* (mol l^{-1})	*Time* (s)	*Relative rate* (s^{-1})
1	0·04	0·05	241	0·00415
2	0·06	0·05	180	0·00556
3	0·08	0·05		0·00819
4	0·1	0·05	103	0·00971

(i) The instructions state that a dry beaker must be used for each experiment.

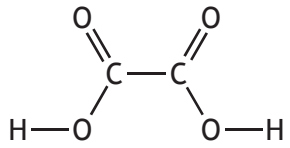
Suggest a reason why the beaker should be dry. **1**

(ii) Calculate the time, in seconds, for the reaction in experiment 3. **1**

(iii) Explain why decreasing the concentration of iodide ions lowers the reaction rate. **1**

3. The leaves of the rhubarb plant are considered poisonous because they contain high levels of oxalic acid.

Oxalic acid is a white, water-soluble solid. It is a dicarboxylic acid that has the structural formula shown.



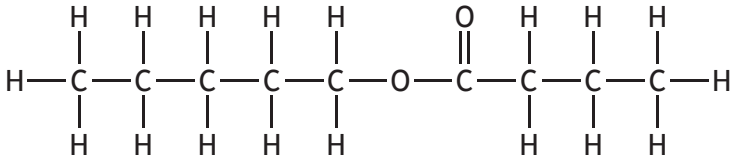
Oxalic acid reacts with bases to form salts.

It can also be oxidised by strong oxidising agents to form carbon dioxide gas. The oxidation equation for oxalic acid is shown.

$$H_2C_2O_4 \quad \rightarrow \quad 2CO_2 + 2e^- + 2H^+$$

Using your knowledge of chemistry, comment on how the mass of oxalic acid in a rhubarb leaf could be determined. **3**

4. Pentyl butanoate is responsible for some of the flavour in apricots and strawberries.



(a) Hydrolysis of pentyl butanoate using sodium hydroxide produces an alcohol and the salt of the carboxylic acid.

(i) Name the alcohol that would be formed when pentyl butanoate is hydrolysed. **1**

(ii) Draw a structural formula for the sodium salt of the carboxylic acid that would be formed. **1**

(b) Fats and oils belong to the same class of compounds as pentyl butanoate.

(i) Name this class of compounds. **1**

(ii) When a fat is hydrolysed using sodium hydroxide, sodium salts of fatty acids are produced.

State a use for sodium salts of fatty acids. **1**

4. (b) (continued)

(iii) Hydrolysis of fats using hydrochloric acid produces fatty acids. Stearic acid is a fatty acid that can be made from hydrolysis of beef fat. It is a fuel sometimes found in fireworks.

During combustion, stearic acid ($C_{17}H_{35}COOH$) produces 623 kJ of energy **per mole of CO_2 produced.**

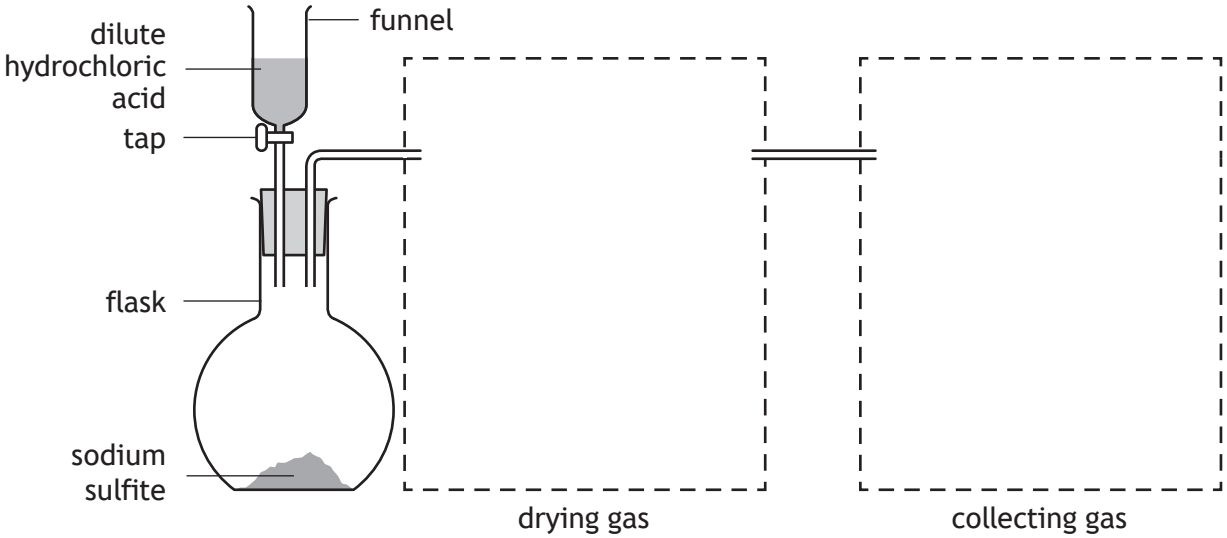
$$C_{17}H_{35}COOH + 26O_2 \rightarrow 18CO_2 + 18H_2O$$

mass of one mole = 284 g

Calculate the energy released, in kJ, by combustion of 10 grams of stearic acid. **2**

5. Sulfur dioxide is a colourless, toxic gas that is soluble in water and more dense than air.

(a) One laboratory method for preparation of sulfur dioxide gas involves adding dilute hydrochloric acid to solid sodium sulfite. The sulfur dioxide gas produced is dried by bubbling the gas through concentrated sulfuric acid. The sulfur dioxide gas can then be collected.



MARKS | DO NOT WRITE IN THIS MARGIN

(i) Complete the diagram by drawing:

in the first box, apparatus suitable for drying the sulfur dioxide gas;

in the second box, apparatus suitable for collecting the gas. **2**

(An additional diagram, if required, can be found on *Page 35*)

5. (a) (continued)

(ii) 0·40 g of sodium sulfite, Na_2SO_3, is reacted with 50 cm^3 of dilute hydrochloric acid, concentration 1·0 mol l^{-1}.

$$Na_2SO_3(s) + 2HCl(aq) \rightarrow H_2O(\ell) + 2NaCl(aq) + SO_2(g)$$

mass of one mole = 126·1 g

Show, by calculation, that sodium sulfite is the limiting reactant. **2**

(b) Another reaction that produces sulfur dioxide gas involves combustion of carbon disulfide in the reaction shown.

$$CS_2(\ell) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

Calculate the enthalpy change, in kJ mol^{-1}, for this reaction using the following information. **2**

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H = -393{\cdot}5$ kJ mol^{-1}

$S(s) + O_2(g) \rightarrow SO_2(g)$ $\quad \Delta H = -296{\cdot}8$ kJ mol^{-1}

$C(s) + 2S(s) \rightarrow CS_2(\ell)$ $\quad \Delta H = +87{\cdot}9$ kJ mol^{-1}

MARKS

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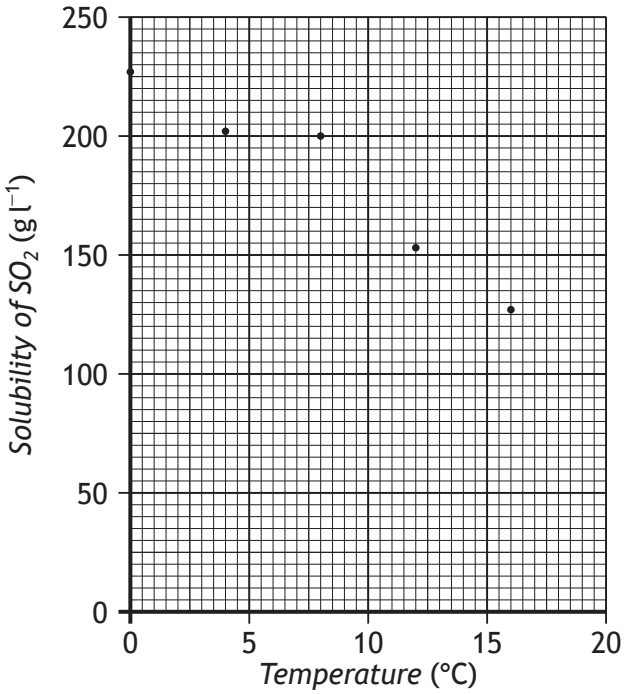
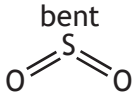
(c) The graph shows results for an experiment to determine the solubility of sulfur dioxide in water.



(i) Determine the solubility of sulfur dioxide, in g l^{-1}, in water at 10 °C. **1**

(ii) Information about sulfur dioxide and carbon dioxide is shown in the table.

	Shape of molecule	*Electronegativity difference between elements*	*Solubility in water at 25 °C* (g l^{-1})
carbon dioxide	linear O=C=O	1·0	1·45
sulfur dioxide	bent 	1·0	94

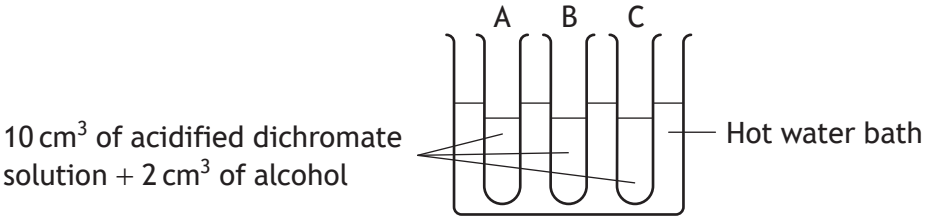
Explain **fully** why carbon dioxide is much less soluble in water than sulfur dioxide is in water. **2**

6. A student was carrying out an investigation into alcohols, aldehydes and ketones.

(a) The student was given three alcohols labelled as **A**, **B** and **C**. These alcohols were all isomers with the formula C_4H_9OH.

(i) Draw a structural formula for the secondary alcohol with the formula C_4H_9OH. **1**

(ii) The student set up the following experiment.



Alcohol	*Observation*
A	Colour change
B	No change
C	Colour change

(A) Suggest why a water bath is an appropriate method of heating the reaction mixture. **1**

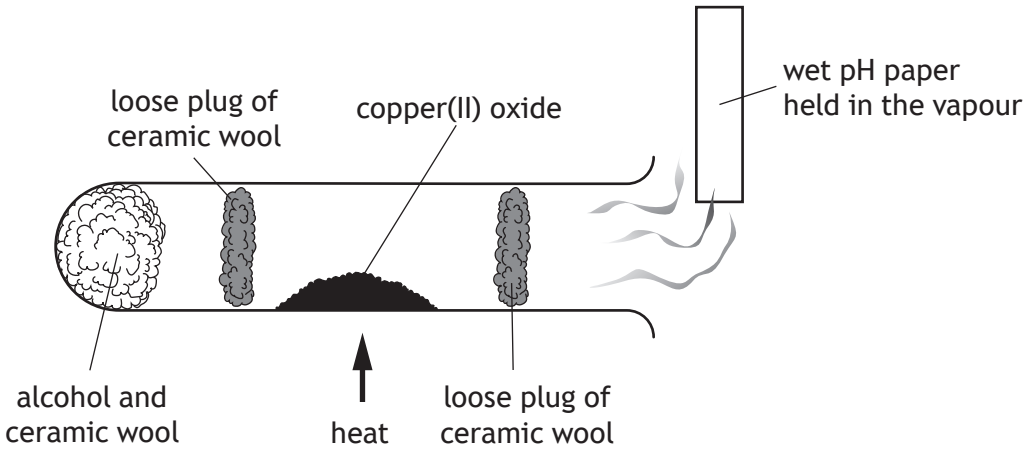
(B) Describe the colour change that would have been observed with alcohols **A** and **C**. **1**

(C) Alcohol **B** is not oxidised.

State the **type** of alcohol which cannot be oxidised by acidified dichromate solution. **1**

6. (a) (continued)

(iii) The student set up a second experiment with alcohol **A**.



Hot copper(II) oxide is an oxidising agent.

(A) When alcohol **A** (C_4H_9OH) is oxidised the product turns the pH paper red.

Suggest a name for the product. **1**

(B) Complete the ion-electron equation for the oxidation reaction. **1**

$C_4H_9OH \rightarrow C_4H_8O_2$

MARKS

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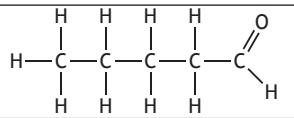
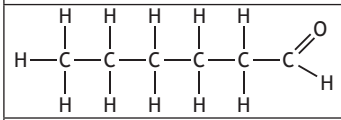
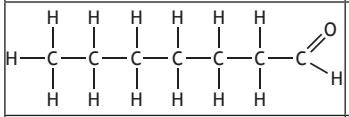
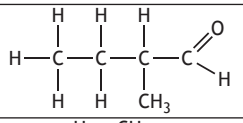
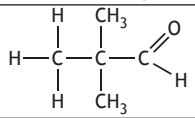
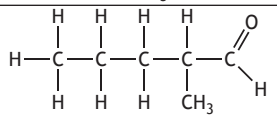
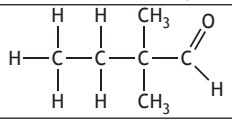
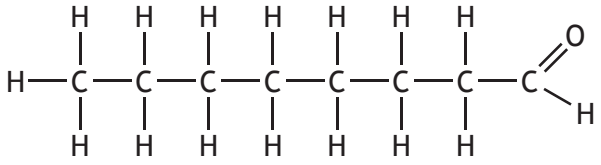
(b) The student found the following information about the boiling points of some aldehydes.

Aldehyde	*Molecular formula*	*Boiling point* (°C)
	$C_5H_{10}O$	102
	$C_6H_{12}O$	130
	$C_7H_{14}O$	153
	$C_5H_{10}O$	95
	$C_5H_{10}O$	75
	$C_6H_{12}O$	119
	$C_6H_{12}O$	111

(i) Name the aldehyde that has a boiling point of 119 °C. **1**

(ii) Predict the boiling point, in °C, of the following molecule. **1**



6. (b) (continued)

(iii) Using information from the table, describe one way in which differences in structure affect the boiling point of **isomeric** aldehydes. **1**

(iv) State what would be observed when an aldehyde is gently heated with Tollens' reagent. **1**

(c) Ketones contain a carbonyl group.

Name the type of intermolecular interaction between ketone molecules. **1**

7. Some people take iron tablets as a dietary supplement. Iron tablets may contain iron(II) sulfate.

(a) A student was investigating the iron(II) content of iron tablets. A work card gave the following instructions for preparing an iron tablet solution.

1. Add five iron tablets to about 50 cm^3 of dilute sulfuric acid in a small beaker and stir to dissolve.
2. Transfer quantitatively to a 100 cm^3 volumetric flask.
3. Make up the solution to the graduation mark on the volumetric flask.
4. Stopper the flask and then invert it to mix the solution.

To 'transfer quantitatively' means that **all** of the iron tablet solution must be transferred into the volumetric flask.

Describe how this is carried out in practice. **1**

(b) The concentration of iron(II) ions (Fe^{2+}) in this iron tablet solution can be determined by a redox titration with permanganate (MnO_4^-) solution.

$$5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$$

(i) Suggest why it is **not** necessary to add an indicator to this titration. **1**

7. (b) (continued)

(ii) Suggest why the titration must be carried out under acidic conditions. **1**

(iii) Three 25·0 cm^3 samples of the iron tablet solution were titrated with a standard solution of 0·020 mol l^{-1} permanganate (MnO_4^-). The results are shown below.

Sample	*Volume of permanganate* (cm^3)
1	14·9
2	14·5
3	14·6

(A) State why the volume of permanganate used in the calculation was taken to be 14·55 cm^3, although this is not the average of the three titres in the table. **1**

(B) Calculate the concentration, in mol l^{-1}, of iron(II) ions in the iron tablet solution. **3**

$$5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$$

7. (b) (iii) (continued)

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

(D) Name an appropriate piece of apparatus which could be used to measure 25·0 cm^3 samples of iron tablet solution. **1**

(c) In a different experiment, five iron tablets were found to contain 0·00126 moles of iron(II) ions.

Calculate the average mass, in **mg**, of iron present in **one** tablet. **1**

(d) It is recommended an adult female takes in 14·8 mg of iron per day.

100 g of a breakfast cereal contains 12·0 mg of iron.

Calculate the percentage of the recommended daily amount of iron provided for an adult female by a 30 g serving. **2**

8. Skin care products contain a mixture of polar covalent, non-polar covalent and ionic compounds. The compounds need to stay mixed within the product.

Skin care products also need to spread easily and remain on the skin for a period of time, as well as provide physical and chemical protection from the sun. In order to do this, skin care products contain a range of chemicals including water, fats and oils, antioxidants, minerals and sun block.

Using your knowledge of chemistry, explain the role of different chemicals in skin care products. **3**

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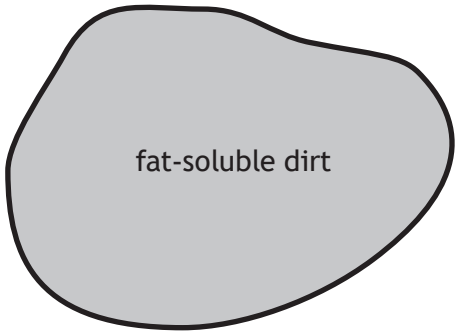
9. Dishwasher tablets contain chemicals which remove dirt from dishes.

(a) Dishwasher tablets include detergents. These molecules act like soaps to allow mixing of fat-soluble dirt and water.

(i) During the cleaning process, the detergent molecules combine with fat-soluble dirt.

A simplified diagram of a detergent molecule is shown.

Complete the diagram below to show how detergent molecules combine with fat-soluble dirt. **1**



(An additional diagram, if required, can be found on *Page 36*)

(ii) State the term used to describe the non-polar, hydrocarbon tail of a detergent molecule. **1**

9. (continued)

(b) Dishwasher tablets produce the bleach hydrogen peroxide, H_2O_2. One action of this oxidising agent is to oxidise food.

(i) Suggest another action of the bleach produced by the dishwasher tablets. **1**

(ii) Hydrogen peroxide decomposes to form water and oxygen.

$$2H_2O_2(\ell) \rightarrow 2H_2O(\ell) + O_2(g)$$

A dishwasher tablet produces 0·051 g of hydrogen peroxide (mass of one mole = 34 g).

Calculate the volume of oxygen that would be produced when 0·051 g of hydrogen peroxide decomposes. **3**

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

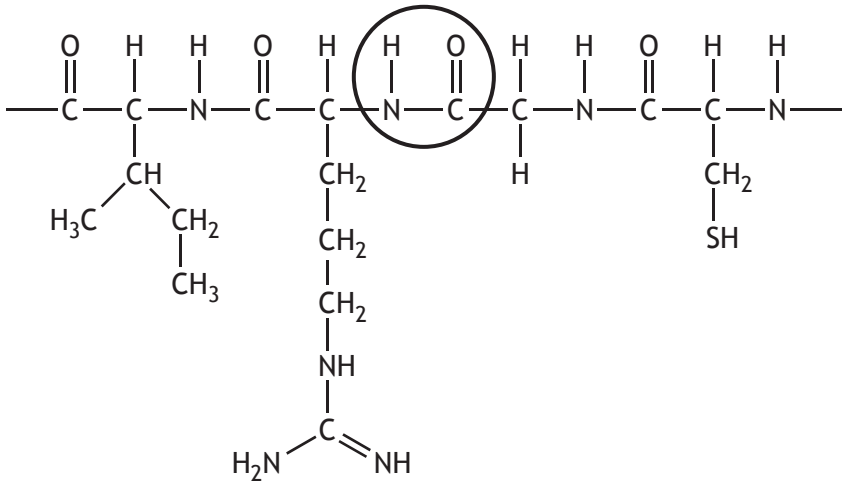
(c) Enzymes are commonly added to dishwasher tablets. These are used to break down proteins.

(i) The proteins are broken down into small, water-soluble molecules.

Name the small, water-soluble molecules made when proteins are broken down completely. **1**

9. (c) (continued)

(ii) The structure of a section of protein chain found in egg white is shown.



(A) Name the functional group circled. **1**

(B) Draw a structural formula for **one** of the molecules that would be made when this section of egg white protein chain is completely broken down. **1**

(iii) As part of the program in the dishwasher, the conditions in the dishwasher change so that the enzyme molecules no longer work because they change shape.

(A) State the term used to describe the change in shape of enzyme molecules. **1**

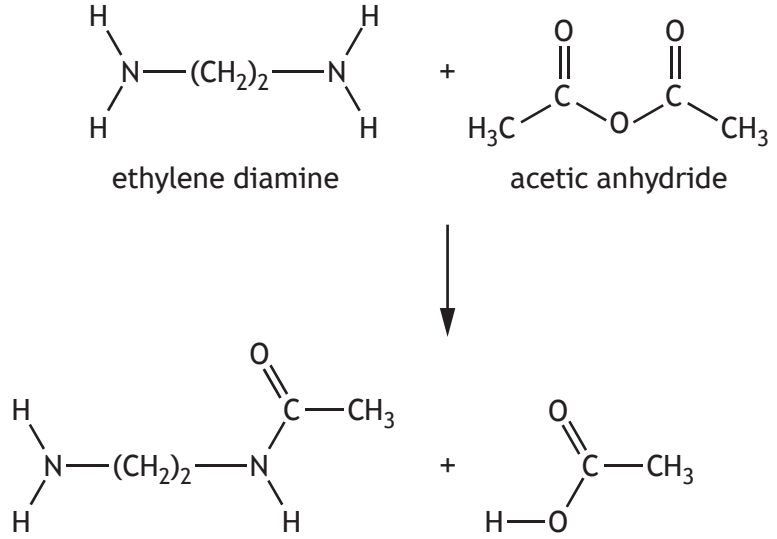
(B) Suggest a change in conditions which would cause the enzyme molecules to change shape. **1**

9. (continued)

(d) A bleach activator is frequently added to dishwasher tablets to speed up the bleaching reaction. One common bleach activator is TAED.

TAED could be produced in a process which involves a number of stages.

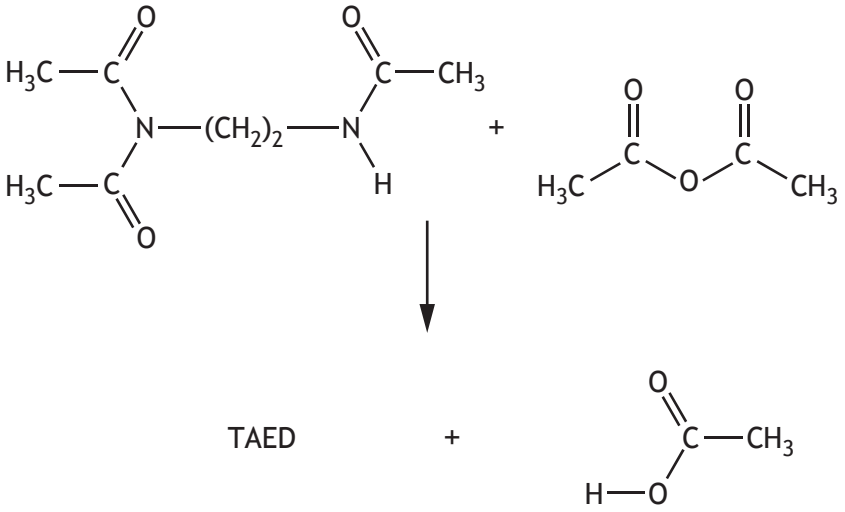
(i) The first stage in producing TAED is shown below.



Suggest a name for this type of reaction. **1**

9. (d) (continued)

(ii) The final stage in the process producing TAED is shown below.



Draw a structural formula for TAED. **1**

10. Essential oils from the lavender plant are used in aromatherapy.

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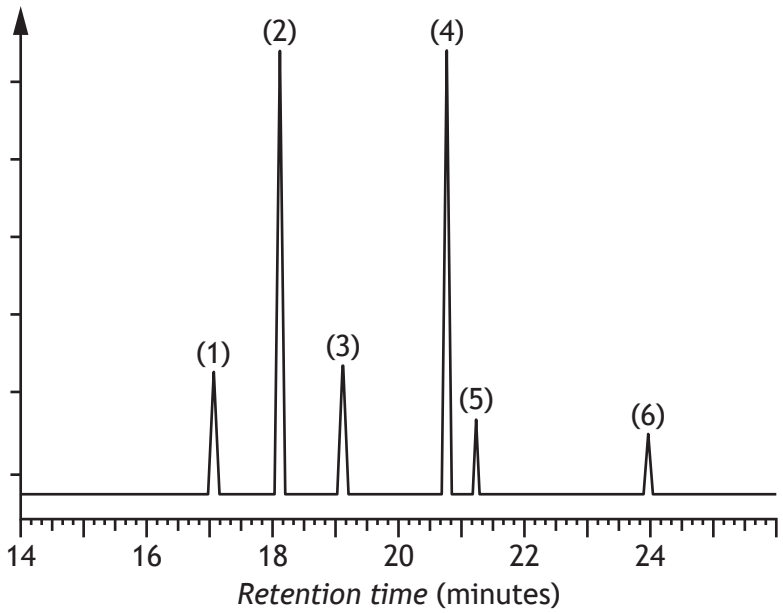
(a) Gas chromatography can be used to separate and identify the organic compounds in lavender oils.

Chromatogram 1 - Lavender oil **A**



Peak	*Component*	*Component peak area*
1	1,8-cineole	7432
2	linalool	31 909
3	camphor	7518
4	linalyl acetate	27 504
5	geranyl acetate	3585
6	farnesene	1362

Total peak area = 79 310

The relative concentration of each component can be calculated using the following formula.

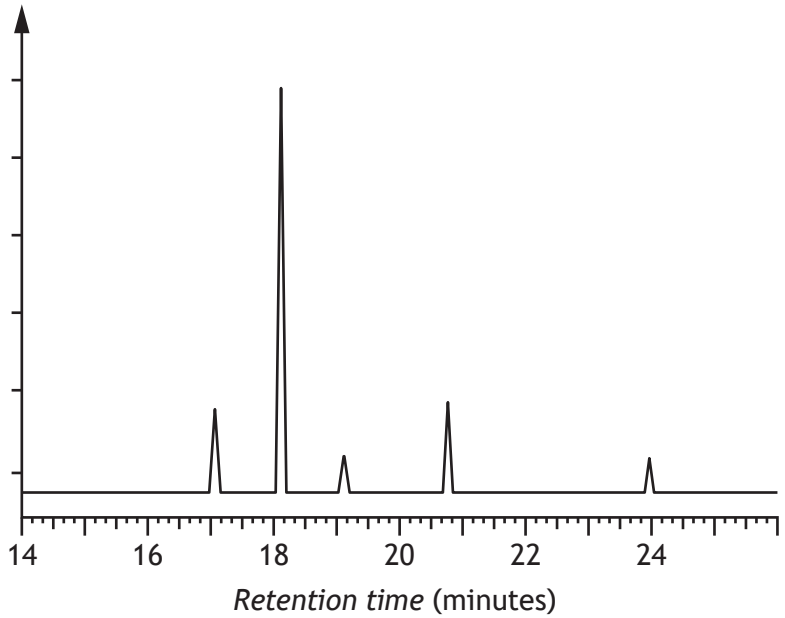
$$\text{Relative concentration} = \frac{\text{Component peak area}}{\text{Total peak area}} \times 100\ (\%)$$

(i) Calculate the relative concentration of linalool in lavender oil **A**. **1**

10. (a) (continued)

(ii) Different varieties of lavender oils have different compositions.

Chromatogram 2 – Lavender oil **B**



Identify the component found in lavender oil **A** that is missing from lavender oil **B**. **1**

(b) A brand of mouthwash contains the component 1,8-cineole at a concentration of 0·92 mg per cm^3. The cost of 1 kg of 1,8-cineole is £59·10.

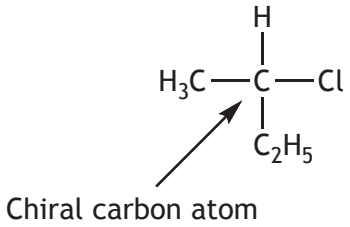
Calculate the cost, in pence, of 1,8-cineole that is present in a 500 cm^3 bottle of this brand of mouthwash. **2**

10. (continued)

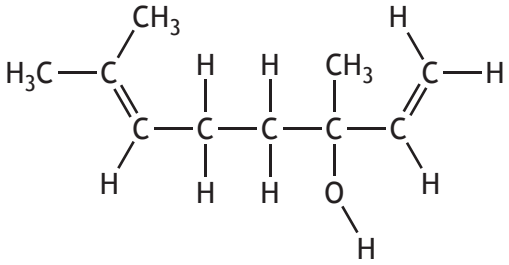
(c) The component molecules found in lavender oils are terpenes or terpenoids.

(i) A chiral carbon is a carbon atom attached to **four** different atoms or groups of atoms.

An example is shown below.



A molecule of the terpenoid linalool has a chiral carbon. Linalool has the following structure.



Circle the chiral carbon atom in the linalool structure. **1**

(An additional diagram, if required, can be found on *Page 36*)

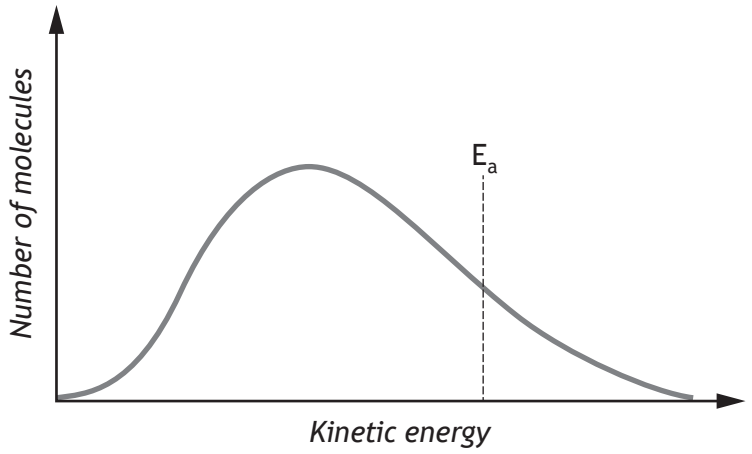
(ii) Farnesene is a terpene consisting of **three** isoprene units (2-methylbuta-1,3-diene) joined together.

Write the molecular formula of farnesene. **1**

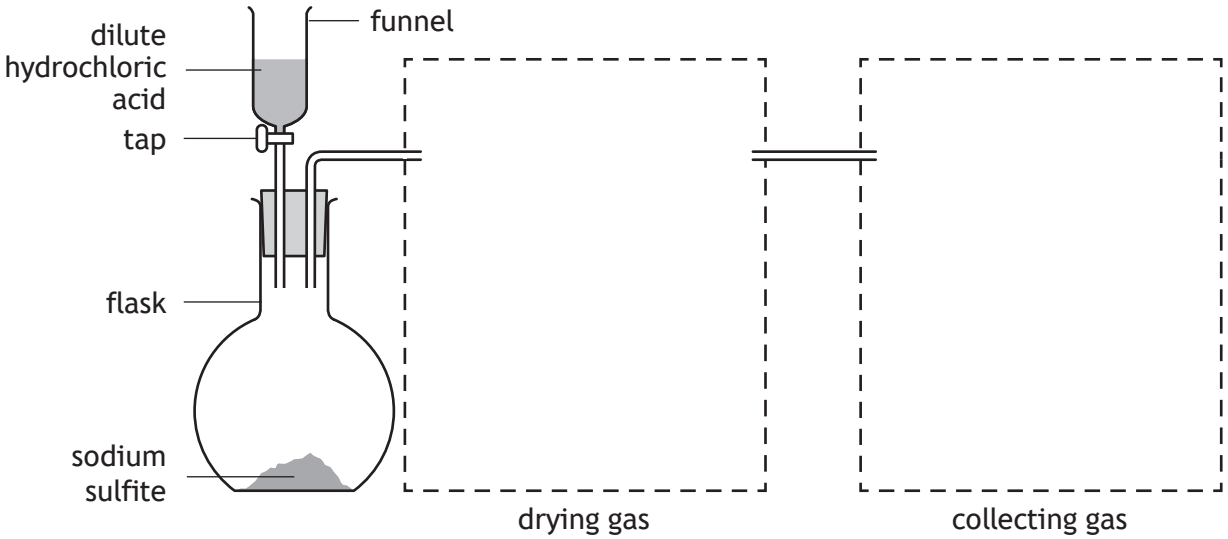
[END OF QUESTION PAPER]

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

ADDITIONAL DIAGRAM FOR USE IN QUESTION 2 (a) (ii)



ADDITIONAL DIAGRAM FOR USE IN QUESTION 5 (a) (i)



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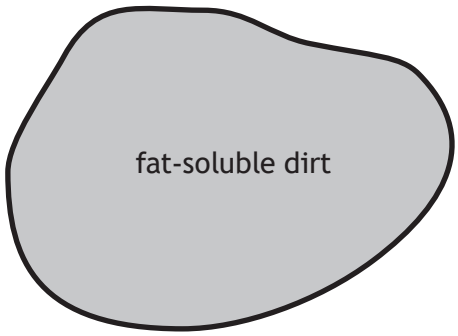
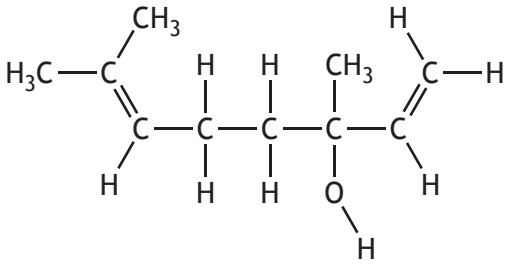
ADDITIONAL DIAGRAM FOR USE IN QUESTION 9 (a) (i)



ADDITIONAL DIAGRAM FOR USE IN QUESTION 10 (c) (i)



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