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9701/23

May/June 2020

**1 hour 15 minutes**

You must answer on the question paper.

You will need: Data booklet

- 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.

- 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 (a) A sample of barium is heated in oxygen.

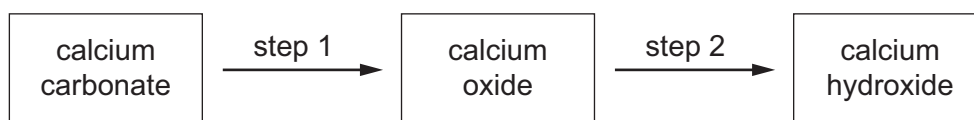
(i) Describe **two** observations for this reaction.

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

(ii) Write an equation for this reaction. Include state symbols.

..... [1]

(b) Calcium carbonate can be converted into calcium hydroxide in a two-step process.



(i) Describe how the two-step process is carried out to convert calcium carbonate into calcium hydroxide. Include relevant equations.

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

(ii) Name the type of reaction occurring when calcium carbonate is converted into calcium oxide.

..... [1]

(iii) State **one** common use for both calcium carbonate and calcium hydroxide.

..... [1]

(c) Gallium is a silver-grey solid. Aluminium and gallium share many similar chemical properties.

- (i) Construct an equation for the reaction of gallium when heated in oxygen to form gallium oxide,  $\text{Ga}_2\text{O}_3$ .

..... [1]

- (ii) Deduce the oxidation number of gallium in  $\text{Ga}_2\text{O}_3$ .

..... [1]

- (iii) Complete the table by predicting the formula of each gallium-containing product formed when gallium oxide reacts separately with hot aqueous hydrochloric acid and with hot concentrated sodium hydroxide.

reagents and conditions	formula of gallium-containing product
gallium oxide + hot $\text{HCl}(\text{aq})$	
gallium oxide + hot concentrated $\text{NaOH}(\text{aq})$	

[2]

[Total: 12]

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

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

- (b) A sample of copper contains two isotopes,  $^{63}\text{Cu}$  and  $^{65}\text{Cu}$ . The relative atomic mass of the copper in this sample is 63.55.

Calculate the percentage abundance of each of these isotopes. Show your working.

percentage abundance of  $^{63}\text{Cu}$  = ..... %

percentage abundance of  $^{65}\text{Cu}$  = ..... %  
[2]

- (c) (i) Name the type of bonding within a sample of solid copper.

..... [1]

- (ii) Draw a labelled diagram to show the bonding within a sample of solid copper.

[2]

- (iii) State the electronic configuration of a copper atom.

$1s^2$  ..... [1]

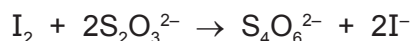
- (d) A student is provided with a sample of hydrated copper(II) sulfate,  $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ , and is asked to determine the value of  $x$ .

The student dissolves a sample of the hydrated copper(II) sulfate in water and adds it to an excess of aqueous potassium iodide to make a total volume of  $250.0\text{ cm}^3$  of solution.



The amount of iodine produced during this reaction is found by titrating a sample of this solution with sodium thiosulfate solution.

$25.0\text{ cm}^3$  of the iodine-containing solution requires  $20.0\text{ cm}^3$  of  $0.10\text{ mol dm}^{-3}$  sodium thiosulfate solution.



- (i) Calculate the amount, in mol, of copper(II) sulfate present in the original sample of hydrated copper(II) sulfate.

Show your working.

amount of copper(II) sulfate = ..... mol [2]

- (ii) A total of  $7.98\text{ g}$  of  $\text{CuSO}_4$  is present in  $10.68\text{ g}$  of  $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ .

Complete each row of the table to calculate the value of  $x$ , where  $x$  is an integer.

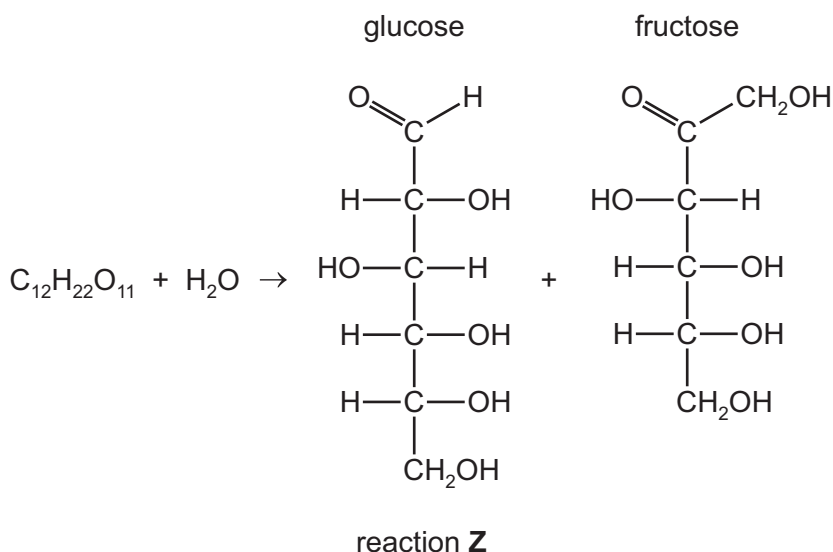
$[M_r: \text{CuSO}_4, 159.6]$

amount of $\text{CuSO}_4$ in $10.68\text{ g}$ of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	..... mol
amount of $\text{H}_2\text{O}$ in $10.68\text{ g}$ of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	..... mol
value of $x$	$x = \dots\dots\dots$

[3]

[Total: 13]

- 3 Sucrose is a white crystalline solid,  $C_{12}H_{22}O_{11}$ . In reaction **Z**, sucrose reacts with water in the presence of a catalyst, aqueous hydrochloric acid, to form glucose and fructose.

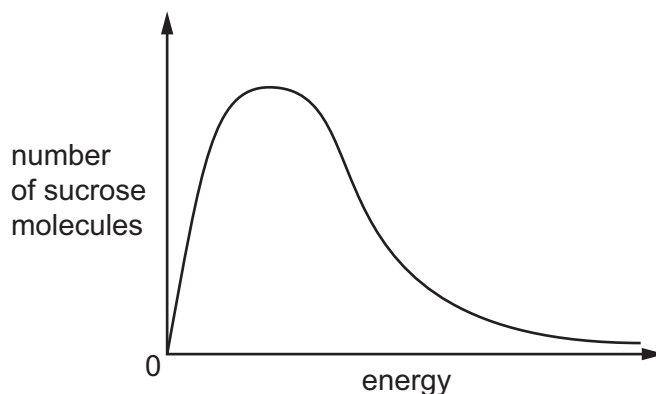


- (a) (i) Suggest a name for the reaction that occurs when sucrose reacts with water to form glucose and fructose.

..... [1]

- (ii) If no catalyst is added in reaction **Z**, the reaction is very slow.

Label the Boltzmann distribution to show the effect of adding a catalyst to the sample of sucrose and water molecules at constant temperature.



Explain your labelled diagram.

.....  
 .....  
 .....

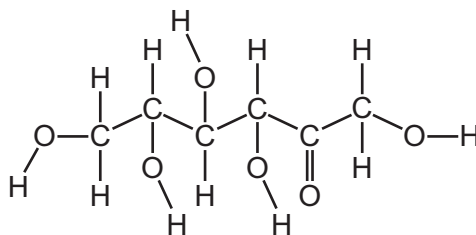
[3]

- (b) Both fructose and glucose contain chiral centres.

- (i) Explain what is meant by the term *chiral centre*.

..... [1]

- (ii) On the diagram of the fructose molecule, label all the chiral centres with an asterisk (\*).



[1]

- (iii) Determine the empirical formula of fructose.

..... [1]

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

.....

..... [2]

- (ii) Write the equation for the complete combustion of sucrose.

..... [1]

The enthalpy change of reaction **Z**,  $\Delta H_r$ , can be calculated using the enthalpy change of combustion data given in the table.

substance	enthalpy change of combustion, $\Delta H_c / \text{kJ mol}^{-1}$
sucrose	-5643
glucose	-2805
fructose	-2810

- (iii) Use the data in the table to calculate the enthalpy change for the reaction occurring when sucrose reacts with water,  $\Delta H_r$ . You should draw a labelled Hess' cycle to show your working.

$\Delta H_r = \dots\dots\dots \text{kJ mol}^{-1}$  [2]

[Total: 12]

- 4 Hexane,  $C_6H_{14}$ , is a colourless liquid.  
Two test-tubes contain equal amounts of hexane.  $1\text{ cm}^3$  of bromine,  $Br_2(aq)$ , is added to both test-tubes. One test-tube is kept in the dark and the other is exposed to sunlight.

The table describes the appearance of each test-tube after one hour.

test-tube conditions	observations
in the dark	no change, mixture remains orange
in sunlight	colour of mixture fades to pale yellow

- (a) The test-tube in the dark is kept cool and is not exposed to ultraviolet light.

Explain the observations for the test-tube kept in the dark.

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

- (b) In sunlight, bromine reacts with hexane by a mechanism which occurs via a series of steps.

- (i) State the name of the mechanism of the reaction that occurs.

..... [1]

- (ii) Give an equation which shows a propagation step in this reaction in which hexane produces  $\bullet C_6H_{13}$ .

..... [1]

- (iii) Give an equation which shows a propagation step in this reaction that produces 1-bromohexane.

..... [1]

- (iv) Give an equation which shows a termination step in this reaction that produces 1-bromohexane.

..... [1]



(c) **A** and **B** are different straight chain alkenes with molecular formula,  $C_6H_{12}$ .

**A** does not show stereoisomerism.

**A** reacts with potassium manganate(VII) to form hexane-1,2-diol.

(i) Draw the structural formula of **A**.

[1]

(ii) State the conditions needed for this reaction of **A**.

..... [2]

(d) **B** reacts with hydrogen gas in the presence of a platinum catalyst to produce hexane.

(i) Name the type of reaction occurring.

..... [1]

(ii) In terms of  $\sigma$  and  $\pi$  bonds, describe any similarities and differences in the type of carbon-carbon bonds in **B** and the type of carbon-carbon bonds in hexane.

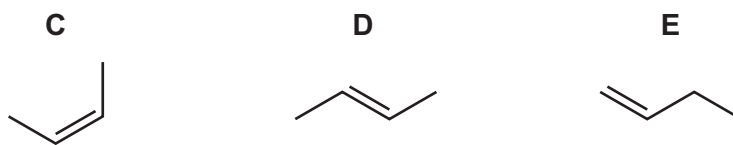
.....

.....

..... [2]

[Total: 12]

- 5 **C**, **D** and **E** are isomers of each other.  
They are made by passing an alcohol vapour over an aluminium oxide catalyst.



- (a) (i) Name the type of reaction occurring.

..... [1]

- (ii) Draw the displayed formula of the alcohol used in this reaction.

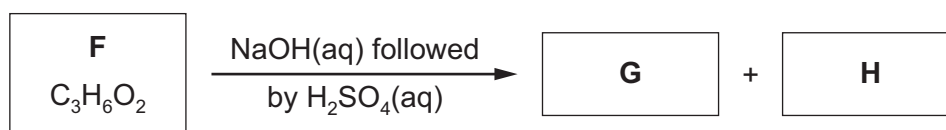
[2]

- (iii) Name the isomers **C**, **D** and **E**.

isomer	name
<b>C</b>	
<b>D</b>	
<b>E</b>	

[2]

- (b) **F** is an organic molecule which has the molecular formula  $C_3H_6O_2$ .  
When **F** is heated with  $NaOH(aq)$  followed by  $H_2SO_4(aq)$  the products **G** and **H** are made.



Separate samples of **G** and **H** are added to

- $Na_2CO_3(aq)$
- sodium metal
- alkaline aqueous iodine.

The observations are described in the table.

reagent(s)	<b>G</b>	<b>H</b>
$Na_2CO_3(aq)$	colourless bubbles of gas produced	no visible reaction
$Na(s)$	colourless bubbles of gas produced	colourless bubbles of gas produced
alkaline aqueous iodine	no visible reaction	yellow precipitate forms

- (i) Complete the table to identify the functional groups present in **F**, **G** and **H**.

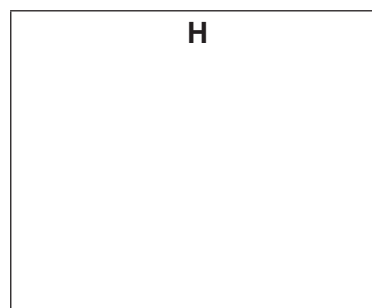
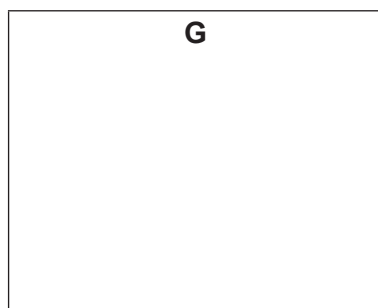
	functional group
<b>F</b>	
<b>G</b>	
<b>H</b>	

[3]

- (ii) Name the yellow precipitate formed when alkaline aqueous iodine reacts with **H**.

..... [1]

- (iii) Draw the structures of **G** and **H**.



[2]

[Total: 11]

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