Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

3721111250 4

CHEMISTRY **9701/21**

Paper 2 AS Level Structured Questions **May/June 2016**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **12** printed pages.

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Answer **all** the questions in the spaces provided.

1 **(a)** Complete the table to show the composition and identity of some atoms and ions.

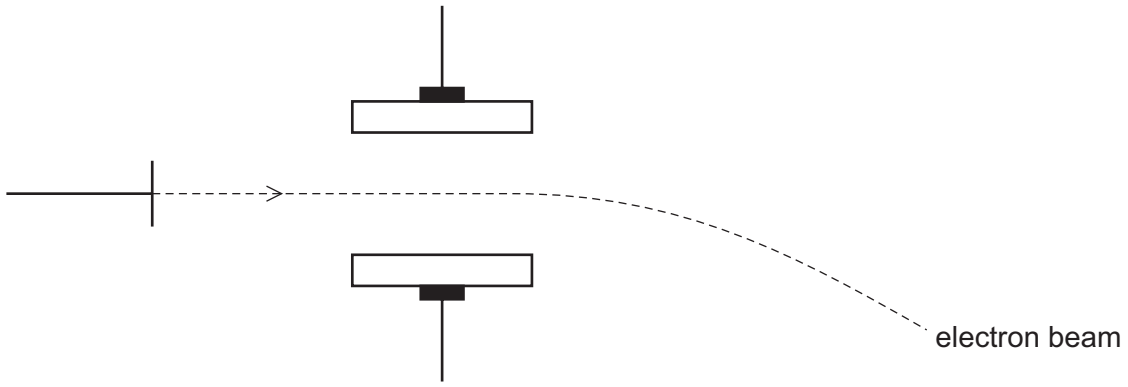
name of element	nucleon number	atomic number	number of protons	number of neutrons	number of electrons	overall charge
lithium	6	3	.....	.....	.....	+1
oxygen	.....	.....	.....	9	10	.....
.....	54	26	26	.....	24	.....
.....	.....	.....	17	18	.....	0

[4]

(b) Beams of protons, neutrons and electrons behave differently in an electric field due to their differing properties.

The diagram shows the path of a beam of electrons in an electric field.

Add and label lines to represent the paths of beams of protons and neutrons in the same field.



[3]

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(c) The fifth to eighth ionisation energies of three elements in the third period of the Periodic Table are given. The symbols used for reference are **not** the actual symbols of the elements.

	ionisation energies, kJ mol^{-1}			
	fifth	sixth	seventh	eighth
X	6274	21 269	25 398	29 855
Y	7012	8496	27 107	31 671
Z	6542	9362	11 018	33 606

(i) State and explain the group number of element **Y**.

group number .....

explanation .....

.....

[1]

(ii) State and explain the general trend in **first** ionisation energies across the third period.

.....

.....

..... [2]

(iii) Explain why the **first** ionisation energy of element **Y** is less than that of element **X**.

.....

.....

.....

..... [2]

(iv) Complete the electronic configuration of element **Z**.

1s^2 ..... [1]

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[Turn over

(d) A sample of strontium exists as a mixture of four isotopes. Information about three of these isotopes is given in the table.

mass number	86	87	88
abundance	9.86%	7.00%	82.58%

(i) Calculate the abundance of the fourth isotope.

abundance = ... % [1]

(ii) The relative atomic mass of this sample of strontium is 87.71.

Calculate the mass number of the fourth isotope.

mass number = ... [2]

[Total: 16]

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2 **D**, **E**, **F**, and **G** are four consecutive elements in the **fourth** period of the Periodic Table. (The letters are **not** the actual symbols of the elements.)

D is a soft, silvery metal with a melting point just above room temperature. Its amphoteric oxide, $\mathbf{D}_2O_3$, has a melting point of 1900 °C and can be formed by heating **D** in oxygen.

G is a solid that can exist as several different allotropes, most of which contain $\mathbf{G}_8$ molecules. **G** burns in air to form $\mathbf{G}O_2$ which dissolves in water to form an acidic solution. This solution reacts with sodium hydroxide to form the salt $Na_2\mathbf{G}O_3$.

(a) Suggest the identities of **D** and **G**.

D ..... **G** .....
[1]

(b) Write equations for the reactions of $\mathbf{D}_2O_3$ with

(i) hydrochloric acid,

..... [2]

(ii) sodium hydroxide.

..... [2]

(c) Suggest the type of bonding and structure in $\mathbf{D}_2O_3$.

..... [1]

(d) Write an equation for the formation of an acidic solution when $\mathbf{G}O_2$ dissolves in water.

..... [1]

[Total: 7]

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[Turn over

3 The elements in Group 2, and their compounds, show many similarities and trends in their properties.

(a) Magnesium, calcium, strontium and barium all react with cold water.

(i) Describe what you would **see** when some calcium is added to cold water.

.....

.....

..... [3]

(ii) Write an equation for the reaction taking place in **(i)**.

..... [1]

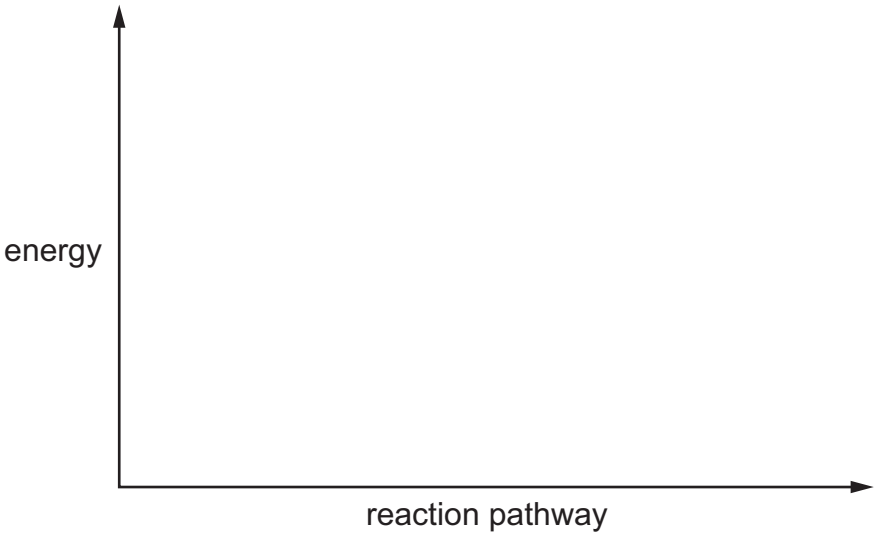
(iii) Describe how the reaction of barium with cold water would differ from the reaction of calcium in **(i)** in terms of what you would **see**.

.....

..... [1]

(b) Magnesium oxide can be formed by the reaction of magnesium and oxygen in the air.

(i) Draw a **fully labelled** reaction pathway diagram for the reaction between magnesium and oxygen.



[2]

(ii) Explain why there is no visible reaction when a piece of magnesium ribbon is exposed to the air.

.....

.....

..... [2]

(iii) Magnesium oxide is used to manufacture heat-resistant bricks for furnace linings in the steel-making industry.

State and explain the property of magnesium oxide that makes it suitable for this use.

.....

.....

.....

..... [2]

(iv) Suggest a reason why magnesium oxide cannot be used as a lining for any furnaces containing acidic materials.

.....

..... [1]

(c) The nitrates and carbonates of the Group 2 elements, from magnesium to barium, decompose when heated.

(i) State the trend in the temperature of thermal decomposition of these Group 2 nitrates and carbonates.

.....

..... [1]

(ii) Give the equation for the thermal decomposition of magnesium carbonate.

..... [1]

(iii) Give the equation for the thermal decomposition of calcium nitrate.

..... [1]

[Total: 15]

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[Turn over

4 This question is about molecules with molecular formula C_4H_8.

(a) Give the structures of a pair of **positional** isomers with the formula C_4H_8.

[1]

(b) Give the structures of a pair of **chain** isomers with the formula C_4H_8, that do **not** exhibit stereoisomerism.

[1]

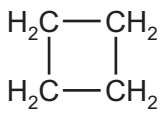
(c) Give the structures and full names of a pair of **stereoisomers** with the formula C_4H_8.

....

[2]

(d) The structure of a molecule, **A**, of formula C_4H_8 is shown.

Draw a functional group isomer of molecule **A** in box **B**. Explain how molecules **A** and **B** could be distinguished by a chemical test.



A **B**

.....

.....

..... [3]

[Total: 7]

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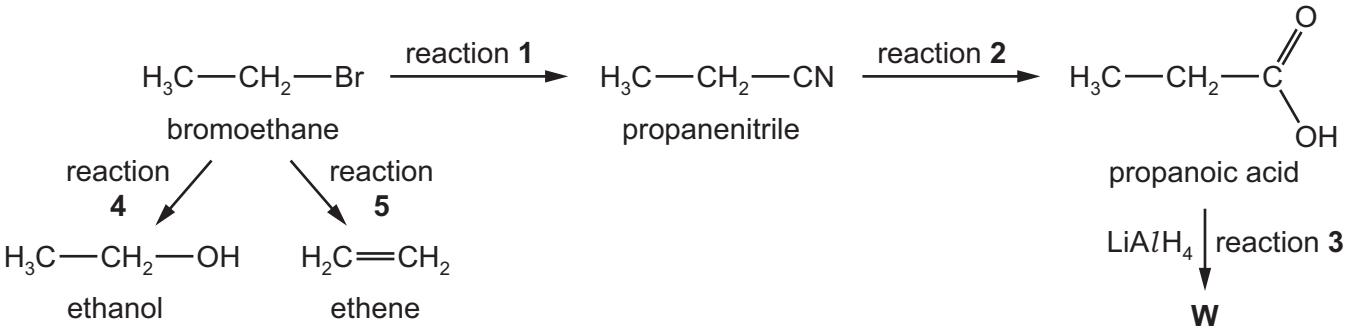
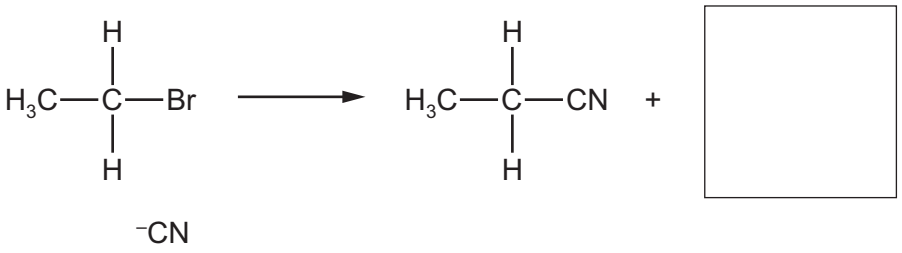
Question 5 starts on the next page.

5 A reaction sequence is shown.



(a) Complete the diagram to show the mechanism of reaction **1**. Include all necessary charges, partial charges, lone pairs and curly arrows.

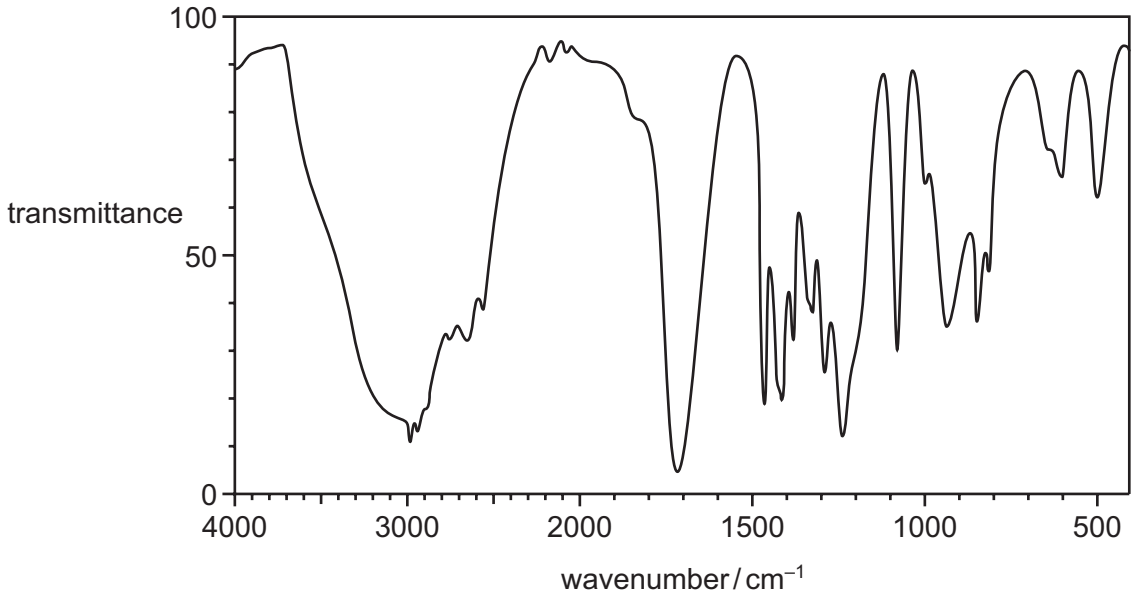


[2]

(b) (i) Give the name of the type of reaction involved in reaction **3**.

..... [1]

The infra-red spectrum of the propanoic acid produced by reaction **2** is shown.



(ii) Describe and explain the main difference between the infra-red spectrum of **W** and that of propanoic acid.

.....

..... [2]

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(c) (i) Reactions **4** and **5** use the same reagent.

Give the reagent and conditions needed for reaction **4**.

reagent .....

conditions ..... [2]

(ii) Give the conditions needed for reaction **5**.

..... [1]

(d) Under appropriate conditions, ethanol and propanoic acid undergo a condensation reaction.

(i) State the condition necessary for the reaction.

..... [1]

(ii) Draw the skeletal formula of the organic product of this reaction.

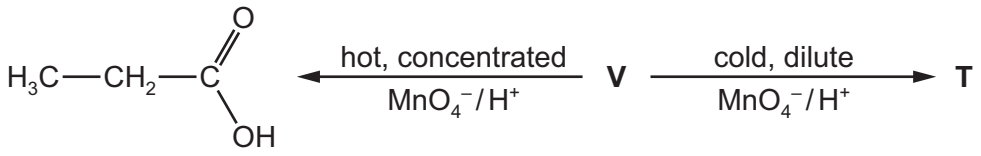
[1]

(iii) Name the organic product of this reaction.

..... [1]

Question 5 continues over the page.

(e) **V** reacts with acidified manganate(VII) ions in two different ways depending on the conditions, as shown in the reaction sequence below.



propanoic acid

V decolourises bromine water.

When the acidified manganate(VII) is hot and concentrated, propanoic acid is the only organic product.

When the acidified manganate(VII) is cold and dilute, the organic product is **T** which has two chiral centres.

(i) Give the structural formulae of **V** and **T**.

V ..... **T** .....

[2]

(ii) Identify the types of stereoisomerism shown by **V** and **T**.

V ..... **T** .....

[2]

[Total: 15]

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