Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

2293807595

CHEMISTRY **9701/21**

Paper 2 AS Level Structured Questions **October/November 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 **10** printed pages and **2** blank pages.

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

1 A 0.17 g sample of a Group 14 chloride, **X**Cl_4, reacted with water to produce an oxide, **X**O_2, and HCl.

equation 1 $\quad$ **X**Cl_4(s) + $2H_2O$(l) $\rightarrow$ **X**O_2(s) + 4HCl(aq)

The HCl produced was absorbed in 100 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution (an excess).

In a titration, the unreacted sodium hydroxide solution required 30.0 cm^3 of 0.20 mol dm^{-3} hydrochloric acid for complete neutralisation.

(a) Calculate the amount, in moles, of hydrochloric acid used in the titration to neutralise the unreacted sodium hydroxide solution.

amount = ... mol [1]

(b) Write the equation for the reaction between hydrochloric acid and sodium hydroxide.

..... [1]

(c) Calculate the amount, in moles, of sodium hydroxide neutralised in the titration.

amount = ... mol [1]

(d) Calculate the amount, in moles, of sodium hydroxide that reacted with the HCl produced by the reaction in equation 1.

amount = ... mol [1]

(e) Calculate the amount, in moles, of HCl produced by the reaction in equation 1.

amount = ... mol [1]

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(f) Calculate the amount, in moles, of **X**Cl_4 in the original 0.17 g sample.

amount = ... mol [1]

(g) Calculate the molecular mass, M_r, of **X**Cl_4.

M_r = ... [1]

(h) Calculate the relative atomic mass, A_r, of **X** and suggest its identity.

A_r of **X** = ...

identity of **X** .....
[2]

[Total: 9]

2 For many compounds the enthalpy change of formation cannot be calculated directly. An indirect method based on enthalpy changes of combustion can be used.

The enthalpy change of combustion can be found by a calorimetry experiment in which the heat energy given off during combustion is used to heat a known mass of water and the temperature change recorded.

(a) (i) Explain the meaning of the term *standard enthalpy change of combustion*.

.....

.....

..... [3]

(ii) Write the equation for the complete combustion of ethanol, C_2H_5OH.

..... [1]

(b) In an experiment to determine the enthalpy change of combustion of ethanol, 0.23 g of ethanol was burned and the heat given off raised the temperature of 100 g of water by 16.3 °C.

(i) Calculate the heat energy change, q, during the combustion of 0.23 g of ethanol.

q = ... J [1]

(ii) Calculate the enthalpy change on burning 1 mole of ethanol. Include a sign in your answer.

ΔH = ... kJ mol^{-1} [1]

(iii) Suggest **two** reasons why the value for the enthalpy change of combustion of ethanol determined by a simple laboratory calorimetry experiment is likely to be lower than the true value.

.....

.....

.....

..... [2]

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(c) The table gives some enthalpy change of combustion values.

substance	enthalpy change of combustion / kJ mol^{-1}
C(s)	–393.5
$H_2(g)$	–285.8
$C_3H_7OH(l)$	–2021.0

(i) Construct a labelled energy cycle to show how these values could be used to calculate the enthalpy change of formation of $C_3H_7OH(l)$, ΔH_f.

$$3C(s) + 4H_2(g) + \tfrac{1}{2}O_2(g) \xrightarrow{\Delta H_f} C_3H_7OH(l)$$

[3]

(ii) Calculate the enthalpy change of formation, ΔH_f, of $C_3H_7OH(l)$.

ΔH_f = ... kJ mol^{-1} [2]

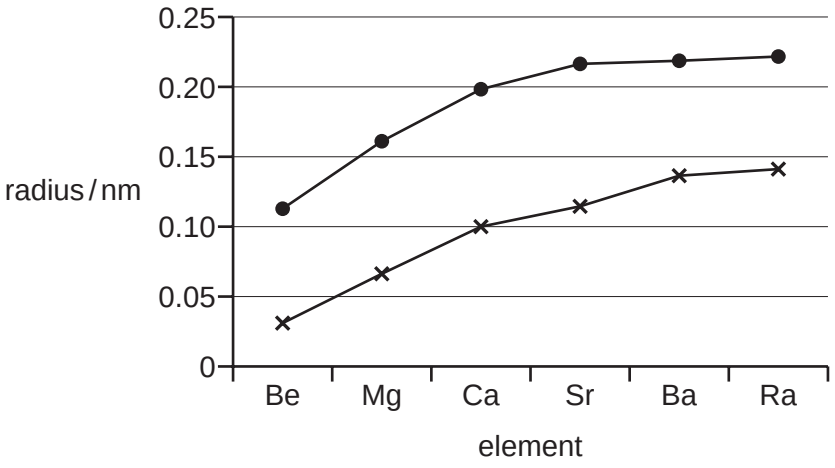
[Total: 13]

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[Turn over

3 The elements in Group 2 and their compounds show various trends in their physical and chemical properties.

(a) The graph below shows the radius values of the atoms and 2+ ions of the elements in Group 2.



(i) Explain why both lines show a steady increase in the values of the radii down the group.

.....

.....

..... [2]

(ii) State and explain which line represents the atomic radii and which represents the ionic radii.

.....

.....

..... [2]

(b) **L** is a salt of a Group 2 element **M**.
When **L** is heated strongly a brown gas is observed and a white solid remains.

The white solid dissolves in water to form a colourless solution of the metal hydroxide **M**$(OH)_2$.

Addition of dilute sulfuric acid to this colourless solution produces a dense white precipitate.

(i) Identify the anion in salt **L**.

..... [1]

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(ii) Identify the element **M** and write an **ionic** equation for the formation of the white precipitate with sulfuric acid.

M = ...

equation .....
[1]

(iii) Give the formula of salt **L** and use it to write an equation for the thermal decomposition of salt **L**.

formula of salt **L** .....

equation .....
[2]

(c) Calcium carbonate and calcium hydroxide can both be used in agriculture to neutralise acidic soils.

(i) Write **ionic** equations for the neutralisation of acid by each of calcium hydroxide and calcium carbonate.

calcium hydroxide .....

calcium carbonate .....
[2]

(ii) Suggest and explain why calcium carbonate is a better choice than calcium hydroxide for this purpose in areas of high rainfall.

.....

.....

..... [2]

(d) Magnesium reacts with both cold water and steam.

Give the formula of the magnesium-containing product of each of these reactions.

with cold water .....

with steam .....
[2]

[Total: 14]

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[Turn over

4 In each section of this question an organic compound is shown. For each compound give its name and answer the questions about it.

(a) $CH_3CH_2CH(CH_3)CH=CHCH_3$

(i) name ..... [1]

(ii) This compound shows stereoisomerism.

Define *stereoisomerism.*

.....

.....

..... [1]

(iii) State and explain how many stereoisomers of this structure there are.

.....

.....

.....

.....

.....

..... [4]

(b) $(CH_3)_2C=C(CH_3)_2$

(i) name ..... [1]

(ii) Draw the **skeletal** formula of the organic product of the reaction of this compound with cold, dilute, acidified manganate(VII) ions.

[1]

(iii) Name the organic product of the reaction of this compound with hot, concentrated, acidified manganate(VII) ions.

..... [1]

(iv) Draw the structure of part of a molecule of the addition polymer formed from this compound, showing exactly **three** repeat units.

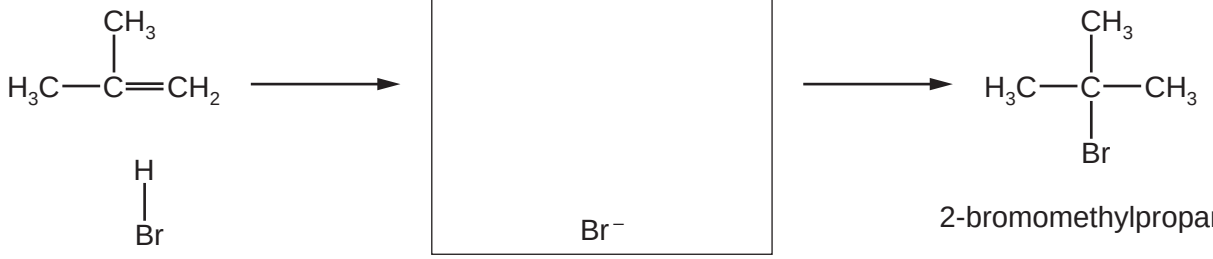
[1]

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(c) $(CH_3)_2C=CH_2$

(i) name ..... [1]

(ii) Complete the mechanism for the reaction of this compound with hydrogen bromide. Include all necessary curly arrows, lone pairs, charges and partial charges.



2-bromomethylpropane

[4]

(iii) Explain fully why 2-bromomethylpropane is the major product of this reaction while only relatively small amounts of 1-bromomethylpropane are produced.

.....

.....

.....

.....

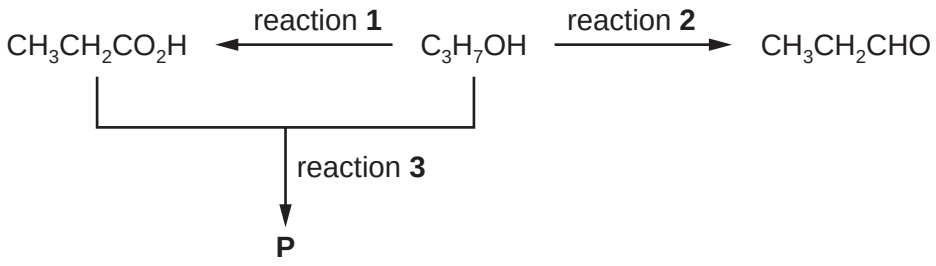
.....

.....

..... [3]

[Total: 18]

5 A sequence of reactions is shown starting with an alcohol, C_3H_7OH.



(a) Draw the skeletal formula of the alcohol C_3H_7OH.

[1]

(b) State the reagents and conditions needed for reaction **1**.

.....

..... [2]

(c) State the reagents and conditions needed for reaction **2**.

.....

..... [2]

(d) Name **P**, the organic product of reaction **3**.

..... [1]

[Total: 6]

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