Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6036196388

CHEMISTRY **9701/21**

Paper 2 AS Level Structured Questions **May/June 2019**

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)** Group 2 elements share common chemical properties.

(i) Calcium reacts in cold water more quickly than magnesium because more energy is required to remove the outer electrons in magnesium. This occurs even though calcium atoms have a greater nuclear charge.

Explain why more energy is required to remove the outer electrons in magnesium than in calcium.

.....

.....

..... [2]

(ii) 0.001 mol of strontium reacts with an excess of cold water. When the reaction is complete a colourless solution is seen.

Construct the equation for the reaction of strontium with cold water. Include state symbols.

..... [2]

(iii) 0.005 mol of calcium and 0.005 mol of strontium are added separately to two beakers. Each beaker contains 100 cm^3 of cold water.
At the end of each reaction a white solid and a colourless solution are seen in both beakers.

Predict which element, calcium or strontium, produces the more alkaline solution. Explain your answer.

.....

.....

..... [2]

(iv) Describe one observation when magnesium carbonate is added to excess dilute sulfuric acid.

.....

..... [1]

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(b) Element **X** is a metal. **X** reacts with oxygen to form a black solid oxide. The oxidation state of **X** in this oxide is +2. The carbonate of **X**, **X**CO_3, is a green solid. It decomposes on heating to form the oxide and a colourless gas.

(i) From the information given, state two similarities and one difference that metal **X** and its compounds have with Group 2 metals and their compounds.

similarity 1 .....

.....

similarity 2 .....

.....

difference 1 .....

.....

[3]

(ii) Write the formula of the oxide of **X**.

..... [1]

(iii) Write an equation for the reaction of **X**CO_3 when it is heated.

..... [1]

[Total: 12]

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[Turn over

2 Magnesium silicide, Mg_2Si, is a compound made by heating magnesium with sand.

(a) Draw a 'dot-and-cross' diagram to show the arrangement of outer electrons present in a formula unit of Mg_2Si. Assume magnesium silicide is an ionic compound.

[2]

(b) When solid Mg_2Si is added to water, silane gas, SiH_4, and a solution of magnesium hydroxide are produced.

Construct the equation for this reaction. Include state symbols.

..... [2]

(c) Suggest, with reference to structure and bonding, why SiH_4 is a gas at room temperature.

.....

.....

..... [2]

(d) The table shows the electronegativity values of carbon, hydrogen and silicon.

element	carbon	hydrogen	silicon
electronegativity	2.5	2.1	1.8

(i) C–H and Si–H bonds have weak dipoles.

Use the electronegativity values in the table to show the polarity of the C–H and Si–H bonds.

C—H Si—H

[2]

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(ii) Explain why methane, CH_4, has no overall dipole moment.

.....

.....

..... [2]

(e) SiH_4 reacts in air without heating but CH_4 must be ignited before combustion occurs.

$$SiH_4 + 2O_2 \rightarrow SiO_2 + 2H_2O$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Suggest, with reference to bond energies from the *Data Booklet*, why SiH_4 reacts in air without heating but CH_4 must be ignited.

.....

.....

..... [2]

(f) Silicon dioxide reacts with hot, concentrated sodium hydroxide.

(i) Identify the **two** products formed during this reaction.

.....

..... [2]

(ii) Describe the behaviour of the silicon dioxide during this reaction.

..... [1]

[Total: 15]

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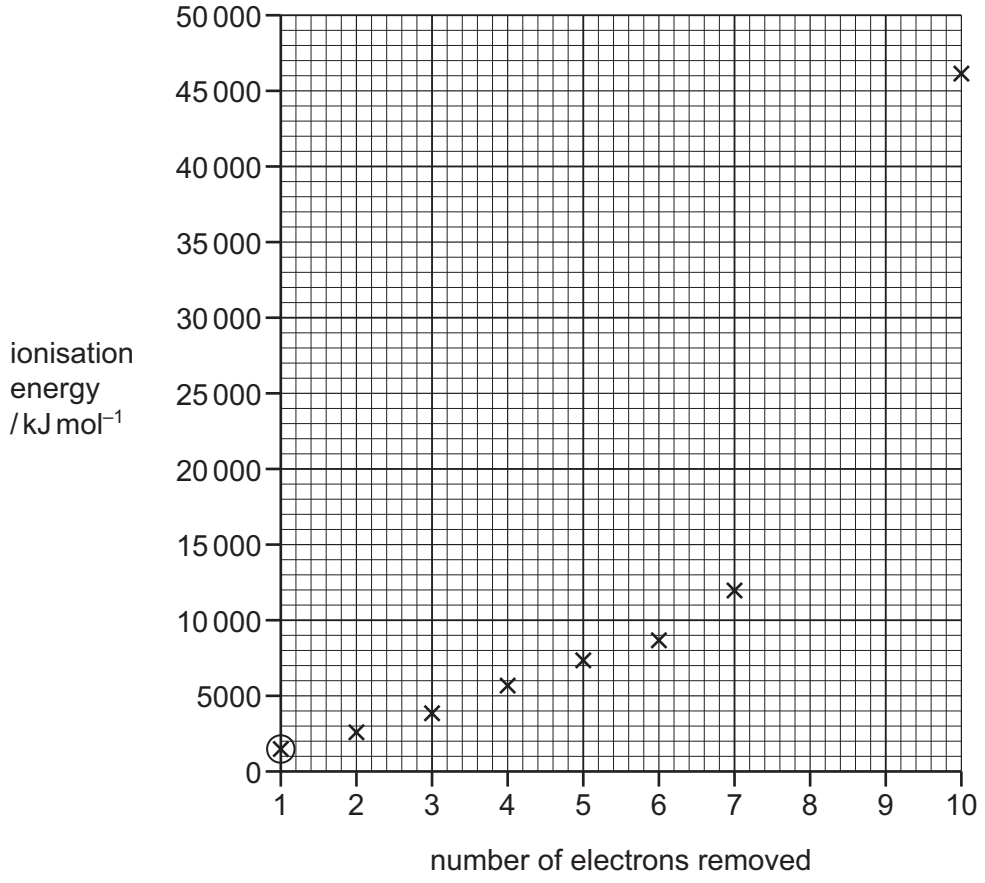
[Turn over

3 **(a)** Construct an equation for the **second** ionisation energy of argon.

..... [1]

(b) The graph shows successive ionisation energies for the element argon.

Complete the graph with predictions for the eighth and ninth ionisation energies of argon. Use a cross (×) for each data point. [2]



(c) The energy value required to remove the first electron from an atom of argon is circled on the graph.

Sketch the shape of the orbital that contains this electron.

[1]

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(d) Chlorine exists as a diatomic gas, Cl_2(g). A sample of Cl_2(g) was made during a chemical reaction. When measured at 404 kPa and 25 °C the sample occupied a volume of 20.0 cm^3.

(i) Calculate the mass, in grams, of Cl_2(g) formed.

For this calculation, assume that chlorine behaves as an ideal gas under these conditions.

mass of Cl_2(g) = ... g [3]

(ii) Calculate the number of chlorine atoms in this sample of Cl_2(g). You may find it helpful to use your answer to **(d)(i)**.

If you are unable to calculate an answer to **(d)(i)**, use 0.36 g of Cl_2. This is **not** the correct answer.

number of chlorine atoms = ... [2]

(iii) Cl_2(g) does **not** behave as an ideal gas under these conditions.

Explain why Cl_2(g) behaves even **less** ideally at:

- very high pressures

.....

.....

.....

- very low temperatures.

.....

.....

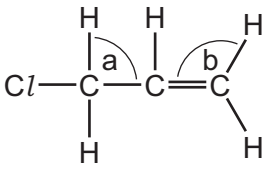
.....

[2]

[Total: 11]

4 The structure of compound **Y** is shown.

Y



(a) Give the systematic name for **Y**.

..... [1]

(b) Predict the values for the bond angles a and b shown in the diagram.

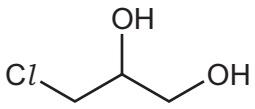
a .....

b .....

[2]

(c) When **Y** reacts with cold, dilute, acidified manganate(VII) ions, compound **Z** is produced.

Z



(i) State the molecular formula of **Z**.

..... [1]

(ii) Name the type of reaction occurring when **Y** is converted into **Z**.

..... [1]

(iii) Alcohols can be classified as primary, secondary or tertiary.

Identify with a tick (✓) the alcohol group(s) present in **Z**.

	alcohol group present in **Z**
primary	
secondary	
tertiary	

[1]

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(d) Samples of organic compounds, **A**, **B**, **C** and **D**, are placed in unlabelled bottles.

A	**B**	**C**	**D**
$CH_3CH_2COCH_3$	$CH_3(CH_2)_2CHO$	CH_3CH_2OH	CH_3CO_2H

(i) Identify all of the compound(s), **A**–**D**, that contain a carbonyl group.

..... [1]

(ii) **A**–**D** are reacted separately with the reagents given in the table.

Complete the table to:
- identify which of the compounds, **A**–**D**, reacts with the reagents
- give an appropriate observation when a reaction occurs.

reagent	compounds identified	observation when a reaction occurs
Tollens' reagent		
alkaline solution of iodine		
sodium metal		

[8]

[Total: 15]

5 Ethanal reacts with a mixture of HCN and NaCN to make 2-hydroxypropanenitrile, $CH_3CH(OH)CN$.

The reaction mechanism is nucleophilic addition.

(a) Explain the meaning of the term *nucleophile* and identify the species which acts as the nucleophile during this reaction.

.....

.....

species acting as nucleophile .....

[2]

(b) $CH_3CH(OH)CN$ exists as a pair of stereoisomers.

(i) Name the type of stereoisomerism shown by $CH_3CH(OH)CN$.

..... [1]

(ii) Draw three-dimensional diagrams of this pair of stereoisomers.

Indicate with an asterisk (*) the chiral centre on one of the structures drawn.

[3]

(c) Give the structure of the organic product of the reaction of $CH_3CH(OH)CN$ with dilute sulfuric acid.

..... [1]

[Total: 7]

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