



# Cambridge International AS & A Level

CANDIDATE  
NAME

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CENTRE  
NUMBER

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NUMBER

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## CHEMISTRY

9701/22

Paper 2 AS Level Structured Questions

May/June 2020

1 hour 15 minutes

You must answer on the question paper.

You will need: Data booklet

### INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.

### INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

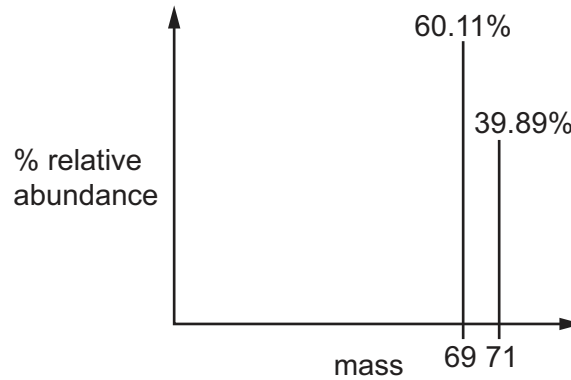
This document has **12** pages. Blank pages are indicated.



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

- 1 Gallium is an element in Group 13.

A sample of gallium is analysed using a mass spectrometer. The mass spectrum produced is shown.



- (a) Explain what is meant by the term *relative atomic mass*.

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

- (b) Calculate the relative atomic mass of gallium in this sample. Give your answer to 4 significant figures.

Show your working.

relative atomic mass = ..... [2]

- (c) Complete the table which describes a gaseous atom of gallium.

isotope	nucleon number	total number of electrons in <b>lowest</b> energy level	type of orbital which contains the electron in the <b>highest</b> energy level
$^{71}\text{Ga}$			

[3]

(d) When gallium is heated in excess chlorine, gallium trichloride,  $\text{GaCl}_3$ , is made.

Draw the shape of the gallium trichloride molecule and suggest the  $\text{Cl-Ga-Cl}$  bond angle.

shape of molecule

bond angle .....

[2]

(e) Gallium oxide,  $\text{Ga}_2\text{O}_3$ , and aluminium oxide react in the same way with  $\text{HCl}(\text{aq})$  and with  $\text{NaOH}(\text{aq})$ .

(i) Suggest the equation for the reaction between  $\text{Ga}_2\text{O}_3$  and  $\text{HCl}(\text{aq})$ .

..... [1]

(ii) Suggest an equation for the reaction between gallium oxide and  $\text{NaOH}(\text{aq})$ .

..... [2]

[Total: 12]

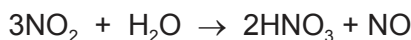
2 Nitric acid can be made in a 3-stage process.

**Stage 1** Ammonia is oxidised by oxygen from the air, to form nitrogen monoxide and water. This reaction is carried out at 10–13 atmospheres pressure and 900 °C in the presence of a platinum catalyst.

**Stage 2** Nitrogen monoxide reacts with more oxygen to form nitrogen dioxide.



**Stage 3** Nitrogen dioxide reacts with water to make nitric acid and nitrogen monoxide.



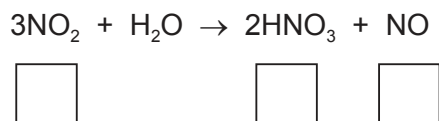
(a) Write an equation to show the reaction occurring in stage 1.

..... [1]

(b) Draw a 'dot-and-cross' diagram to show the arrangement of outer electrons in a molecule of ammonia.

[1]

(c) (i) In the boxes, give the oxidation numbers of nitrogen in the nitrogen-containing species for the reaction in stage 3.



[2]

(ii) Explain why the reaction in stage 3 is described as a disproportionation reaction. Include reference to transfer of electrons in your answer.

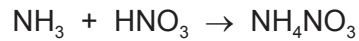
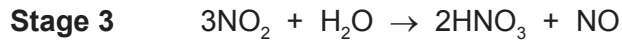
.....  
 .....  
 ..... [2]

- (d) The release of nitrogen monoxide into the atmosphere causes atmospheric pollution.

State and explain the effect of nitrogen monoxide gas in contact with moist air.

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

- (e) The nitric acid made in stage 3 can then be reacted with ammonia to form ammonium nitrate.



Calculate the volume of nitrogen dioxide, measured at room temperature and pressure, required to make 40 tonnes of ammonium nitrate.

[1 tonne = 1000 kg]

Show your working.

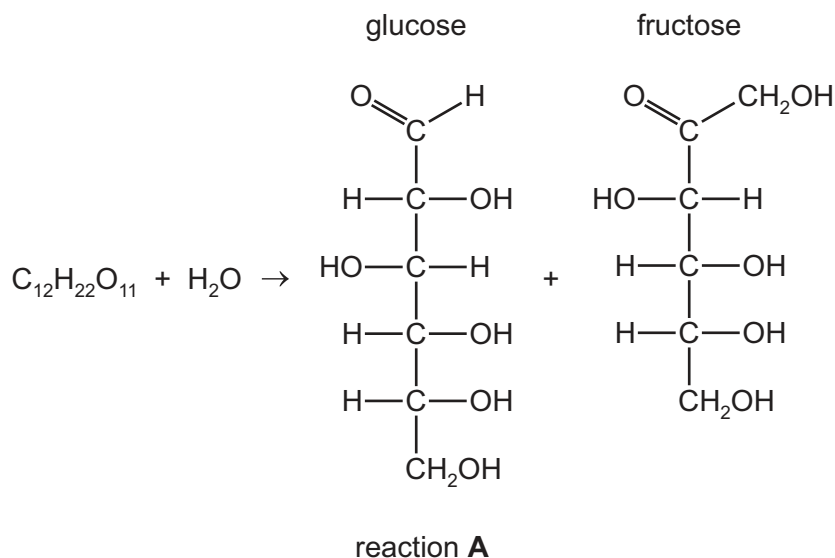
volume of nitrogen dioxide = ..... [3]

- (f) State **one** use of ammonium nitrate.

..... [1]

[Total: 12]

- 3 Sucrose,  $C_{12}H_{22}O_{11}$ , reacts with water to form glucose and fructose in reaction **A**.



- (a) Suggest a name for this type of reaction.

..... [1]

- (b) Explain in detail, why glucose and fructose are a pair of structural isomers. Your answer should refer specifically to these two molecules.

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

- (c) Reaction **A** occurs faster in the presence of an enzyme. This is reaction **B**.

- (i) The activation energy for reaction **B** is  $+29 \text{ kJ mol}^{-1}$ .

Predict a value for the activation energy of reaction **A**.

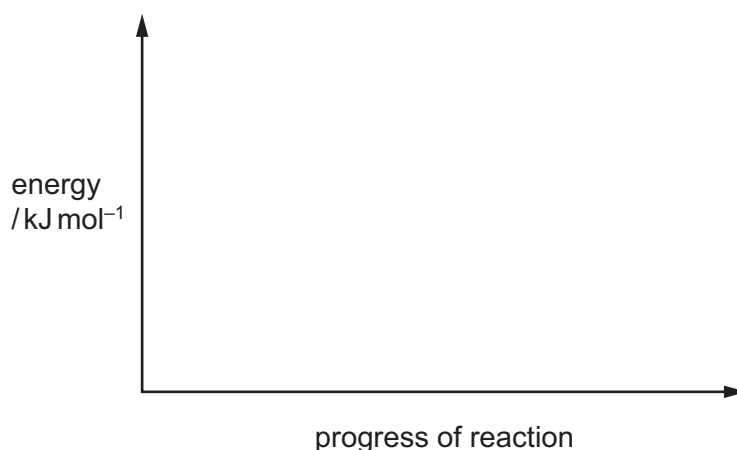
..... [1]

- (ii) The enthalpy change for reaction **A** is  $-14 \text{ kJ mol}^{-1}$ .

Predict a value for the enthalpy change for reaction **B**.

..... [1]

- (iii) Sketch a labelled energy level diagram for reaction B. Use relevant values from (c)(i) and (c)(ii).



[2]

- (d) 1.00 g of sucrose,  $C_{12}H_{22}O_{11}$ , is completely combusted. The heat energy produced is used to increase the temperature of 250 g of water inside a calorimeter from  $25.0^{\circ}\text{C}$  to  $40.7^{\circ}\text{C}$ .

These data can be used to calculate the enthalpy change of combustion of sucrose.

- (i) Explain what is meant by the term *enthalpy change of combustion of sucrose*.

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

- (ii) Use the *Data Booklet* to calculate the enthalpy change, in  $\text{kJ mol}^{-1}$ , for the combustion of sucrose.

Assume that all of the heat energy produced is transferred to the water.

Show your working.

enthalpy change of combustion of sucrose = .....  $\text{kJ mol}^{-1}$   
 [3]

[Total: 12]

- 4 (a) An unlabelled bottle contains a straight-chain halogenoalkane, **Q**. The molecular formula of **Q** is  $C_5H_{11}X$ , where **X** is a halogen; bromine, chlorine or iodine.

A test is carried out to identify the halogen present in **Q**.

A sample of **Q** is added to  $NaOH(aq)$  and warmed. Dilute nitric acid is then added followed by a few drops of aqueous silver nitrate. A cream precipitate is observed.

- (i) Suggest the identity of **X**.

..... [1]

- (ii) Write an ionic equation to describe the formation of the cream precipitate. Include state symbols.

..... [1]

- (iii) Describe a further test which would confirm the identity of **X**.

test .....

expected result .....

[2]

- (b) The reaction of **Q** with  $NaOH(aq)$  tends to proceed via an  $S_N2$  mechanism.

- (i) Suggest the structural formula of the straight-chain halogenoalkane **Q**.

[1]

- (ii) Explain why the reaction tends to proceed via an  $S_N2$  mechanism rather than an  $S_N1$  mechanism.

.....

.....

..... [2]



- (c) Two different halogenoalkanes, **P** and **R**, both with the molecular formula  $C_4H_9Cl$ , are separately dissolved in ethanol and heated under reflux with sodium hydroxide.

The major organic product of each of these reactions is methylpropene.

- (i) Name the type of reaction occurring.

..... [1]

- (ii) Write an equation, using molecular formulae, to represent the reaction occurring.

..... [1]

- (iii) Draw the skeletal formula of methylpropene.

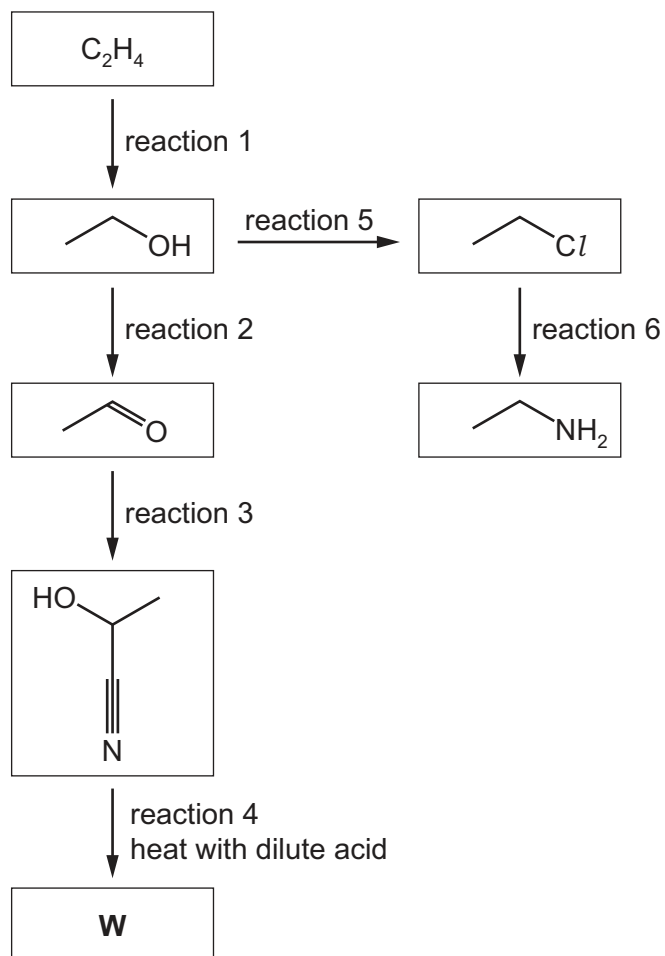
[1]

- (iv) Give the names of **P** and **R**.

..... [2]

[Total: 12]

5 The reaction sequence shows how ethene,  $C_2H_4$ , can be converted into other organic molecules.



(a) Complete the table to give

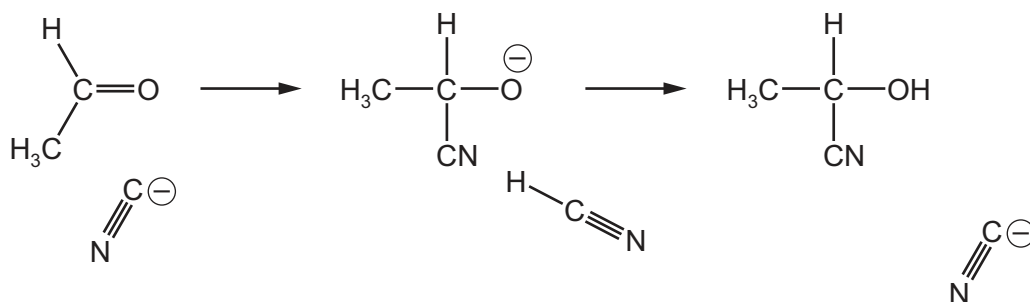
- the name of the reaction mechanisms of reactions 1 and 6
- the reagents and conditions required for reactions 1, 2 and 6.

reaction	name of mechanism	name of reagents and conditions
1		
2		
6		

[6]

(b) In reaction 3 the organic molecule reacts with HCN and a KCN catalyst.

(i) Complete the diagram to show the mechanism of the reaction occurring. Include all relevant dipoles, lone pairs and curly arrows in your answer.



[3]

(ii) Name the functional groups present in the product of reaction 3.

..... [2]

(c) Draw the structure of the organic molecule **W** formed in reaction 4.

[1]

[Total: 12]

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