FOR OFFICIAL USE

National Qualifications 2018

Mark

X713/76/01

Chemistry
Section 1 — Answer Grid and Section 2

MONDAY, 21 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:

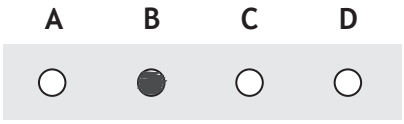
A fractional distillation

B chromatography

C fractional crystallisation

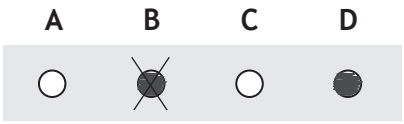
D filtration.

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

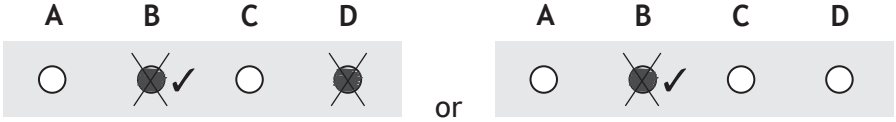


Changing an answer

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 of group 7 in the periodic table are known as the halogens.

(a) Going down group 7 the electronegativity of the halogens decreases.

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

(ii) Explain why electronegativity values decrease going down group 7. **1**

(b) Explain **fully** why the boiling points of the halogens increase going down group 7.

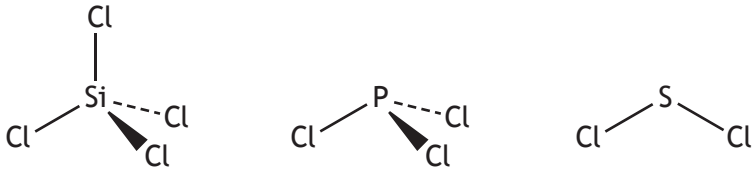
In your answer you should name the intermolecular forces involved. **3**

2. The elements sodium to argon form the third period of the periodic table.

(a) Explain the decrease in atom size going across the third period from sodium to argon. **1**

(b) Elements in the third period of the periodic table form chlorides.

The structures of three of these chlorides are shown.



(i) Circle the structure of the molecule above that contains **bonds** with the lowest polarity. **1**

(An additional diagram, if required, can be found on *page 37*).

(ii) Explain **fully** why, of these three chlorides, silicon tetrachloride is the most soluble in hexane. **2**

[Turn over

2. (continued)

(c) Silicon tetrachloride can be used to make silicon nitride (Si_3N_4), a compound found in many cutting tools.

(i) Silicon nitride has a melting point of 1900 °C and does not conduct electricity when molten.

Explain **fully**, in terms of structure and bonding, why silicon nitride has a high melting point. **2**

(ii) An equation for the formation of silicon nitride is shown.

$3SiCl_4$	+	$16NH_3$	→	Si_3N_4	+	$12NH_4Cl$
mass of one mole = 170·1 g		mass of one mole = 17·0 g		mass of one mole = 140·3 g		mass of one mole = 53·5 g

Calculate the atom economy for the formation of silicon nitride. **2**

2. (continued)

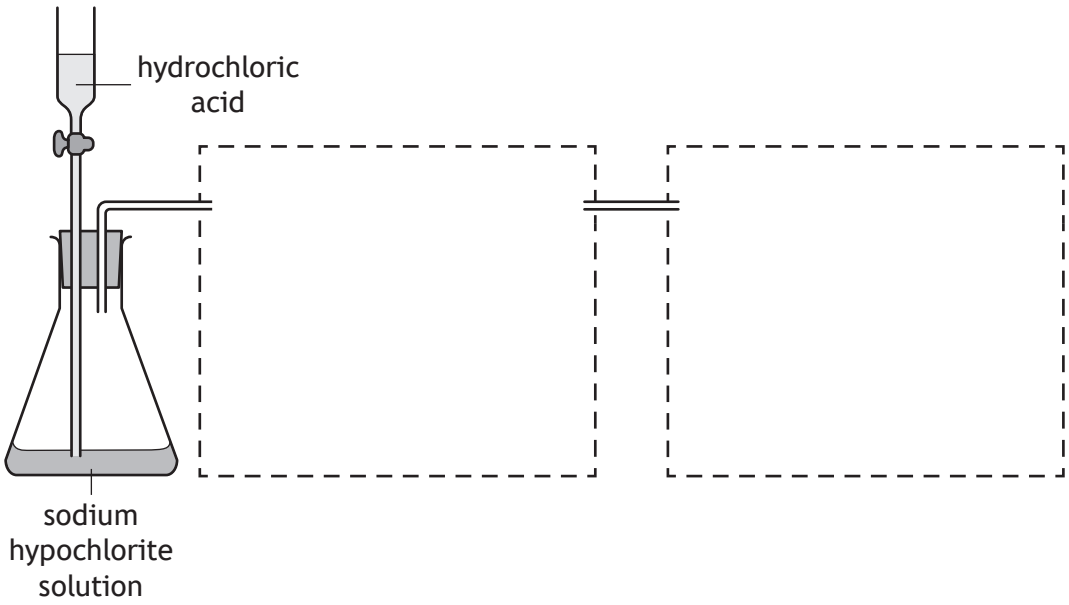
(d) Aluminium, another element in the third period, also forms a chloride. Aluminium chloride is prepared by reacting aluminium metal and chlorine gas.

Chlorine gas is produced by the reaction between hydrochloric acid and sodium hypochlorite. The chlorine is then passed over heated aluminium foil, forming aluminium chloride as a hot gas. The hot aluminium chloride gas and unreacted chlorine gas are passed into a flask where the aluminium chloride cools to a fine white powder.

For safety it is important that any unreacted chlorine gas can escape from the flask.

(i) Complete a labelled diagram to show an apparatus suitable for carrying out this preparation. **2**

(An additional diagram, if required, can be found on *page 37*).

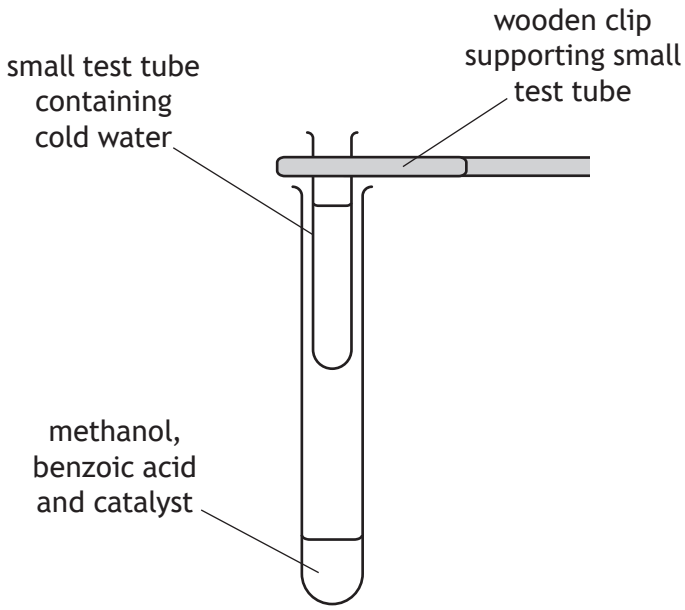


(ii) Explain why the aluminium foil needs to be heated at the start of the preparation, despite the reaction being highly exothermic. **1**

[Turn over

3. Methyl benzoate is commonly added to perfumes as it has a pleasant smell.

A student carries out a reaction to produce methyl benzoate using the following apparatus.



(a) The reaction mixture needs to be heated.

Describe a safe method of heating a flammable mixture. **1**

(b) Suggest a reason why there is a small test tube filled with cold water in the neck of the tube containing the reaction mixture. **1**

3. (continued)

(c) The chemical reaction involved in the experiment is shown.

$C_6H_5COOH(s)$	+	$CH_3OH(\ell)$	→	$C_6H_5COOCH_3(\ell)$	+	**X**
benzoic acid				methyl benzoate		
mass of one mole = 122 g		mass of one mole = 32 g		mass of one mole = 136 g		

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

(ii) In a laboratory experiment, a student used 5·0 g of benzoic acid and 2·5 g of methanol to produce methyl benzoate.

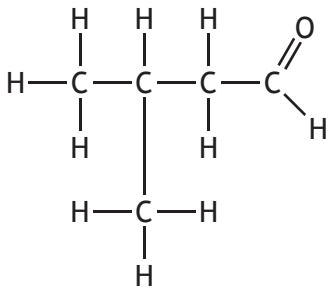
Explain why benzoic acid is the limiting reactant.

You must include calculations in your answer. **2**

(iii) The student produced 3·1 g of methyl benzoate from 5·0 g of benzoic acid. Benzoic acid costs £39·80 for 500 g.

Calculate the cost, in £, of the benzoic acid needed to make 100 g of methyl benzoate using the student's method. **2**

4. 3-Methylbutanal is a compound that is found in low concentrations in many types of food. The structure of 3-methylbutanal is shown.



(a) Draw a structural formula for a ketone that is an isomer of 3-methylbutanal. **1**

(b) Name a reagent which could be used to distinguish between 3-methylbutanal and a ketone. **1**

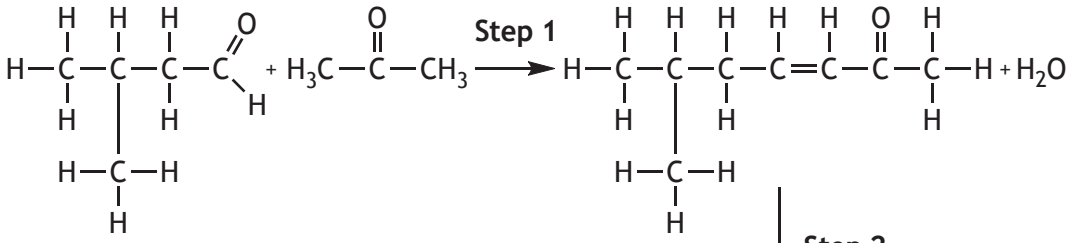
(c) Name the strongest intermolecular force that occurs between 3-methylbutanal molecules. **1**

4. (continued)

(d) 3-Methylbutanal is found in olive oil. **2**

Explain **fully** what can happen to 3-methylbutanal that will cause the olive oil to develop an unpleasant taste.

(e) 3-Methylbutanal can be used as a reactant in the production of other compounds. One reaction scheme involving 3-methylbutanal is shown.



3-methylbutanal propanone

product A

(i) Explain why **step 1** is described as a condensation reaction. **1**

(ii) Give the systematic name for **product A**. **1**

5. Many chemical compounds are related to each other by their structural features, the way they are made and how they are used.

Using your knowledge of chemistry, describe the relationships between fats, oils, detergents, soaps and emulsifiers. **3**

[Turn over for next question

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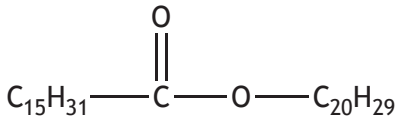
6. Skin creams contain many different chemicals.

(a) Retinol (vitamin A) promotes cell regeneration.

One method of supplying retinol to the skin is by using a skin cream containing the compound retinyl palmitate.



retinyl palmitate

Retinyl palmitate is absorbed into the skin and then broken down to form retinol.

(i) Name the type of reaction that occurs when retinyl palmitate is broken down to form retinol. **1**

(ii) Write a molecular formula for retinol. **1**

(b) Skin creams often contain vitamin E to prevent damage to the skin caused by free radicals.

(i) Describe how free radicals are formed. **1**

6. (b) (continued)

(ii) Hydroxyl free radicals (•OH) can attack fatty acids present in cell membranes. One step in the chain reaction is shown below.

$$C_{18}H_{31}O_2 \quad + \quad \bullet OH \quad \rightarrow \quad C_{18}H_{30}O_2\bullet \quad + \quad H_2O$$

State the name given to this step in the chain reaction. **1**

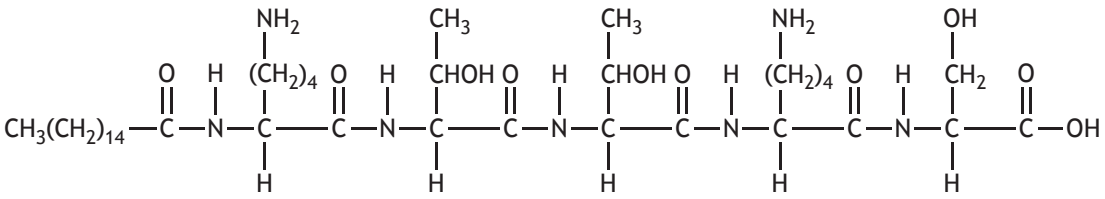
(iii) The antioxidant vitamin E is a free radical scavenger.

State how free radical scavengers prevent further chain reactions. **1**

[Turn over

6. (continued)

(c) Palmitoyl pentapeptide-4 is also used in skin creams.



(i) Circle a peptide link in the above structure. **1**

(An additional diagram, if required, can be found on *page 37*).

(ii) Palmitoyl pentapeptide-4 is formed from palmitic acid and three different amino acids.

Molecule	*Number of molecules used to form one molecule of palmitoyl pentapeptide-4*
palmitic acid	1
threonine	2
serine	1
lysine	2

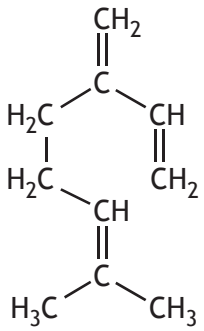
Draw a structural formula for the amino acid serine. **1**

7. Terpenes consist of joined isoprene units (2-methylbuta-1,3-diene). They are classified by the number of isoprene units in the molecule.

Class of terpene	*Number of isoprene units*
hemiterpene	1
monoterpene	2
sesquiterpene	3
diterpene	4
triterpene	6

(a) Myrcene and humulene are terpenes present in hops which give beer its characteristic flavour and aroma.

(i) Circle an isoprene unit on the myrcene structure below. **1**



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

(ii) Humulene has the molecular formula $C_{15}H_{24}$.

Name the class of terpene to which humulene belongs. **1**

[Turn over

7. (continued)

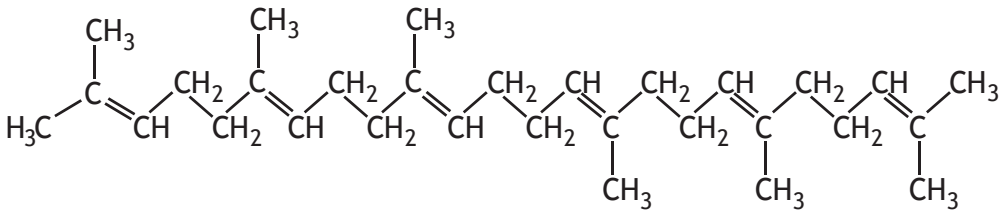
(b) (i) Squalene, a triterpene, is included in some flu vaccines to enhance the body's immune response. A single dose of flu vaccine contains 10·69 mg of squalene.

Calculate the mass of squalene required to produce a batch of 500 000 doses of flu vaccine.

Your answer must be given in kg. **2**

(ii) Squalane is a fully saturated hydrocarbon used in skin moisturising cream.

Squalane can be made by the reaction of squalene with hydrogen.

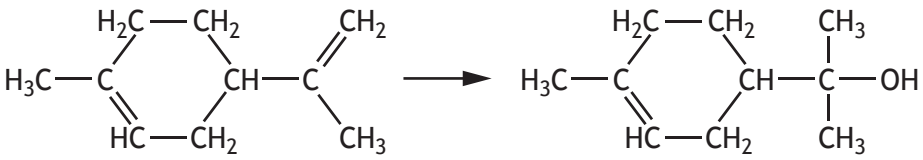


squalene

State the number of moles of hydrogen needed to fully saturate one mole of squalene to produce one mole of squalane. **1**

7. (continued)

(c) The monoterpene limonene, found in lemon oil, can be converted into the alcohol, terpineol.



limonene terpineol

(i) Name the type of reaction taking place. **1**

(ii) When terpineol is heated with copper(II) oxide, no reaction takes place.

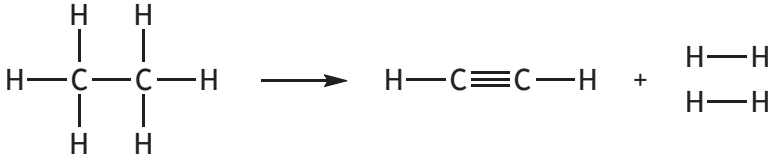
Explain why no reaction takes place. **1**

[Turn over

8. The alkynes are a homologous family of hydrocarbons.

(a) The simplest member of the family is ethyne, C_2H_2, used in welding torches.

Ethyne can be produced from ethane.



Using bond enthalpies and mean bond enthalpies from the data book, calculate the enthalpy change, in kJ mol^{-1}, for this reaction. **2**

(b) Hess's Law can be used to calculate the enthalpy change for reactions that do not normally take place, such as the formation of propyne from its elements.

$$3C(s) + 2H_2(g) \rightarrow C_3H_4(g)$$

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

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H = -394$ kJ mol^{-1}

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell)$ $\quad \Delta H = -286$ kJ mol^{-1}

$C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(\ell)$ $\quad \Delta H = -1939$ kJ mol^{-1}

8. (continued)

(c) Propyne, C_3H_4 (1 mole = 40 g), has been suggested as a possible rocket fuel.

(i) The enthalpy of combustion of propyne is $-1939\ kJ\ mol^{-1}$.

Calculate the energy released, in kJ, when 1 kg of propyne is burned completely. **1**

(ii) The mass of air required to burn 1 g of fuel can be calculated using the relationship shown.

Mass of air, in g = 4·3 × mass of oxygen, in g, for complete combustion of 1 g of fuel

Calculate the mass of air, in g, required to burn 1 g of propyne. **2**

$$C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(\ell)$$

8. (c) (continued)

(iii) The table shows the mass of air required to burn 1 g of different fuels.

Fuel	*Mass of 1 mole (g)*	*Mass of air required to burn 1 g*
ethane	30	16·1
propane	44	15·6
methanol	32	6·5
ethanol	46	9·0

Suggest why methanol and ethanol, compared to the other fuels, require less air to burn 1 g. **1**

[Turn over for next question

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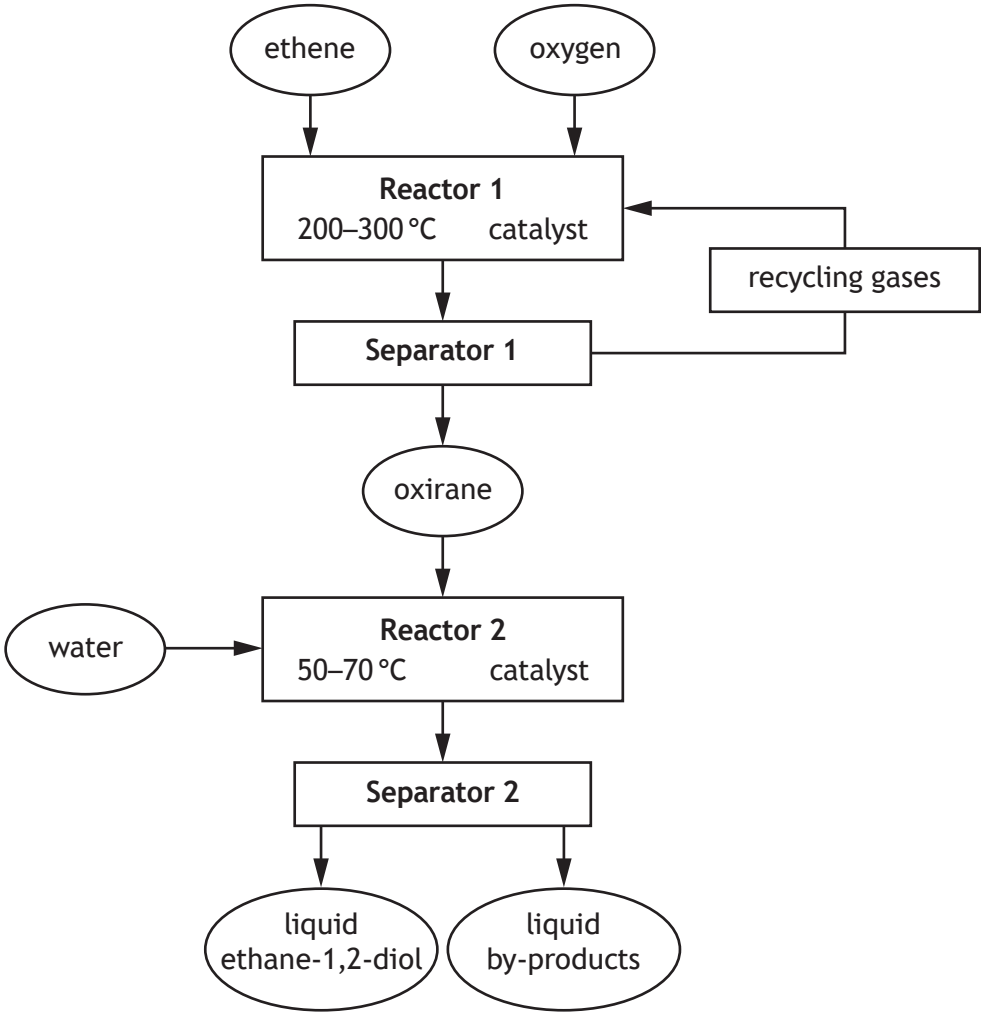
9. Ethane-1,2-diol can be made from ethene.

(a) The flow chart of an industrial process to produce ethane-1,2-diol is shown.



(i) Industrial processes are designed to maximise profit.

Using the flowchart, suggest two ways to maximise profit in this industrial process. **2**

9. (a) (continued)

(ii) Name the process used in **Separator 2** to separate ethane-1,2-diol from the larger liquid by-products. **1**

(b) Explain fully why ethane-1,2-diol is more viscous than propan-1-ol. **2**

(c) Draw a structural formula for a diol that contains three carbon atoms. **1**

[Turn over

9. (continued)

(d) Ethane-1,2-diol has been found to be harmful to animals. Treatment for affected animals involves using a 20% ethanol solution.

(i) The 20% ethanol solution is prepared by accurately measuring 20 cm^3 of ethanol and then making up to exactly 100 cm^3 with water.

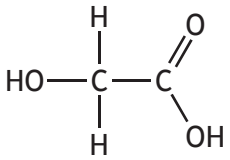
Describe the procedure which should be used to prepare 100 cm^3 of the 20% ethanol solution. **2**

(ii) An affected animal must be treated with 9 doses of 20% ethanol solution. Each dose contains 5 cm^3 of the ethanol solution for every kilogram body mass of the animal.

Calculate the total volume, in cm^3, of the 20% ethanol solution needed to treat a 3·5 kg animal. **1**

9. (d) (continued)

(iii) Ethane-1,2-diol is harmful because it is oxidised in the body to form glycolic acid.



glycolic acid

(A) Draw a structural formula for another possible product of oxidation of ethane-1,2-diol. **1**

(B) Glycolic acid can be neutralised by sodium hydroxide to form sodium glycolate.

Give a formula for sodium glycolate. **1**

[Turn over

10. The molar volume (in units of litres per mole) is the same for all gases at the same temperature and pressure.

Using your knowledge of chemistry, suggest how the molar volume of gases could be measured and compared. Any suitable chemicals and apparatus can be used. Some suggested chemicals and apparatus are given below. **3**

Chemicals	*Apparatus*
hydrochloric acid	gas syringe
zinc	measuring cylinder
magnesium	delivery tube
calcium	stoppers
water	500 cm^3 flask
sodium carbonate	vacuum pump
calcium carbonate	balance
cylinder of nitrogen	cork ring
cylinder of hydrogen	burette
cylinder of carbon dioxide	filter funnel

10. (continued)

[Turn over

11. Iodine is required for a healthy diet. Food grown in certain parts of the world is low in iodine. To prevent iodine deficiency in people's diets, table salt can be 'iodised' by the addition of very small quantities of potassium iodide, KI.

The number of moles of iodide in a sample of salt can be determined by the following procedure.

Step 1

Prepare a standard salt solution by dissolving an accurately weighed sample of iodised salt (50·0 g) in water to give a final volume of 250 cm^3.

Step 2

Transfer 50 cm^3 of salt solution to a conical flask and add excess bromine solution to convert the iodide ions to iodine.

Step 3

Titrate the iodine (I_2) released with sodium thiosulfate solution ($Na_2S_2O_3$).

(a) Describe a procedure to accurately weigh out a 50·0 g sample of iodised table salt. **1**

(b) The overall equation for the reaction of bromine solution with iodide ions is shown.

$$2I^-(aq) + Br_2(aq) \rightarrow I_2(aq) + 2Br^-(aq)$$

Write the ion-electron equation for the oxidation reaction. **1**

11. (continued)

(c) Three samples were prepared as described in **step 2**. Each sample was titrated with 0·0010 mol l^{-1} sodium thiosulfate solution.

The results are shown below.

Sample	*Volume of sodium thiosulfate* (cm^3)
1	10·0
2	9·4
3	9·6

(i) Calculate the average volume, in cm^3, of sodium thiosulfate solution that should be used to determine the number of moles of iodine released. **1**

(ii) Calculate the number of moles of iodine released from 50 cm^3 of the standard salt solution. **2**

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

[Turn over

12. Many modern antiseptics are based on phenol. The table shows the germ-killing power of some phenol compounds.

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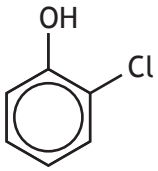
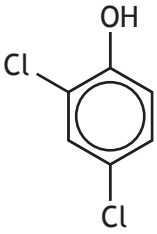
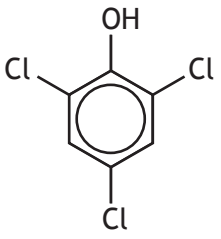
(a)

Compound	*Structure*	*Germ-killing power (relative to phenol)*
phenol		1·0
4-methylphenol		2·5
2-chlorophenol		3·6
4-ethylphenol		7·5
2,4-dichlorophenol		13·0
4-propylphenol		20·0
2,4,6-trichlorophenol		23·0

12. (a) (continued)

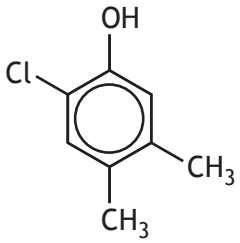
(i) Suggest two ways in which structural features increase germ-killing power of phenol compounds. **2**

(ii) The names of the phenol compounds in the table are derived from their structures using the following rules.

Phenol is used as the parent name for the compound.

1. The –OH functional group is assigned as being on carbon 1 of the ring.
2. The ring can be numbered clockwise or anticlockwise to assign numbers to the other atoms or groups. The numbers should be assigned so that the lowest possible numbers are used.
3. If two or more identical atoms or groups are present, use one of the prefixes di, tri or tetra.
4. The names of the atoms or groups attached to the ring are listed alphabetically (ignoring the prefixes for alphabetical purposes).

Using these rules, name this molecule.



1

[Turn over

12. (continued)

(b) There are different methods of producing phenol.

(i) In the early 1900s, phenol was produced by the following reaction.

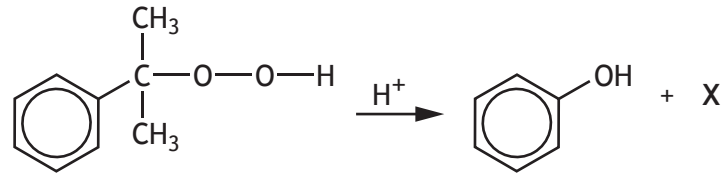
$$\underset{\text{benzene}}{C_6H_6} + H_2SO_4 + 2NaOH \rightarrow \underset{\text{phenol}}{C_6H_5OH} + Na_2SO_3 + 2H_2O$$

mass of one mole = 78·0 g

mass of one mole = 94·0 g

Calculate the mass of phenol, in kg, produced from 117 kg of benzene if the percentage yield is 90%. **2**

(ii) Phenol is now usually produced by the Cumene Process.



cumene hydroperoxide

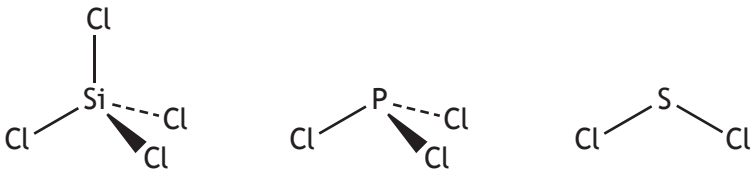
phenol

Name the other product, **X**, formed in the Cumene Process. **1**

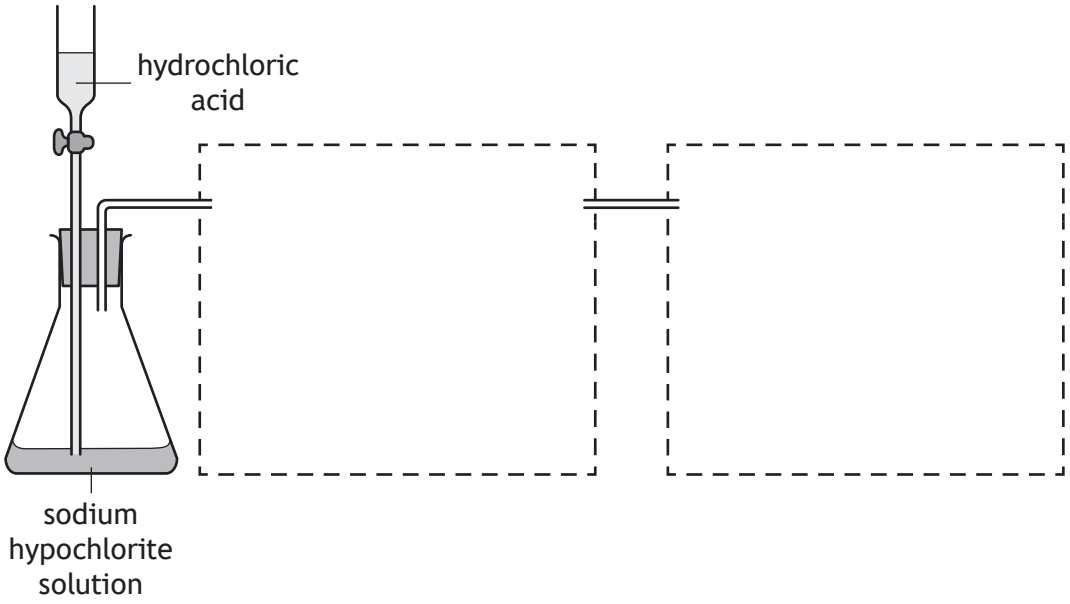
[END OF QUESTION PAPER]

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

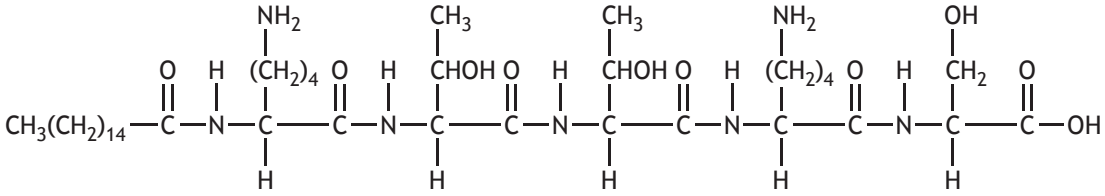
ADDITIONAL DIAGRAM FOR USE IN QUESTION 2 (b)



ADDITIONAL DIAGRAM FOR USE IN QUESTION 2 (d) (i)



ADDITIONAL DIAGRAM FOR USE IN QUESTION 6 (c) (i)



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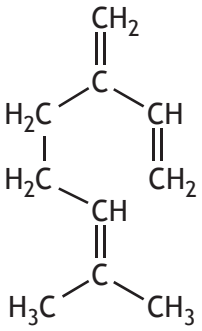
ADDITIONAL DIAGRAM FOR USE IN QUESTION 7 (a) (i)



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