Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

7040470612

CHEMISTRY **9701/21**

Paper 2 AS Level Structured Questions **May/June 2017**

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 Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds.

(a) Define the term *relative molecular mass*.

.....

.....

.....

..... [2]

(b) **T** is an alcohol, C_xH_yO. A gaseous sample of **T** occupied a volume of 20 cm^3 at 120 °C and 100 kPa.

The sample was completely burned in 200 cm^3 of oxygen (an excess). The final volume, measured under the same conditions as the gaseous sample, was 250 cm^3.

Under these conditions, all water present is vaporised. Removal of the water vapour from the gaseous mixture decreased the volume to 170 cm^3.

Treating the remaining gaseous mixture with concentrated alkali, to absorb carbon dioxide, decreased the volume to 110 cm^3.

The equation for the complete combustion of **T** can be represented as shown.

$$C_xH_yO + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(i) Use the data given to calculate the value of *x*.

x = ... [1]

(ii) Use the data given to calculate the value of *y*.

y = ... [1]

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If you were unable to calculate values for x and y then use $x = 4$ and $y = 10$ for the remaining parts of this question. These are **not** the correct values.

(iii) Complete the equation for the complete combustion of the alcohol, **T**.

..... + ...O_2 → .....CO_2 + ...H_2O

[1]

(iv) Give the skeletal formulae for two possible structures of **T**.

Name each alcohol.

.....	.....

[2]

(v) Use the general gas equation to calculate the mass of **T** present in the original 20 cm^3 gaseous sample, which was measured at 120 °C and 100 kPa.

Give your answer to **three** significant figures. Show your working.

mass = ... g [3]

[Total: 10]

2 Structure and bonding can be used to explain many of the properties of substances.

(a) Copper, ice, silicon(IV) oxide, iodine and sodium chloride are all crystalline solids.

Complete the table with:
- the name of a type of bonding found in each crystalline solid,
- the type of lattice structure for each crystalline solid.

crystalline solid	type of bonding	type of lattice structure
copper		
ice		
silicon(IV) oxide		
iodine		
sodium chloride		

[5]

(b) (i) Name the strongest type of intermolecular force in ice.

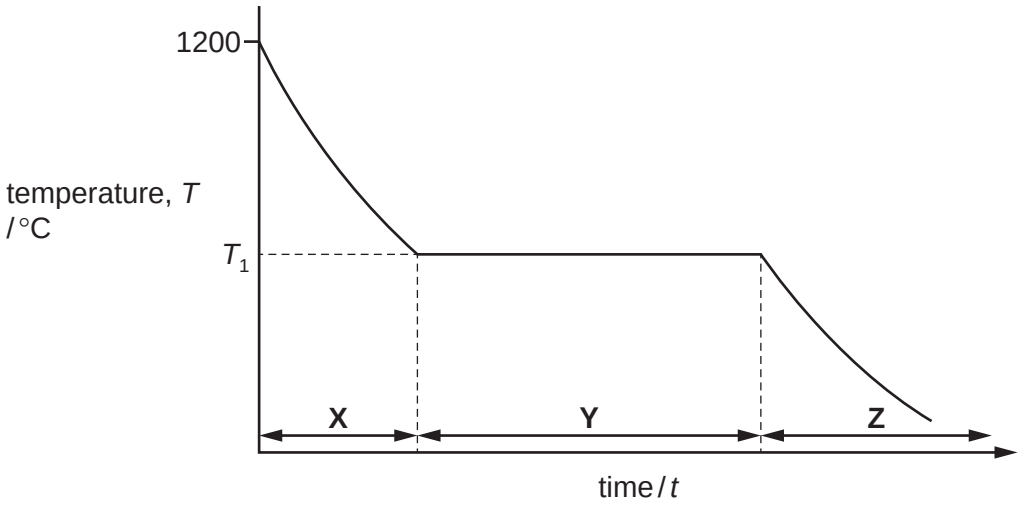
..... [1]

(ii) Draw a fully labelled diagram of two water molecules in ice, showing the force in **(i)** and how it forms.

[3]

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(c) The graph represents how the temperature of a sample of copper (melting point 1085 °C) changes as it is gradually cooled from 1200 °C.



(i) Identify the state(s) of matter present during each stage of the process shown in the graph.

X .....

Y .....

Z .....
[2]

(ii) State what is happening to the energy and movement of the particles in the copper during stage **X**.

.....

.....

..... [2]

(iii) Explain why the temperature stays constant at T_1 during stage **Y**.

.....

.....

.....

..... [2]

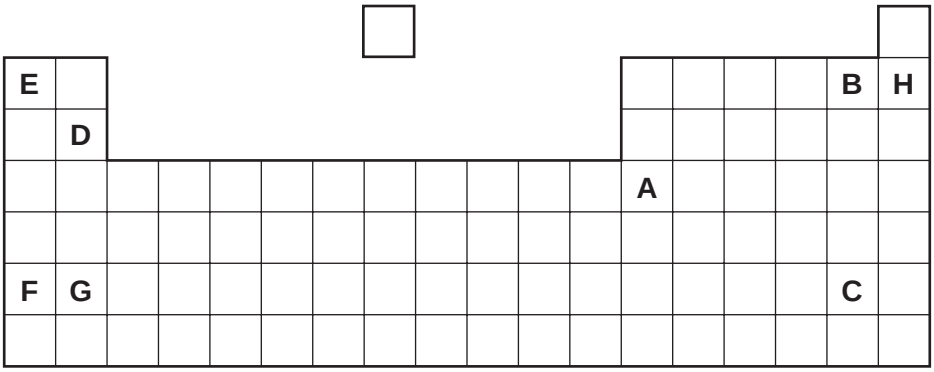
[Total: 15]

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[Turn over

3 The properties of elements and their compounds show similarities, differences and trends depending on the positions of the elements in the Periodic Table.

(a) The positions of some elements are indicated. The letters used are **not** the symbols of the elements.



From the elements labelled, give the letter for;

(i) the element that forms an amphoteric oxide, ... [1]

(ii) the element with the highest first ionisation energy, ... [1]

(iii) the element that forms a soluble hydroxide and an insoluble sulfate, ... [1]

(iv) the most volatile element in a group that contains elements in all three states of matter at room temperature and pressure,

..... [1]

(v) the element that forms the largest cation. ..... [1]

(b) The elements in Group 2 all react with oxygen and with water.

(i) State and explain the conditions needed for magnesium to react with oxygen.

.....

..... [2]

(ii) State what would be seen during the reaction in **(b)(i)**.

.....

..... [1]

(iii) Write an equation for the reaction of magnesium with cold water.
Include state symbols.

..... [2]

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(c) The carbonates and nitrates of the elements in Group 2 can all be decomposed by heating.

(i) Write an equation for the thermal decomposition of magnesium nitrate.

..... [1]

(ii) The thermal decomposition of calcium carbonate forms a solid product that is industrially important. This solid product reacts with water to form a compound commonly known as slaked lime.

Write equations for the thermal decomposition of calcium carbonate and the reaction of the solid product to form slaked lime.

thermal decomposition .....

formation of slaked lime .....
[2]

(d) Calcium carbonate and calcium hydroxide both have an important use in agriculture.

(i) Describe this use and explain what makes these two compounds suitable for it.

.....

.....

..... [2]

(ii) Write an ionic equation to illustrate this use of calcium carbonate.

..... [1]

[Total: 16]

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[Turn over

4 **P**, **Q** and **R** all have the molecular formula C_3H_6O. They are all structural isomers of each other.

P and **Q** each contain an oxygen atom bonded directly to a carbon atom that is sp^2 hybridised. **R** contains an oxygen atom bonded directly to a carbon atom that is sp^3 hybridised.

(a) **(i)** Explain the meaning of the term *structural isomers*.

.....

.....

.....

..... [2]

(ii) Explain how sp^2 and sp^3 hybridisation can occur in carbon atoms.

sp^2 hybridisation .....

.....

sp^3 hybridisation .....

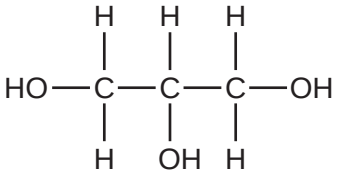
.....
[2]

(iii) State the bond angles normally associated with each type of hybridisation in carbon atoms.

sp^2 .....

sp^3 .....
[2]

(b) **R** contains two different functional groups, one of which is an alkene group.
R reacts with cold, dilute, acidified manganate(VII) ions to form propane-1,2,3-triol.



propane-1,2,3-triol

(i) Give the displayed formula of **R**.

[1]

(ii) State the type of reaction and what you would observe when **R** reacts with bromine water.

.....

..... [2]

(iii) Draw the structure of the product formed when **R** reacts with bromine water.

[1]

(iv) Identify the gaseous product formed when **R** reacts with hot, concentrated, acidified manganate(VII) ions.

..... [1]

(c) **P** and **Q** (C_3H_6O) both form an orange precipitate when reacted with 2,4-DNPH. Only **Q** produces a yellow precipitate when reacted with alkaline aqueous iodine.

(i) Name **P** and **Q**.

P .....

Q .....
[2]

(ii) Identify the yellow precipitate formed by the reaction of **Q** with alkaline aqueous iodine.

..... [1]

(d) **P** and **Q** each react with hydrogen cyanide to form a single product.
The product formed from **P** exists as a pair of optical isomers.
The product formed from **Q** does not exhibit optical isomerism.

(i) Explain the meaning of the term *optical isomers*.

.....

.....

.....

..... [2]

(ii) Ethanal, CH_3CHO, also reacts with hydrogen cyanide. The product of this reaction is $CH_3CH(OH)CN$.

Draw the mechanism of this reaction.
Include all necessary charges, dipoles, lone pairs and curly arrows.

[3]

[Total: 19]

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