FOR OFFICIAL USE

AH

National Qualifications 2018

Mark

X713/77/01

Chemistry Section 1 — Answer Grid and Section 2

MONDAY, 21 MAY

9:00 AM – 11:30 AM

* X 7 1 3 7 7 0 1 *

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

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

Total marks — 100

SECTION 1 — 30 marks

Attempt ALL questions.

Instructions for the completion of Section 1 are given on *page 02*.

SECTION 2 — 70 marks

Attempt ALL questions.

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.

* X 7 1 3 7 7 0 1 0 1 *

SECTION 1 — 30 marks

The questions for Section 1 are contained in the question paper X713/77/02.

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:

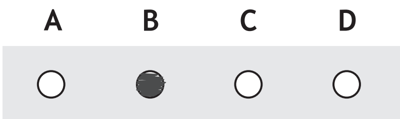
A fractional distillation

B chromatography

C fractional crystallisation

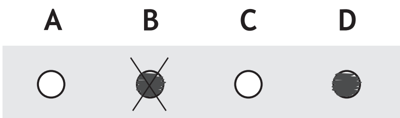
D filtration.

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

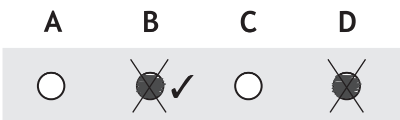


Changing an answer

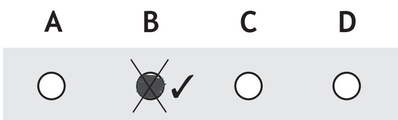
If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



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:



or



OBJ30AD1

	A	B	C	D
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
13	○	○	○	○
14	○	○	○	○
15	○	○	○	○
16	○	○	○	○
17	○	○	○	○
18	○	○	○	○
19	○	○	○	○
20	○	○	○	○
21	○	○	○	○
22	○	○	○	○
23	○	○	○	○
24	○	○	○	○
25	○	○	○	○
26	○	○	○	○
27	○	○	○	○
28	○	○	○	○
29	○	○	○	○
30	○	○	○	○

X713770103

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X713770104

SECTION 2 — 70 marks

Attempt ALL questions

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1. Roman pottery contains traces of metals.

(a) The metals present in Roman pottery can be identified using atomic emission spectroscopy.

Analysis of a sample from a Roman pot produced a series of spectral lines. The data in the table shows the results for three of the spectral lines produced.

Metal	*Wavelength of spectral line* (nm)	*Relative intensity*
aluminium	620	651
	589	485
titanium	498	375

(i) Name the metal that produces the orange-yellow spectral line at 589 nm. **1**

(ii) A fourth line observed in the spectrum obtained from the Roman pot sample was caused by a transition with an energy value of 282 kJ mol^{-1}.

Calculate the wavelength, in nm, of this spectral line. **2**

(iii) The Roman pot sample was found to have a titanium content of 435 mg kg^{-1}.

A different pot sample produced a spectral line at 498 nm with a relative intensity of 75.

Calculate the titanium content, in mg kg^{-1}, for this sample. **1**

X713770105

1. (continued)

(b) The Romans may have inadvertently made aluminium metal while producing pottery.

Aluminium has the following electronic configuration.

$$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$$

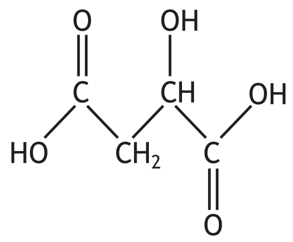
(i) This electronic configuration is consistent with the aufbau principle.

State the aufbau principle. **1**

(ii) For the 3p electron in aluminium, complete the table to show one possible set of values for the four quantum numbers. **1**

Quantum number	*n*	*l*	*m*	*s*
Value				

2. Apple jam contains malic acid.



malic acid

(a) Malic acid dissociates in two stages. The equation for the first stage dissociation of malic acid is

$$HOOCCH_2CH(OH)COOH(aq) + H_2O(\ell) \rightleftharpoons HOOCCH_2CH(OH)COO^-(aq) + H_3O^+(aq)$$

(i) Write an expression for the first stage dissociation constant, K_a, for malic acid. **1**

(ii) Complete the equation to show the second stage dissociation of malic acid. **1**

$$HOOCCH_2CH(OH)COO^-(aq) + H_2O(\ell) \rightleftharpoons$$

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2. (continued)

(b) While making apple jam, the jam will only thicken if the pH is between 2·7 and 3·3.

(i) The pH of the apple jam is determined by the first stage dissociation of malic acid ($K_a = 3{\cdot}2 \times 10^{-4}$).

The concentration of malic acid in the jam is 0·0051 mol l^{-1}.

Show by calculation that the jam will thicken at this concentration of malic acid. **3**

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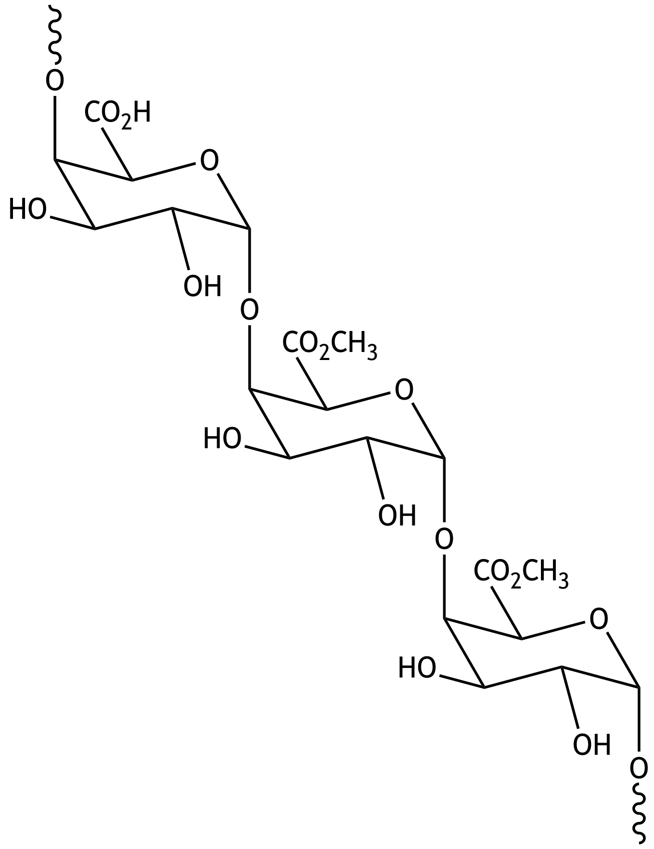
2. (b) (continued)

(ii) Pectin is a natural polymer found in apples which helps jam to thicken.

Part of the structure of pectin is shown.



Pectin binds to itself to help the jam thicken.

Suggest how the hydroxyl groups allow pectin molecules to bind. **1**

3. Sodium carbonate can exist as different hydrated salts with the general formula $Na_2CO_3.nH_2O$.

To determine *n* in the general formula, a 250 cm^3 solution containing 8·10 g of hydrated sodium carbonate was prepared. 25·0 cm^3 samples of this solution were titrated with 0·358 mol l^{-1} hydrochloric acid.

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(\ell) + CO_2(g)$$

The following results were obtained.

Titre	*Volume of HCl added* (cm^3)
1	20·2
2	19·5
3	19·4

(a) Describe the procedure for the accurate preparation of the 250 cm^3 solution from the weighed sample of hydrated sodium carbonate. **2**

3. (continued)

(b) (i) Calculate the number of moles of sodium carbonate in the 250 cm^3 solution. **2**

(ii) Calculate the value of *n* in the formula $Na_2CO_3.nH_2O$ **2**

3. (continued)

(c) Titration is a very useful analytical technique for volumetric analysis.

Using your knowledge of chemistry, discuss factors which should be considered when selecting appropriate chemicals for a titration. **3**

4. But-2-yne and but-1-yne can undergo addition reactions with hydrogen using a palladium-based catalyst.

$H_3C-C\equiv C-CH_3$ $H-C\equiv C-CH_2CH_3$

but-2-yne   but-1-yne

(a) State how transition metals can act as catalysts. **1**

(b) In the reaction of but-2-yne with hydrogen, *cis*-but-2-ene is formed.

Draw the skeletal structure of *cis*-but-2-ene. **1**

(c) In the reaction of but-1-yne with hydrogen, but-1-ene is formed.

Explain why but-1-ene has no geometric isomers. **1**

4. (continued)

(d) The equation for the hydrogenation of but-2-yne is shown.

$$C_4H_6(\ell) + H_2(g) \rightarrow C_4H_8(g)$$

Substance	*Standard free energy of formation, $\Delta G°_f$* (kJ mol^{-1})	*Standard enthalpy of formation, $\Delta H°_f$* (kJ mol^{-1})
$C_4H_6(\ell)$	185	119
$H_2(g)$	0	0
$C_4H_8(g)$	65·9	–6·99

(i) For the hydrogenation of but-2-yne, use the data in the table to calculate:

(A) the standard enthalpy change, $\Delta H°$, in kJ mol^{-1}; **1**

(B) the standard entropy change, $\Delta S°$. **3**

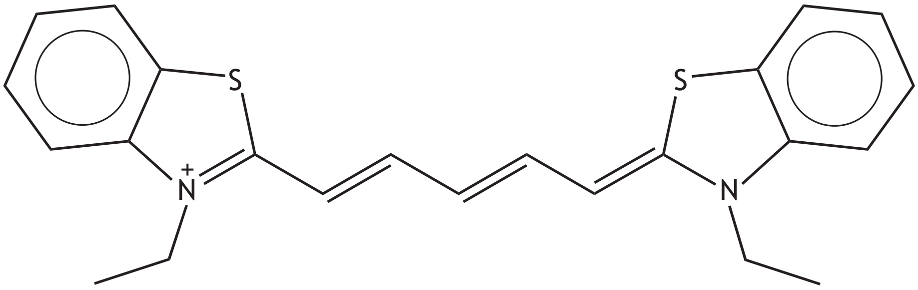
X713770114

4. (d) (continued)

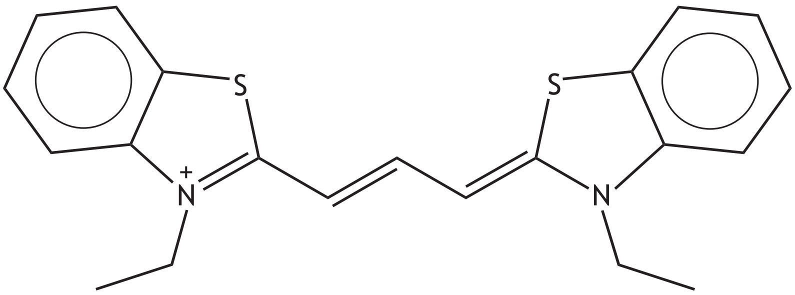
(ii) Calculate the temperature, in K, below which this reaction is feasible. **2**

5. Some dyes contain molecules that are coloured.

The structures of two different dye molecules are shown below.



blue-green



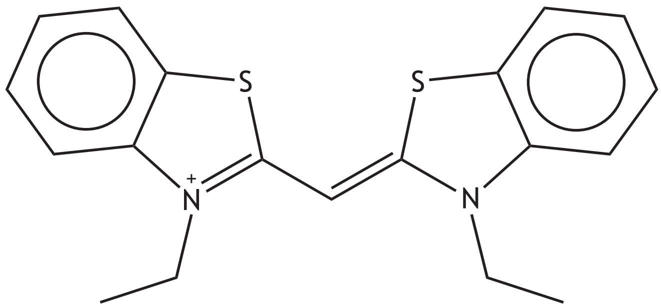
purple

(a) State the structural feature present that is responsible for the colour of these dye molecules. **1**

(b) Explain fully how colour arises in these dye molecules. **2**

5. (continued)

(c) A third dye molecule has the following structure.



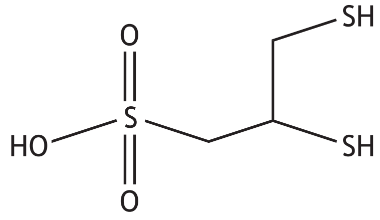
Explain fully why this dye molecule will absorb a shorter wavelength of light than the other two dye molecules. **2**

MARKS | DO NOT WRITE IN THIS MARGIN

6. Ligands can be used in medicine and in quantitative analysis.

(a) Explain how ligands bond to metal ions to form complexes. **1**

(b) DMPS is a ligand that can be used to treat mercury poisoning.



DMPS

(i) Write the molecular formula for DMPS. **1**

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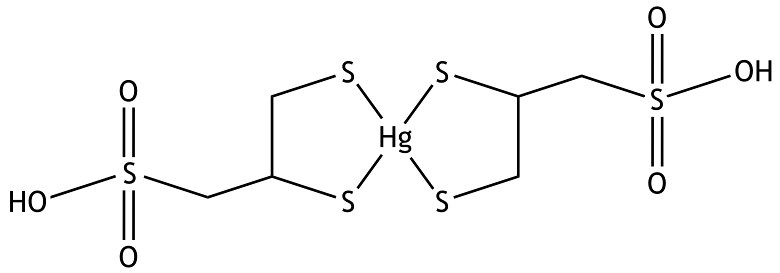
6. (b) (continued)

(ii) A possible structure for the mercury-DMPS complex is



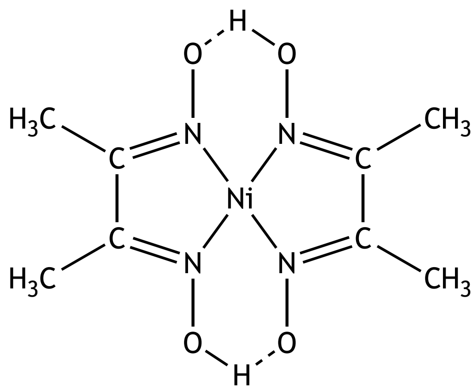
(A) State the term used to classify the DMPS ligand in this complex. **1**

(B) State the co-ordination number of mercury in this complex. **1**

6. (continued)

(c) Nisil is an alloy of nickel and silicon.

The mass of nickel in the Nisil alloy can be determined by quantitative analysis using a procedure in which the ligand dimethylglyoxime forms a solid complex with nickel ions. This complex is collected, dried and weighed.



nickel-dimethylglyoxime complex
GFM 288·7 g

(i) Name the type of quantitative analysis being carried out. **1**

(ii) It was found that 1·02 g of Nisil alloy formed 4·82 g of the complex.

Calculate the percentage by mass of nickel in the alloy. **2**

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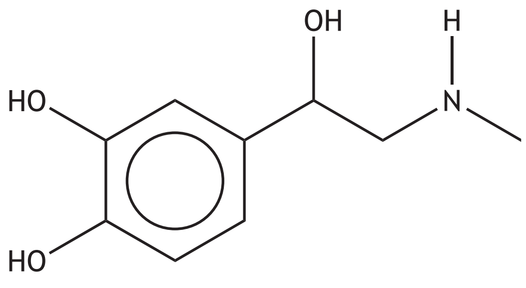
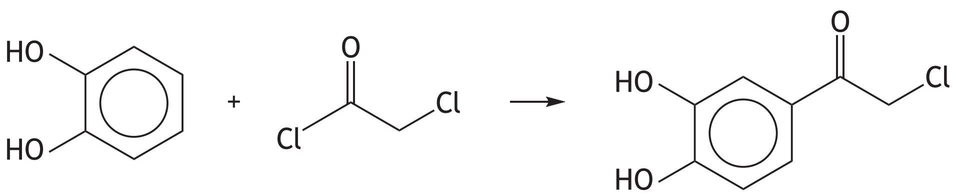
7. Adrenaline is a natural hormone produced in the body.



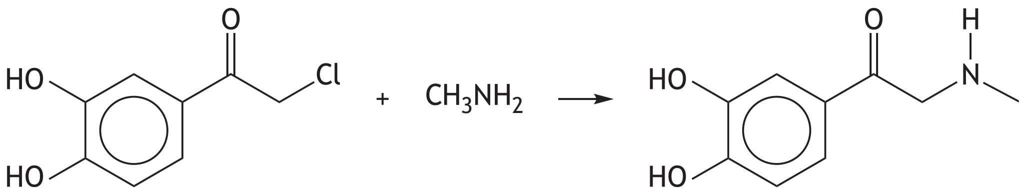
adrenaline

(a) Adrenaline can be artificially synthesised in the process shown below.

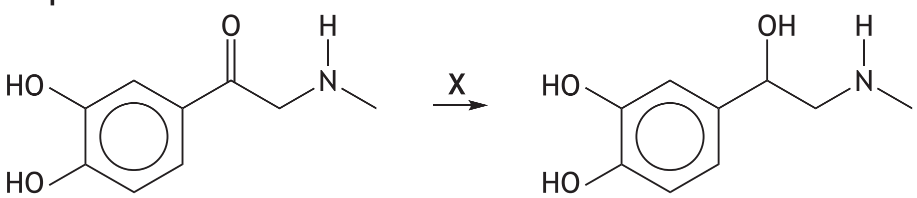
Step 1



Step 2



Step 3



7. (a) (continued)

(i) Suggest the type of chemical reaction taking place in **step 1**. **1**

(ii) The aromatic product formed in **step 2** contains an amine functional group.

State the type of amine formed. **1**

(iii) Name reagent **X** used in **step 3**. **1**

(iv) Identify the step(s) in which the product has a carbon chiral centre. **1**

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7. (continued)

(b) Adrenaline is used as a treatment for severe allergic reactions.

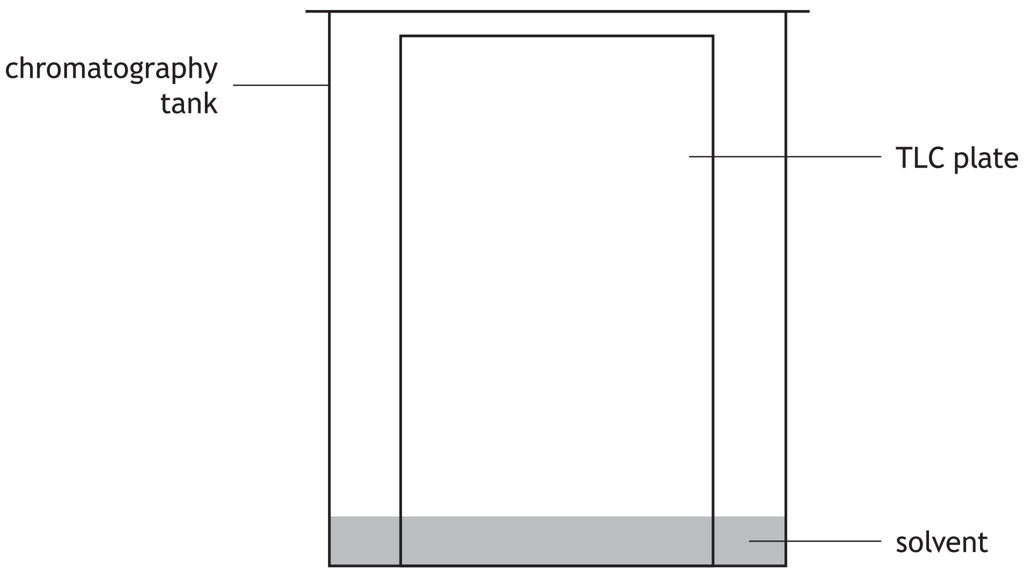
A typical dose contains 0·3 cm^3 of 500 ppm adrenaline solution.

Calculate the mass of adrenaline, in mg, delivered in one dose. **1**

(c) Adrenaline can be extracted from the leaves of the agnimantha plant. The adrenaline extracted can be identified using thin layer chromatography, TLC.

Complete and label the diagram to show how the TLC should be set up to compare the extracted adrenaline with a sample of pure adrenaline. **1**

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



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X713770125

8. Ethanol biofuel can be made from corn starch. The flow diagram shows the steps involved in the production of ethanol biofuel.

corn starch in water

↓ **Step 1** Hydrolysis and fermentation

13% ethanol solution

↓ **Step 2** Distillation

96% ethanol solution

↓ **Step 3** Pass through a molecular sieve

pure ethanol biofuel

(a) **Step 1** produces a solution with a concentration of 13% ethanol by volume. This can be checked by measuring the density of the solution and comparing it to a calculated value. The density of the solution can be calculated using the following expression.

$$d = \frac{m_1 + m_2}{100}$$

d = density of solution, in $g\,cm^{-3}$
m_1 = mass of ethanol, in g, in 100 cm^3 of solution
m_2 = mass of water, in g, in 100 cm^3 of solution

Mass of 1 cm^3 of ethanol = 0·79 g   Mass of 1 cm^3 of water = 1·00 g

Calculate the density of the ethanol solution, in $g\,cm^{-3}$, formed in **step 1**. **2**

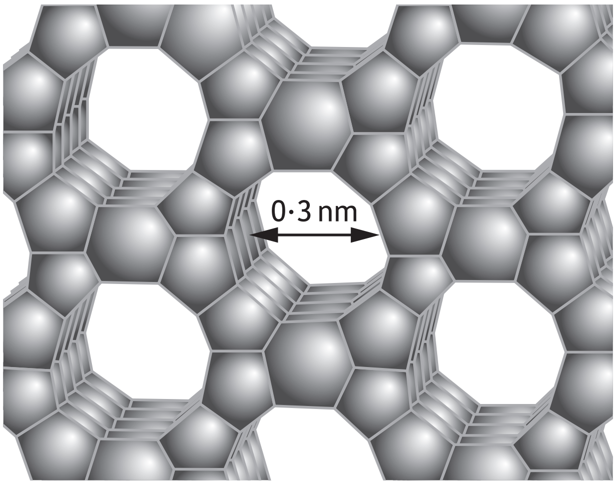
8. (continued)

(b) In **step 2**, 96% ethanol solution is produced by distillation.

Suggest why pure ethanol biofuel cannot be obtained from an ethanol/water mixture by distillation alone. **1**

(c) **Step 3** uses a molecular sieve to remove water from the 96% ethanol solution.

Part of the structure of a molecular sieve is shown.



Suggest how this molecular sieve could remove the water. **1**

8. (continued)

(d) Ethanol can also be prepared by a nucleophilic substitution reaction.

Using your knowledge of chemistry, discuss the role of nucleophilic substitution reactions in the preparation of other chemicals. **3**

[Turn over for next question

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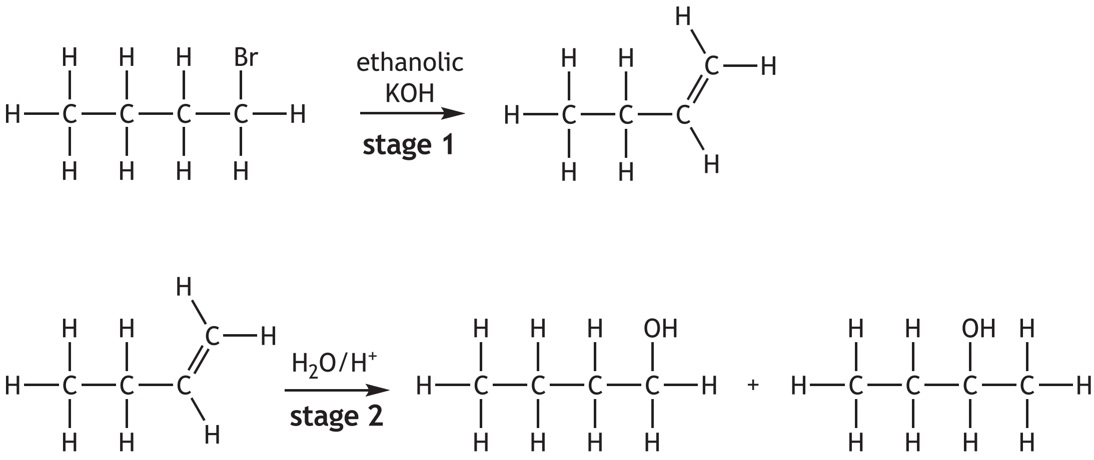
X713770129

9. A mixture of butan-1-ol and butan-2-ol can be synthesised from 1-bromobutane in a two-stage process.

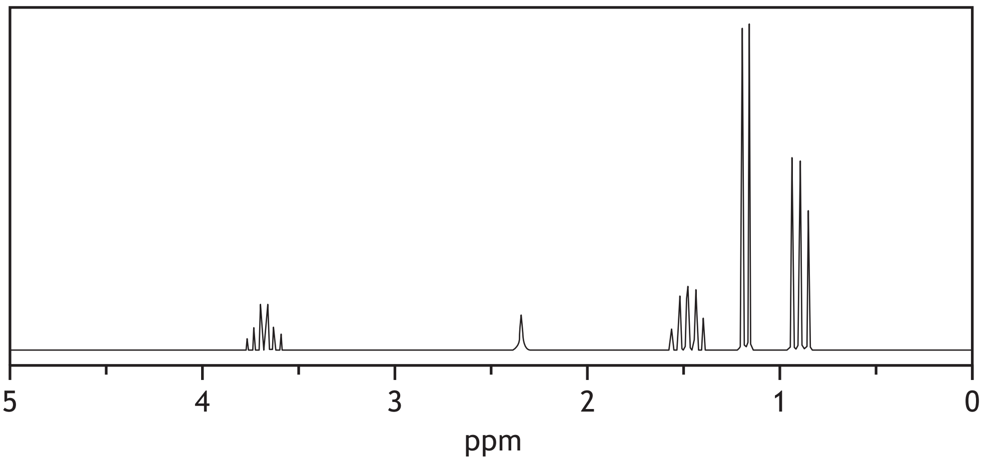


(a) Name the type of chemical reaction taking place in **stage 1**. 1

(b) Using structural formulae and curly arrow notation, outline a possible mechanism for the production of butan-2-ol in **stage 2**. 3

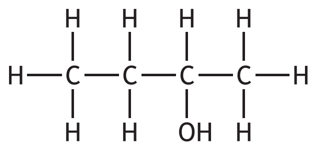
9. (continued)

(c) The high-resolution proton NMR spectrum for butan-2-ol is shown.



Circle the hydrogen atom(s) on the structure below responsible for the multiplet at 3·7 ppm. **1**

(An additional structure, if required, can be found on *page 36*).



9. (continued)

(d) Butan-1-ol can also be synthesised from 1-bromobutane by a different type of chemical reaction.

An experiment was carried out to determine the kinetics for the reaction. Under certain conditions, the following results were obtained.

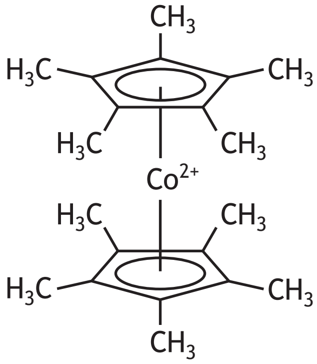
$[C_4H_9Br]$ (mol l^{-1})	$[OH^-]$ (mol l^{-1})	*Initial rate* (mol l^{-1} s^{-1})
0·25	0·10	$3·3 \times 10^{-6}$
0·50	0·10	$6·6 \times 10^{-6}$

(i) The reaction is first order with respect to both reactants.

Write the overall rate equation for the reaction. **1**

(ii) Calculate the value for the rate constant, *k*, including the appropriate units. **2**

10. Decamethylcobaltocene is a powerful reducing agent.



decamethylcobaltocene

(a) The ligand in decamethylcobaltocene has an aromatic ring.

State the feature that provides stability to aromatic rings. **1**

(b) Write the electronic configuration, in terms of s, p and d orbitals, for Co^{2+} in this complex ion. **1**

10. (continued)

(c) Decamethylcobaltocene can be dissolved in petroleum ether to produce a coloured solution. The concentration of this solution can be determined using colorimetry.

(i) (A) The first stage is to prepare a calibration graph.

Describe fully the procedure required to obtain results that would allow a calibration graph to be drawn. **2**

(B) The second stage is to determine the concentration of a sample of the decamethylcobaltocene solution.

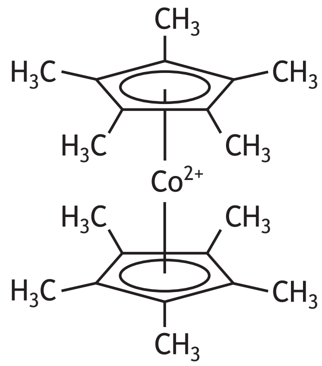
Describe how this would be carried out. **1**

(ii) Name the compound produced when decamethylcobaltocene solution reduces propanal. **1**

10. (continued)

(d) Decamethylcobaltocene oxidises easily creating impurities in the sample.

The purity of decamethylcobaltocene can be checked using low-resolution ^{1}H NMR.

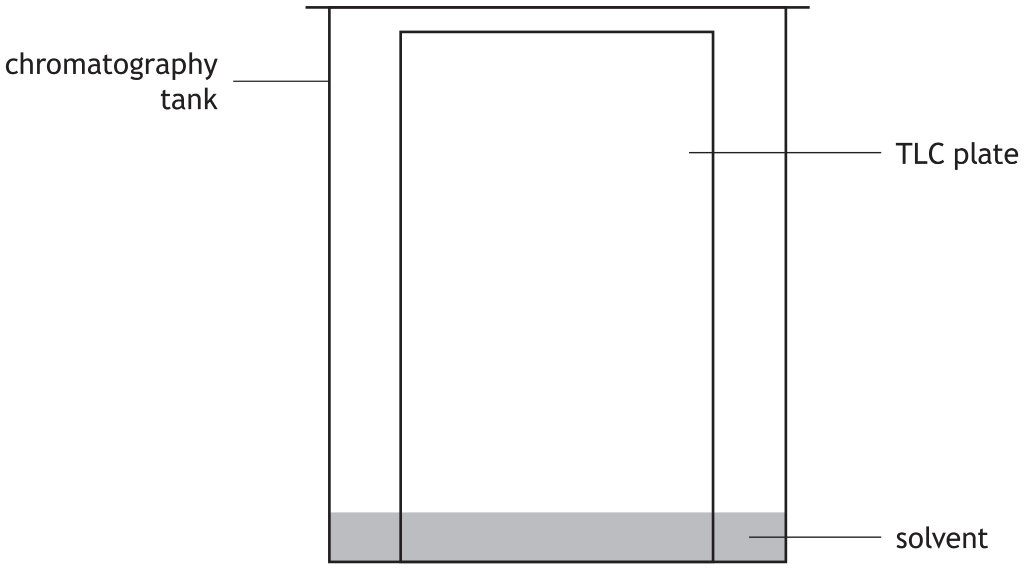


decamethylcobaltocene

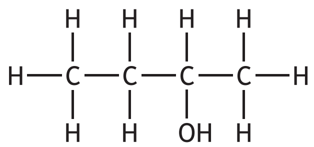
Predict the number of peaks that would be observed in a low-resolution ^{1}H NMR spectrum of a pure sample of decamethylcobaltocene. **1**

[END OF QUESTION PAPER]

ADDITIONAL DIAGRAM FOR USE IN QUESTION 7 (c)



ADDITIONAL STRUCTURE FOR USE IN QUESTION 9 (c)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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