OCR
Oxford Cambridge and RSA

# AS Level Chemistry A

## H032/02 Depth in chemistry

## Friday 10 June 2016 – Afternoon

### Time allowed: 1 hour 30 minutes

**You must have:**
- the Data Sheet for Chemistry A (sent with general stationery)

**You may use:**
- a scientific calculator

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| First name | | | | | | | | | |
| Last name | | | | | | | | | |
| Centre number | | | | | | Candidate number | | | | |

**INSTRUCTIONS**
- Use black ink. HB pencil may be used for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional answer space is required, you should use the lined page(s) at the end of the booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

**INFORMATION**
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **20** pages.

Answer **all** the questions.

**1** Group 2 elements are metals that react with oxygen and water.

**(a)** Magnesium is oxidised when it burns in oxygen to form an ionic compound.

**(i)** Write the electron configuration, in terms of sub-shells, of a magnesium atom.

..... **[1]**

**(ii)** Explain what happens when magnesium is oxidised in terms of electron transfer.

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..... **[1]**

**(b)** The trend in the first and second ionisation energies of Group 2 elements can be linked to the increase in chemical reactivity down the group.

The first and second ionisation energies of calcium and strontium are given in the table.

| Element | First ionisation energy / kJ mol$^{-1}$ | Second ionisation energy / kJ mol$^{-1}$ |
|---|---|---|
| Ca | 590 | 1145 |
| Sr | 550 | 1064 |

**(i)** Write an equation, including state symbols, to represent the **second** ionisation energy of strontium.

..... **[1]**

**(ii)** Explain why the first ionisation energy of strontium is less than the first ionisation energy of calcium.

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..... **[3]**

**(c)** A student reacts a Group 2 metal, M, with water.

$$M(s) + 2H_2O(l) \longrightarrow M(OH)_2(aq) + H_2(g)$$

The student measures the volume of hydrogen gas produced.

0.162 g of the metal produces 97.0 $cm^3$ of gas measured at room temperature and pressure.

**(i)** Draw a labelled diagram of the apparatus that can be used to carry out this experiment.

**[2]**

**(ii)** Identify the Group 2 metal, M.

Show your working.

Group 2 metal = ..... **[3]**

**(d)** The student plans to repeat the experiment using the same mass of a Group 2 metal from further down the group.

Predict whether the volume of hydrogen produced would be greater than, less than or the same as the volume in the first experiment.

Explain your answer.

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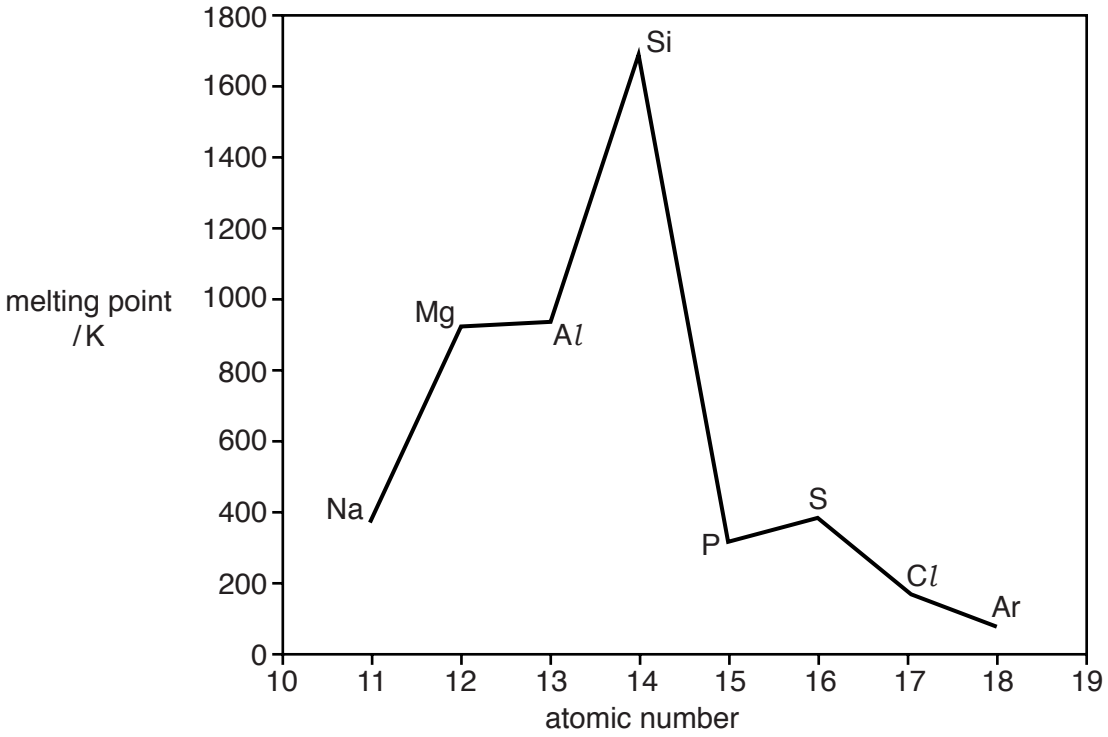
..... **[1]**

**2** The graph shows the melting points of the elements in Period 3 of the periodic table.




**(a)** Phosphorus and chlorine have simple molecular structures.
More information about phosphorus and chlorine is given in the table below.

| Element | Molecular formula |
|---|---|
| phosphorus | $P_4$ |
| chlorine | $Cl_2$ |

Explain the differences in the melting points of phosphorus and chlorine.

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..... **[3]**

**(b)** Magnesium and silicon have different types of giant structures.

Describe the bonding in magnesium and in silicon.

Include the names of the particles and describe the forces between the particles in the structures.

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..... **[4]**

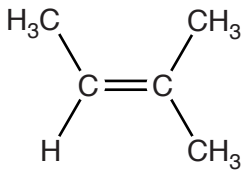
**(c)** Aluminium forms a sulfide, $Al_2S_3$.

$Al_2S_3$ reacts with water to form aluminium hydroxide and hydrogen sulfide, $H_2S$.

Write an equation for the reaction of $Al_2S_3$ with water.

..... **[1]**

**3** Compound **A** is an alkene.




compound **A**

**(a)** The C=C bond in a molecule of compound **A** has restricted rotation because it comprises a σ bond and a π bond.

**(i)** Describe **one** difference between the σ bond and the π bond.

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..... **[1]**

**(ii)** Explain why compound **A** does **not** have *E*/*Z* isomers.

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..... **[1]**

**(iii)** A structural isomer of compound **A** has *E*/*Z* isomers.

Draw the structure of the *Z* isomer and then name this isomer.

structure of *Z* isomer

name .....

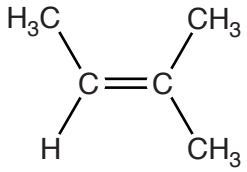
**[2]**

**(b)** Compound **A** can be made from alcohol **B** by heating with an acid catalyst.

Suggest **two** possible structures for alcohol **B**.

**[2]**

**(c)*** Compound **A** reacts with hydrogen bromide to form a mixture of two different organic products.




compound **A**

Give the structures of the **two** possible organic products of the reaction.

Outline the mechanism, using the 'curly arrow' model, for the formation of one of the organic products from compound **A**.

Explain which of the two organic products is more likely to be formed.

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..... **[6]**

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**Turn over for the next question**

**4** Nitrogen forms several different oxides.

$N_2O$ is a useful anaesthetic and NO has been linked to the depletion of ozone in the stratosphere.

**(a)** The standard enthalpy changes of formation of $N_2O$ and NO are given in the table.

| Compound | $\Delta_f H^\ominus$ / kJ mol$^{-1}$ |
|---|---|
| $N_2O$ (g) | + 82.0 |
| NO (g) | + 90.2 |

**(i)** Explain, in terms of bond breaking and bond making, why the enthalpy change of formation of NO is endothermic.

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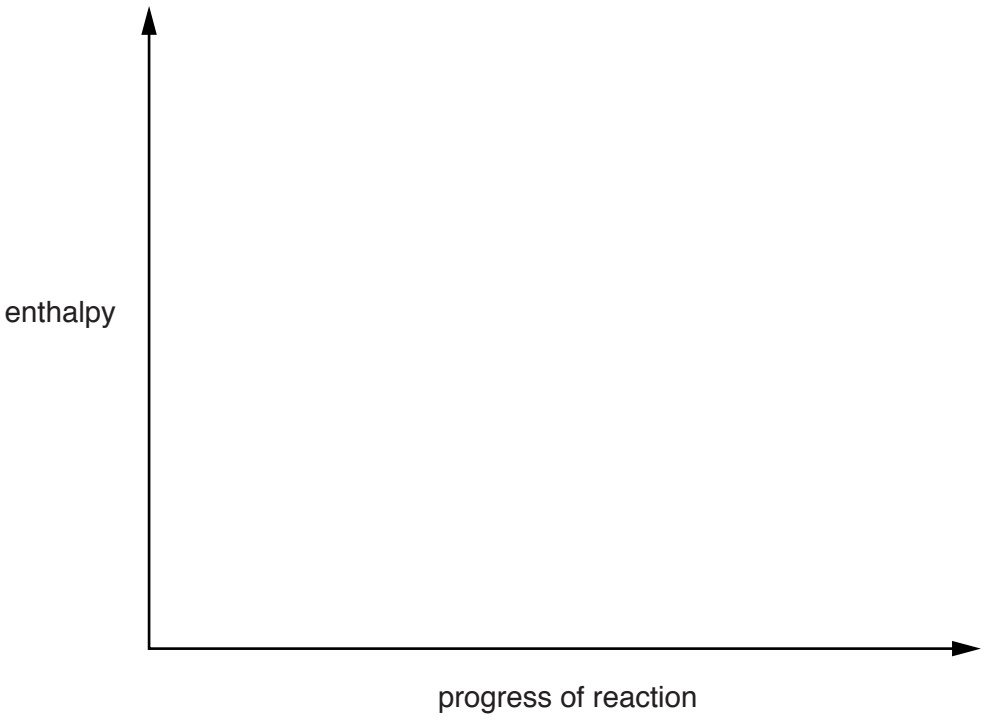
.....

..... **[1]**

**(ii)** Draw a fully labelled enthalpy profile diagram to represent the enthalpy change of formation of $N_2O$.

The formulae, with state symbols, of the reactants and products should be included as part of the diagram.

You are **not** expected to show the activation energy for the reaction.




**[2]**

**(b)** $N_2O$ is supplied as a compressed gas in steel cylinders for use as an anaesthetic.
The cylinders are stored at 20.0 °C.

Calculate the gas pressure, in Pa, in a 2.32 $dm^3$ steel cylinder containing 187 g of $N_2O$ gas.

Give your answer in standard form to **three** significant figures.

pressure = ..... Pa **[4]**

**(c)** NO radicals catalyse the breakdown of ozone in the stratosphere.

Write **two** equations to show how NO radicals catalyse this breakdown.

.....

..... **[2]**

**5** A student investigates the reaction between strontium carbonate and dilute nitric acid.

$$SrCO_3 + 2HNO_3 \longrightarrow Sr(NO_3)_2 + CO_2 + H_2O$$

The rate of reaction is determined from the loss in mass over a period of time.

**(a) (i)** Explain why there is a loss in mass during the reaction.

.....

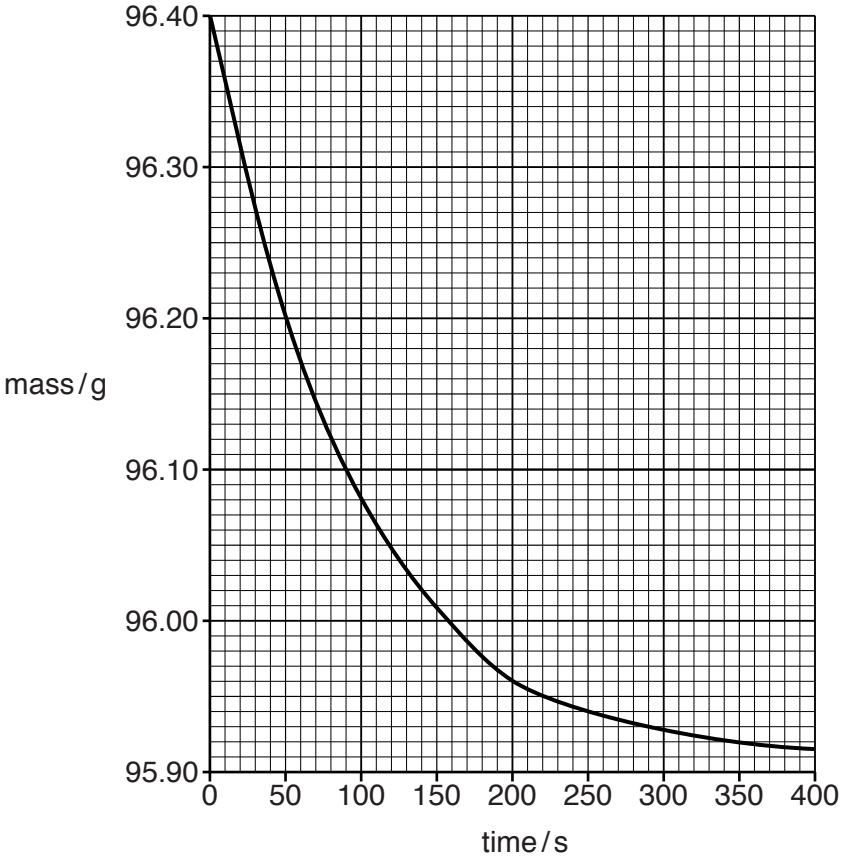
..... **[1]**

**(ii)** An excess of strontium carbonate, $SrCO_3$, is mixed with 20.0 $cm^3$ of 1.25 mol $dm^{-3}$ nitric acid, $HNO_3$.

Calculate the mass of $SrCO_3$ that reacts with the $HNO_3$.

mass = ..... g **[3]**

**(b)** The student plots a graph of total mass (reagents + container) against time.



**(i)** Describe and explain the change in the rate of the reaction during the first 200 seconds of the experiment.

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..... **[2]**

**(ii)** Using the graph, calculate the rate of reaction, in $g\,s^{-1}$, at 200 seconds.

Show your working on the graph.

rate of reaction = ..... $g\,s^{-1}$ **[2]**

**(c)** Outline a method that could be used to obtain the results that are plotted on the graph.

Your answer should include the apparatus required and the procedure for the experiment.

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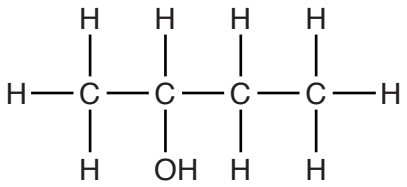
..... **[3]**

**6** This question is about the properties and reactions of butan-2-ol.



Some properties of butan-2-ol are listed in the table.

| | |
|---|---|
| **Melting point** | –115 °C |
| **Boiling point** | 99.5 °C |

**(a)** Why is butan-2-ol classified as a secondary alcohol?

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..... **[1]**

**(b)** The shape around the oxygen atom in butan-2-ol is non-linear.

Predict the C–O–H bond angle and explain this shape.

bond angle .....

explanation .....

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..... **[4]**

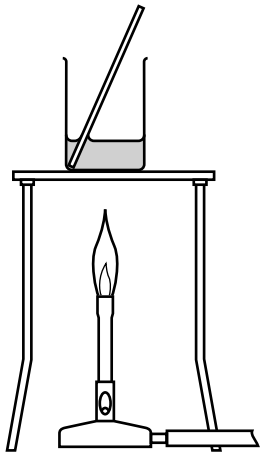
**(c)** Butan-2-ol can be oxidised by heating with an oxidising agent.

**(i)** Write an equation for the reaction.

Use [O] to represent the oxidising agent and show the structure of the organic product.

**[2]**

**(ii)** A student plans to carry out this oxidation using the apparatus shown in the diagram.



Give **one** reason why the apparatus is **not** suitable and describe a more suitable way of carrying out this oxidation.

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..... **[2]**

**(d)** 20.2 g of butan-2-ol is reacted with excess sodium bromide and sulfuric acid.

$CH_3CH(OH)CH_2CH_3 + NaBr + H_2SO_4 \longrightarrow CH_3CHBrCH_2CH_3 + NaHSO_4 + H_2O$

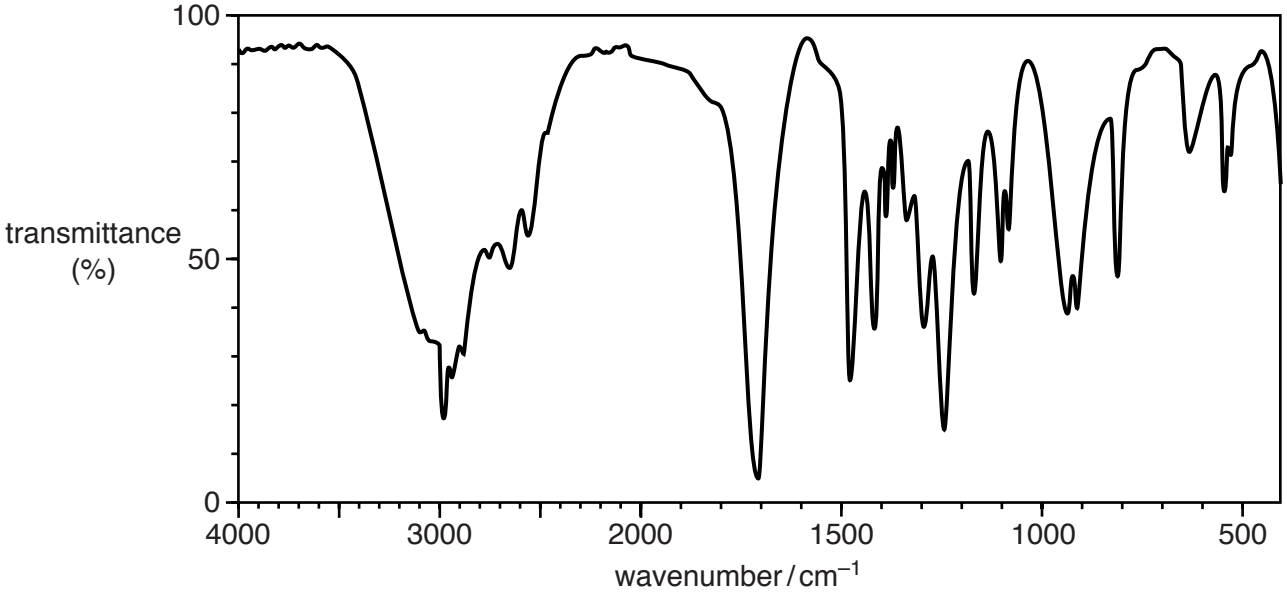
25.2 g of $CH_3CHBrCH_2CH_3$ is formed.

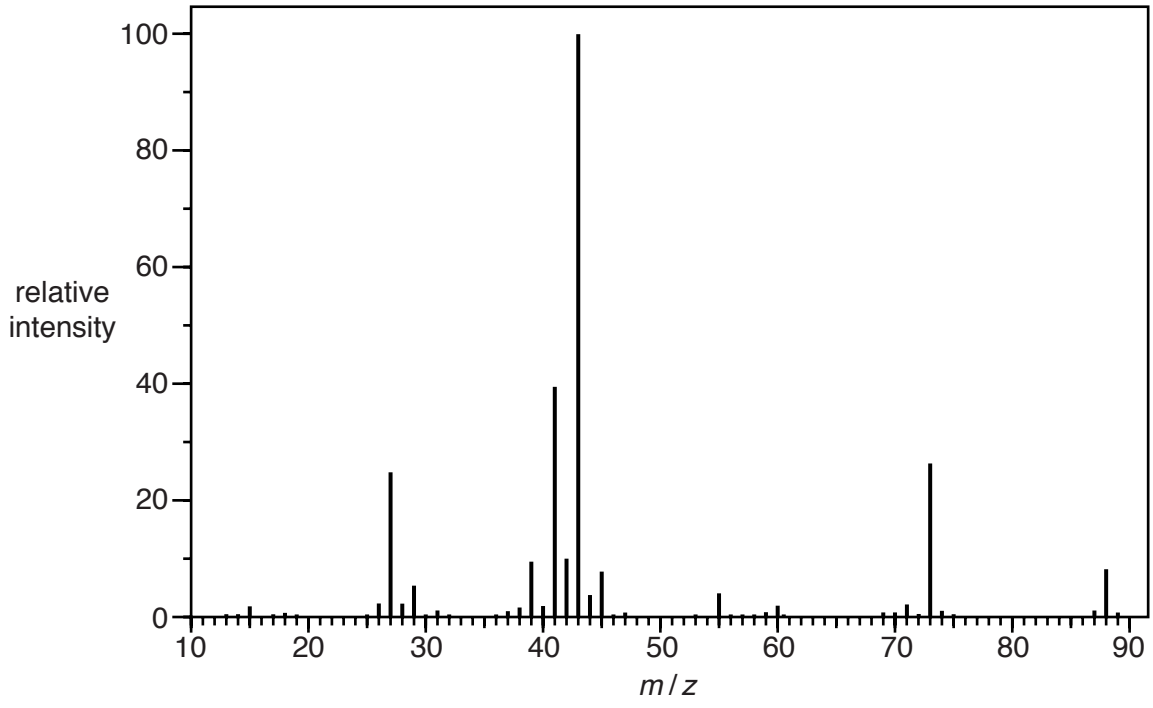
Calculate the percentage yield of $CH_3CHBrCH_2CH_3$.

percentage yield = ..... % **[3]**

**7*** Organic compound **C** has the following percentage composition by mass:
C, 54.5%; H, 9.1%; O, 36.4%.

The infrared spectrum and mass spectrum of compound **C** are shown below.




In the mass spectrum, a secondary carbocation is responsible for the peak with the greatest relative intensity.

Identify compound **C**.

In your answer you should make clear how your conclusion is linked to all the evidence.

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..... **[6]**

**END OF QUESTION PAPER**

## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).