

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

I declare this is my own work.

GCSE CHEMISTRY

H

Higher Tier Paper 2

Wednesday 10 June 2020

Morning

Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:

- a ruler
- a scientific calculator
- the periodic table (enclosed).

Instructions

- Use black ink or black ball-point pen.
- Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- In all calculations, show clearly how you work out your answer.

Information

- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use

Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	



0 1

This question is about chemical analysis.

A student tested copper sulfate solution and calcium iodide solution using flame tests.

This is the method used.

1. Dip a metal wire in copper sulfate solution.
2. Put the metal wire in a blue Bunsen burner flame.
3. Record the flame colour produced.
4. Repeat steps 1 to 3 using the same metal wire but using calcium iodide solution.

0 1 . 1

What flame colour is produced by copper sulfate solution?

[1 mark]

Green (Cu^{2+})



0 1 . 2

Calcium compounds produce an orange-red flame colour.

The student **left out an important step** before reusing the metal wire.

The student's method did **not** produce a distinct orange-red flame colour using calcium iodide solution.

Explain why.

[2 marks]

The metal wire was not cleaned between tests.
 CuSO_4 was still present, producing green.
 So the colours are mixed and not distinct.



0 1 . 3 The student added sodium hydroxide solution to:

- copper sulfate solution
- calcium iodide solution.

Give the results of the tests.

[2 marks]

Copper sulfate solution Blue precipitate $\text{Cu}(\text{OH})_2$

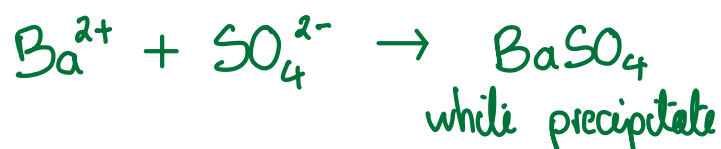
Calcium iodide solution White precipitate $\text{Ca}(\text{OH})_2$

0 1 . 4 To test for sulfate ions the student added dilute hydrochloric acid to copper sulfate solution.

Name the solution that would show the presence of sulfate ions when added to this mixture.

[1 mark]

Barium chloride



0 1 . 5 To test for iodide ions the student added dilute nitric acid to calcium iodide solution.

Name the solution that would show the presence of iodide ions when added to this mixture.

Give the result of the test.

[2 marks]

Solution Silver nitrate AgNO_3

Result Yellow precipitate

Turn over ►



0 2

This question is about water.

0 2 . 1

In the UK, potable (drinking) water is produced from different sources of fresh water.

Explain how potable water is produced from fresh water.

[4 marks]

Select an appropriate source of fresh water
(e.g. rivers, streams, lakes or boreholes)

Pass through filter beds to remove undissolved solids.

Sterilise using chlorine, ozone or UV light
to destroy harmful microbes.

0 2 . 2

A different country has:

- very little rainfall
- a long coastline
- plentiful energy supplies.

Suggest **one** process this country could use to obtain most of its potable water.

[1 mark]

Distillation, reverse osmosis, desalination of sea water.



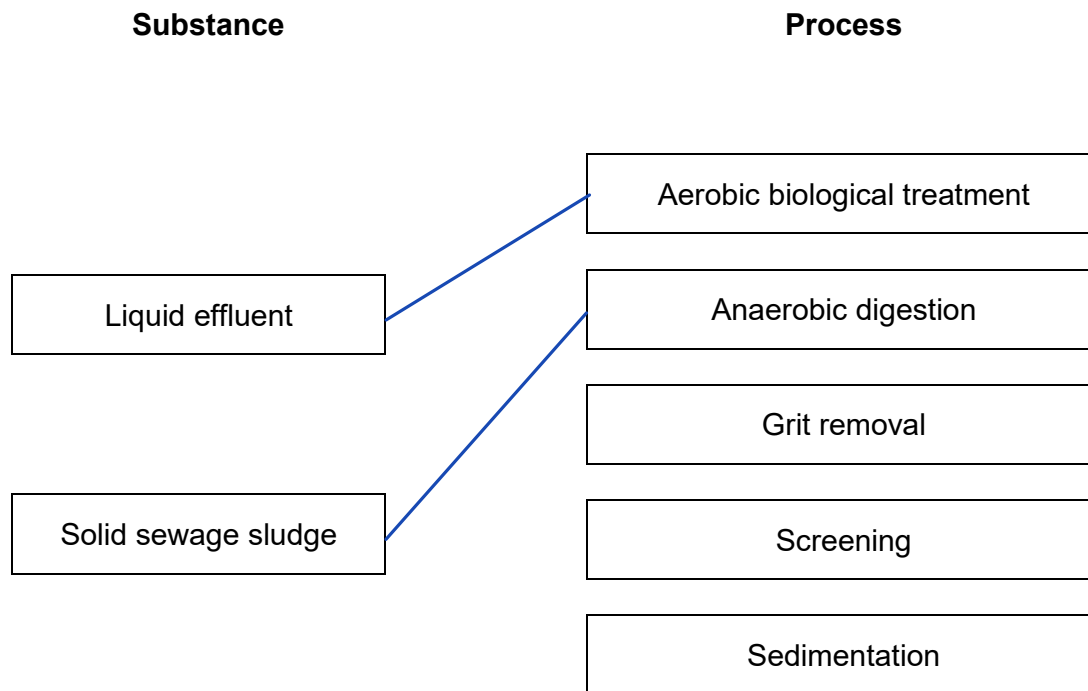
0 2 . 3 Waste water is not fit to drink.

Treatment of waste water produces two substances:

- liquid effluent
- solid sewage sludge.

Draw **one** line from each substance to the way the substance is processed.

[2 marks]



Question 2 continues on the next page

Turn over ►



Table 1 shows information about the disposal of processed solid sewage sludge in the UK in 1992 and in 2010.

Table 1

Year	Mass of processed solid sewage sludge in millions of kilograms				
	Used as fertiliser	Sent to landfill	Burned	Other methods	Total
1992	440	130	90	338	998
2010	1118	9	260	26	1413

0 2 . 4 Calculate the percentage of processed solid sewage sludge that was burned in 2010.

Give your answer to 3 significant figures.

Use **Table 1**.

[3 marks]

$$\frac{260}{1413} \times 100\% = 18.4\% \quad (3 \text{ s.f.})$$

Percentage (3 significant figures) = 18.4 %



0 2 . 5

Suggest **one** reason why the total mass of processed solid sewage sludge increased between 1992 and 2010.

[1 mark]

Population increase, more waste water produced.

0 2 . 6

Between 1992 and 2010 the proportion of processed solid sewage sludge used as fertiliser increased.

Suggest **two** reasons why.

[2 marks]

1 Increased demand for food (increased population)

2 Energy/resources conservation.

13

Turn over for the next question

Turn over ►



0 3

This question is about hydrocarbons.

Hexane and hexene are hydrocarbons containing six carbon atoms in each molecule.

Hexane is an alkane and hexene is an alkene.

0 3 . 1

Draw **one** line from each hydrocarbon to the formula of that hydrocarbon.

[2 marks]

Hydrocarbon	Formula
Hexane	C_6H_8
Hexene	C_6H_{10}
	C_6H_{12}
	C_6H_{14}
	C_6H_{16}

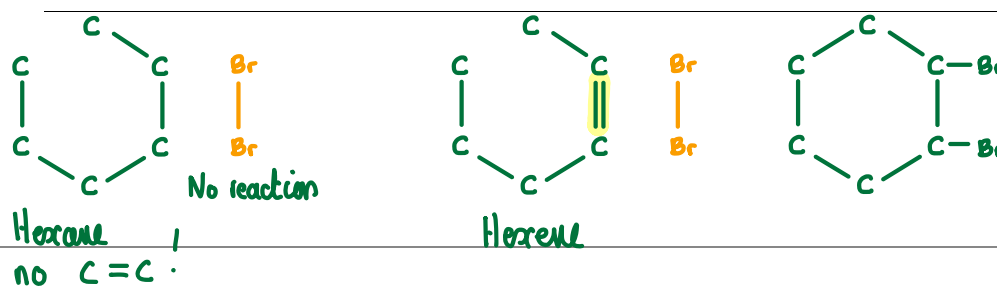
Handwritten blue lines connect Hexane to C_6H_{12} and Hexene to C_6H_{10} .

0 3 . 2

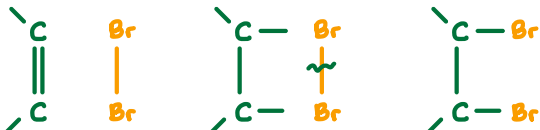
Bromine water is added to hexane and to hexene.

What would be observed when bromine water is added to hexane and to hexene?

[2 marks]

Hexane Remains orangeHexene Becomes colourless

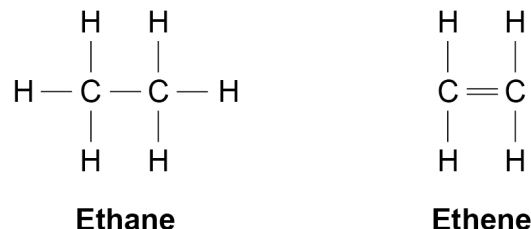
0 8



0 3 . 3 Ethane is an alkane and ethene is an alkene.

Figure 1 shows the displayed structural formulae of ethane and of ethene.

Figure 1



Compare ethane with ethene.

You should refer to:

- their structure and bonding
- their reactions.

[6 marks]

Structure & Bonding

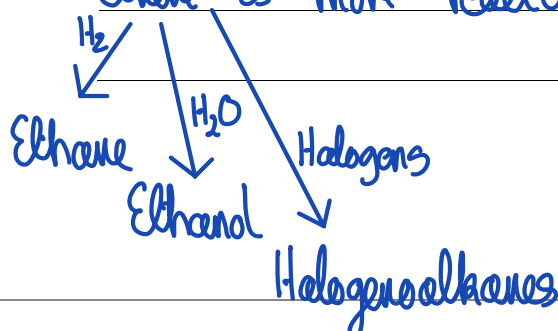
Both hydrocarbons, containing 2 carbons per molecule
Ethane contains 6 H atoms, but ethene has 4H

Both have covalent bonds, ethane contains a
single C-C, but ethene has a double bond C=C.
Both contain C-H bonds and are small molecules.

Reactions

Both react with O_2 in complete combustion to
produce $\text{CO}_2 + \text{H}_2\text{O}$, and incomplete combustion C, CO, H_2O
Ethene decolorises Br_2 water, ethane does not.

Ethene is more reactive than ethane



Ethene can undergo
addition & polymerisation
reactions

10

Turn over ►



0 4

This question is about ink.

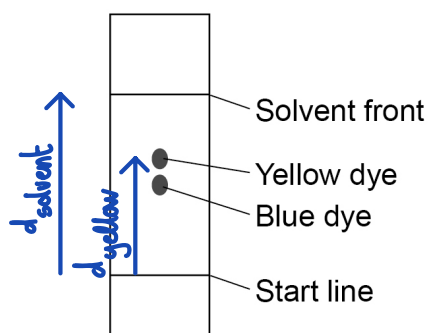
A student investigated green ink using paper chromatography in a beaker.

The student used water as the solvent.

Figure 2 shows the chromatogram obtained.

Figure 2

Diagram not to scale



$$R_f = \frac{d_{\text{yellow}}}{d_{\text{solvent}}}$$

0 4 . 1

The R_f value of the yellow dye = 0.60

The distance moved by the yellow dye = 5.7 cm d_{yellow}

Calculate the distance moved by the solvent. d_{solvent}

[3 marks]

$$R_f = \frac{d_{\text{yellow}}}{d_{\text{solvent}}}$$

$$0.60 = \frac{5.7 \text{ cm}}{d_{\text{solvent}}}$$

$$d_{\text{solvent}} = \frac{5.7 \text{ cm}}{0.60} = 9.5 \text{ cm}$$

Distance moved by the solvent = 9.5 cm



0 4 . 2 The green ink contains more than two compounds.

Suggest **one** reason why only two spots are seen on **Figure 2**.

[1 mark]

Some of the compounds are colourless or the dyes have the same R_f values.

0 4 . 3 On the student's chromatogram, the yellow and blue spots are very close together.

Which **two** ways could increase the distance between the spots?

[2 marks]

Tick (✓) **two** boxes.

Allow the solvent front to travel further.

Dry the chromatogram more slowly.

Use a different solvent.

Use a larger beaker.

Use a larger spot of green ink.

0 4 . 4 The manufacturers of the green ink always use the same proportions of yellow dye and blue dye.

Suggest **one** reason why.

[1 mark]

To ensure that the shade of green is the same

Turn over ►



0 4 . 5 The R_f value of a dye depends on:

- the solubility of the dye in the solvent
- the attraction of the dye to the paper.

Which will **definitely** produce a smaller R_f value if the solvent and paper are both changed?

[1 mark]

Tick (✓) **one** box.

The dye is less soluble in the new solvent and less attracted to the new paper.

The dye is less soluble in the new solvent and more attracted to the new paper.

The dye is more soluble in the new solvent and less attracted to the new paper.

The dye is more soluble in the new solvent and more attracted to the new paper.

8



Turn over for the next question

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ANSWER IN THE SPACES PROVIDED**

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0 5

This question is about materials used to make food plates.

Food plates are made from paper, polymers or ceramics.

Table 2 shows information about plates of the same diameter made from each of these materials.

Table 2

	Food plate material		
	Paper	Polymers	Ceramics
Raw material	Wood	Crude oil	Mined clay
Number packaged in 10 dm ³ cardboard box	500	100	50
Average number of times used	1	400	1000
Biodegradable?	Yes	No	No
Recyclable?	Yes	Yes	No

0 5 . 1

Table 2 does **not** show information about energy usage.

Suggest **two** pieces of information about energy usage which would help to produce a complete life cycle assessment (LCA) for the three food plate materials.

[2 marks]

- 1 Energy used in extracting/processing of raw materials
- 2 Energy used in transportation, disposal or recycling



0 5 . 2

Evaluate the use of these materials for making food plates.

You should use features of life cycle assessments (LCAs).

Use **Table 2**.

[4 marks]

Raw Materials: Trees are renewable, Oil/clay are finite

Manufacturing/Packaging: Paper plates use the least packaging so conserve raw materials and need less transportation overall as more plates in a 10 dm³ cardboard box.

Use and Operation: Paper plates are single use, replaced often. Ceramic plates last longer than polymer plates so must be replaced less often.

Disposal: Polymer/ceramic plates take up landfill space. Paper/polymer plates can be used to make new products. Recycling conserves raw materials.

0 5 . 3

Describe how ceramic food plates are produced from clay.

[2 marks]

Wet clay is shaped into a plate and then heated (fired) in a kiln or furnace.



0 6

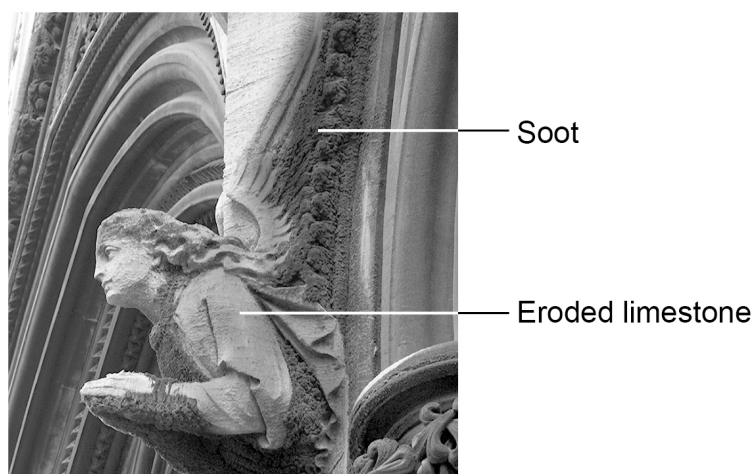
This question is about atmospheric pollution.

Figure 3 shows a limestone carving which has been damaged by atmospheric pollution.

The carving has been:

- blackened by soot
- eroded where the limestone has reacted with atmospheric pollutants.

Figure 3



Carbon, C
↑

Hydrocarbons
↑

0 6 . 1

Explain why soot is formed when some fossil fuels are burned.

[2 marks]

Incomplete combustion produces Carbon particles when there is insufficient oxygen available



0 6 . 2 Fossil fuels are burned in car engines.

Explain how reducing the amount of sulfur in fossil fuels reduces the erosion of limestone.

[4 marks]

Sulfur reacts with oxygen to form sulfur dioxide which forms 'acid rain'.

Reducing amount of sulfur \Rightarrow less sulfur dioxide emitted, so less acid rain, so less limestone reacts with acid rain.

0 6 . 3 Oxides of nitrogen are atmospheric pollutants which are formed in car engines.

Explain why oxides of nitrogen are formed in car engines.

[2 marks]

Internal combustion engine works at high temperatures. Air in the engine contains nitrogen which reacts with oxygen (also in the air.)

8

Turn over for the next question

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0 7

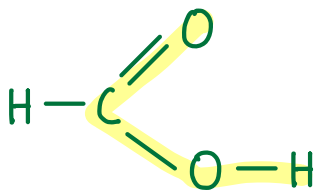
This question is about **carboxylic acids**.

Carboxylic acids belong to a homologous series.

Table 3 shows information about the first three carboxylic acids in this homologous series.

Table 3

Name	Formula	pH of a 0.01 mol/dm ³ solution
Methanoic acid	HCOOH	2.91
Ethanoic acid	CH ₃ COOH	3.39
	CH ₃ CH ₂ COOH	3.44



0 7

. 1

Complete **Table 3**.

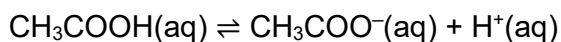
[2 marks]

0 7

. 2

Ethanoic acid ionises in water.

The equation for the reaction is:



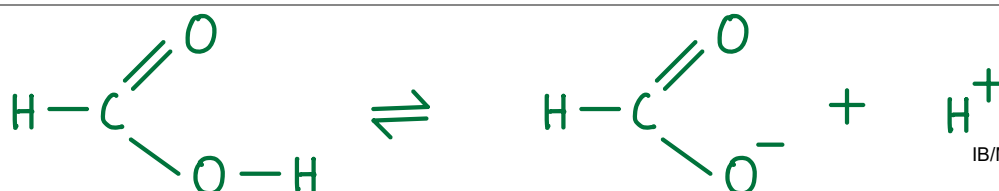
Explain how the equation shows that ethanoic acid is a weak acid.

[2 marks]

Because the reaction is reversible and shows partial or incomplete ionisation.



1 8



07.3

A student adds a solution of ethanoic acid to zinc carbonate in an open flask on a balance.

Explain what happens to the mass of the flask and its contents during the reaction.

[3 marks]

Mass of flask and contents decreases because CO_2 is produced which, as a gas, escapes from the flask.

07.4

The student compares the rates of the reaction of zinc carbonate with:

- 0.01 mol/dm^3 methanoic acid
- 0.01 mol/dm^3 ethanoic acid.

The rate of the reaction with methanoic acid is greater than the rate of the reaction with ethanoic acid.

Explain why.

You should refer to ions in your answer.

Use **Table 3**.

[3 marks]

Methanoic acid is a stronger acid (lower pH) therefore Methanoic acid has a higher concentration of H^+ ions.

Therefore: More collisions per unit time, hence increasing the rate.

Turn over ►

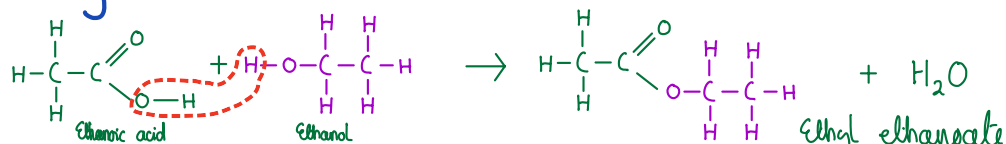


Ethanoic acid reacts with ethanol to produce an ester.

0 7 . 5 Give the name of the ester produced when ethanoic acid reacts with ethanol.

[1 mark]

Ethyl ethanoate



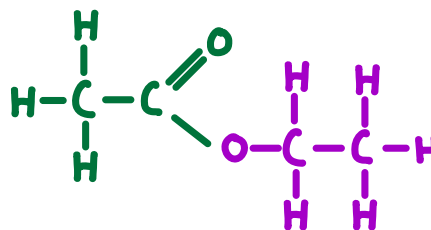
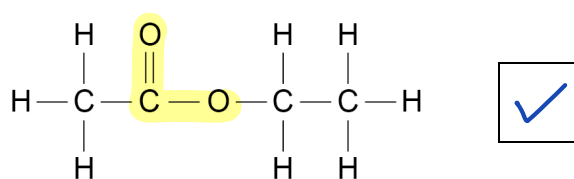
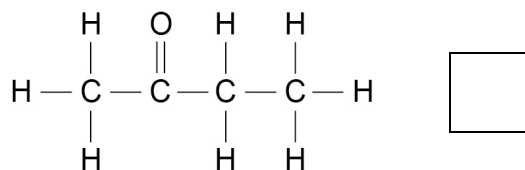
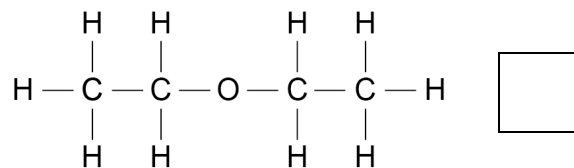
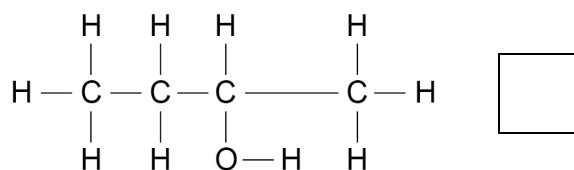
0 7 . 6 Hexanedioic acid and ethanediol join together to produce a polyester.

Ethanoic acid and ethanol join together in the same way to produce an ester.

Which is the displayed structural formula of the ester produced when ethanoic acid reacts with ethanol?

[1 mark]

Tick (✓) one box.



Ester
link.



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0 8

This question is about the rate of the reaction between hydrochloric acid and calcium carbonate.

A student investigated the effect of changing the size of calcium carbonate lumps on the rate of this reaction.

This is the method used.

1. Pour 40 cm³ of hydrochloric acid into a conical flask.
2. Add 10.0 g of small calcium carbonate lumps to the conical flask.
3. Attach a gas syringe to the conical flask.
4. Measure the volume of gas produced every 30 seconds for 180 seconds.
5. Repeat steps 1 to 4 using 10.0 g of large calcium carbonate lumps.

The student calculated the number of moles of gas from each volume of gas measured.

Table 4 shows the student's results for large calcium carbonate lumps.

Table 4

Time in seconds	Number of moles of gas
0	0.0000
30	0.0011
60	0.0020
90	0.0028
120	0.0034
150	0.0038
180	0.0040

The student plotted the results for small calcium carbonate lumps on **Figure 4**.

0 8 . 1

Complete **Figure 4**.

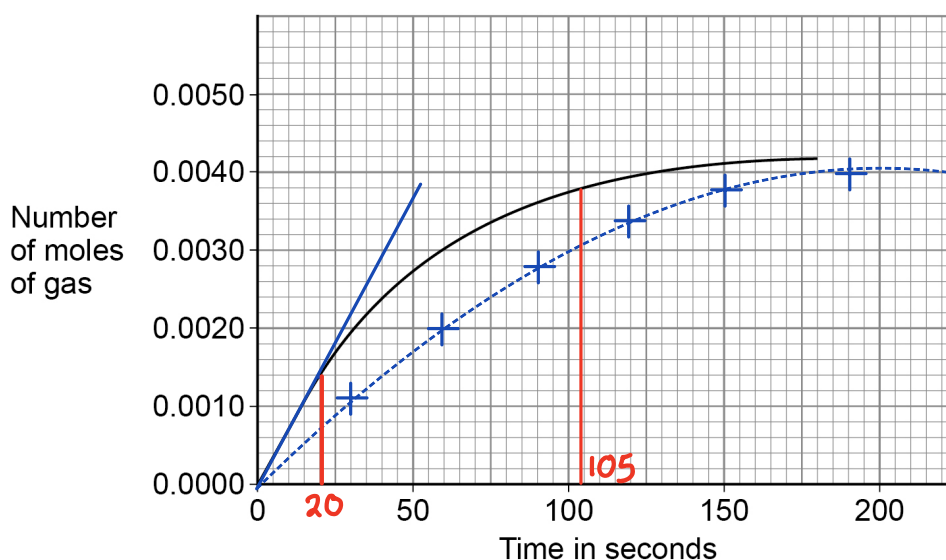
You should:

- plot the data for large calcium carbonate lumps from **Table 4**
- draw a line of best fit.

[3 marks]



Figure 4



0 8 . 2

Determine the mean rate of reaction for **small** calcium carbonate lumps between 20 seconds and 105 seconds.

Give the unit.

Use **Figure 4**.

[4 marks]

$$\begin{aligned} \text{No. moles at } 20\text{s} &= 0.0014 \text{ mol} \\ 105\text{s} &= 0.0038 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{Rate} = \text{gradient} &= \frac{\Delta y}{\Delta x} = \frac{0.0038 - 0.0014 \text{ mol}}{105 - 20 \text{ s}} \\ &= 2.8 \times 10^{-5} \text{ mol/s} \end{aligned}$$

$$\text{Mean rate of reaction} = 2.8 \times 10^{-5} \quad \text{Unit } \text{mol s}^{-1}$$

0 8 . 3

The student concluded that the large calcium carbonate lumps reacted more slowly than the small calcium carbonate lumps.

How do the student's results show that this conclusion is correct?

[1 mark]

For larger lumps a smaller number of moles of gas is collected in the same time.

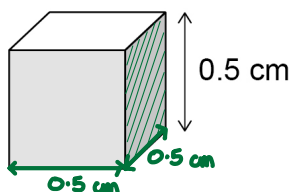
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The difference in the rates of reaction of large lumps and of small lumps of calcium carbonate depends on the surface area to volume ratios of the lumps.

Figure 5 shows a cube of calcium carbonate.

Figure 5



Area of one side:

$$0.5 \text{ cm} \times 0.5 \text{ cm} = 0.25 \text{ cm}^2$$

N^o. of sides of a cube
= 6.

- 0 8 . 4 Calculate the surface area to volume ratio of the cube in Figure 5.

Give your answer as the simplest whole number ratio.

[3 marks]

$$\text{Surface Area} = 0.5 \text{ cm} \times 0.5 \text{ cm} \times 6 = 1.5 \text{ cm}^2$$

$$\text{Volume} = 0.5 \text{ cm} \times 0.5 \text{ cm} \times 0.5 \text{ cm} = 0.125 \text{ cm}^3$$

$$\text{Surface Area} : \text{Volume} = 1.5 : 0.125$$

$$\underline{1.5} : \underline{0.125}$$

(÷ by smallest value)

$$\underline{0.125} \quad \underline{0.125}$$

$$12 : 1$$

$$\text{Surface area} : \text{volume} = 12 : 1$$

- 0 8 . 5 A larger cube of calcium carbonate has sides of 5 cm

Describe how the surface area to volume ratio of this larger cube differs from that of the cube shown in Figure 5.

[1 mark]

Surface Area : Volume ratio would decrease by a factor of 10

Side length has increased $0.5 \rightarrow 5 \times 10$

S.A. Increases by $10 \times 10 = 100$

Vol. " " $10 \times 10 \times 10 = 1000$

$$12 : 1$$

$$2 \times 100 : 1 \times 1000$$

$$1200 : 1000$$

$$1.2 : 1$$

Ratio has decreased by factor of 10.



0 9

This question is about algae.

A student:

- placed algae in water containing dissolved carbon dioxide
- shone bright light on the algae.

Gas bubbles were collected as the algae photosynthesised.

0 9 . 1

Describe a test that would identify the gas collected.

Give the result of the test.

[2 marks]

Test Use a glowing splint

Result Relights

0 9 . 2

Glucose is produced when algae photosynthesise.

Name **two** naturally occurring polymers produced from glucose.

[2 marks]

Starch and Cellulose

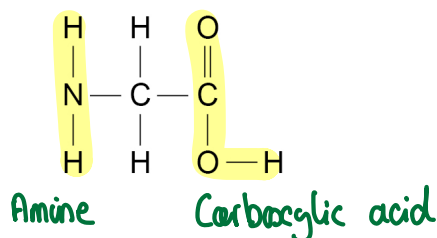
Question 9 continues on the next page

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Figure 6 shows the displayed structural formula of an amino acid called glycine.

Figure 6

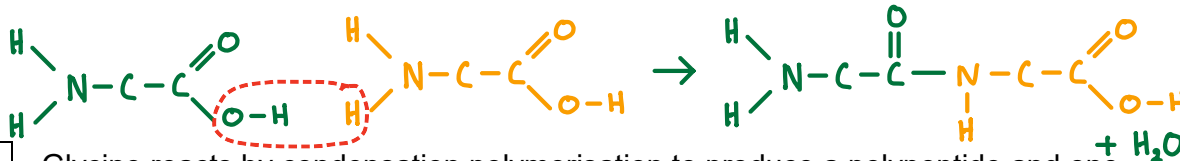


0 9 . 3 How many functional groups are there in the molecule in **Figure 6**?

[1 mark]

Tick (✓) **one** box.

1 2 3 4



0 9 . 4 Glycine reacts by condensation polymerisation to produce a polypeptide and one other substance.

Name the other substance produced.

[1 mark]

Water

0 9 . 5 Scientists think that algae may have used gases in Earth's early atmosphere.

Algae need an element to produce the molecule in **Figure 6** which is **not** present in water or carbon dioxide.

Which **two** gases from Earth's early atmosphere could have provided this element?

[2 marks]

Ammonia and Nitrogen

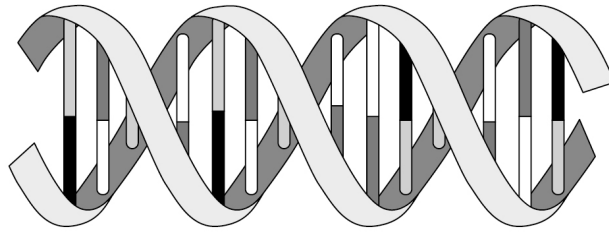


09.6

The development and function of algae are controlled by a naturally occurring polymer.

Figure 7 represents the shape and structure of this polymer.

Figure 7



Describe the shape and structure of this polymer.

[3 marks]

Polymer comprises two polymer chains,

four different monomers (nucleotides)

in a double helix structure.

11

Turn over for the next question

Turn over ►

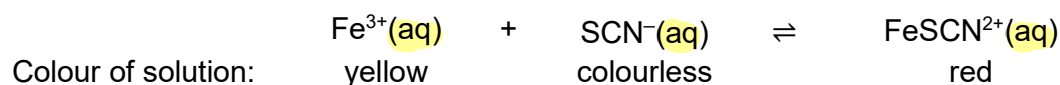


1 0

This question is about a reversible reaction.

The reaction between solutions of iron(III) ions (Fe^{3+}) and thiocyanate ions (SCN^-) is reversible.

The ionic equation for the reaction is:



The colour of the equilibrium mixture is orange at room temperature.

1 0 . 1

Give the name of the solvent used to dissolve the ions in this reaction.

[1 mark]

Aqueous, therefore water.

1 0 . 2

A few drops of a colourless solution containing a high concentration of thiocyanate ions (SCN^-) are added to the orange equilibrium mixture.

Explain the colour change observed.

[3 marks]

Becomes more red because the position of the equilibrium moves to the right.

Thus the concentration of FeSCN^{2+} (red) increases.



1 0 . 3 A water bath is set up at a temperature above room temperature.

When a test tube containing the orange equilibrium mixture is placed in the water bath, the mixture becomes more yellow.

Explain what this shows about the energy change for the forward reaction.

[3 marks]

Colour change indicates equilibrium moves to the left hand side - to reduce the temperature

This shows that the energy change for the forward reaction is exothermic

1 0 . 4 Explain why a change in pressure does **not** affect the colour of the equilibrium mixture.

[2 marks]

There are no gases present and therefore no change in equilibrium position.

1 0 . 5 Other metal ions form coloured equilibrium mixtures with thiocyanate ions.

Which metal ion could form a coloured equilibrium mixture with thiocyanate ions?

[1 mark]

Tick (✓) **one** box.

Al³⁺

Co²⁺

Mg²⁺

Na⁺

SCN⁻ ions form coloured complexes with certain metal ions due to the formation of co-ordination complexes.

Co²⁺ can form a deep blue coloured equilibrium mixture

Other metal ions form colourless complexes.

END OF QUESTIONS



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