AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

GCSE CHEMISTRY

H

Higher Tier Paper 1

Thursday 14 May 2020 Morning Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:
- a ruler
- a 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	
TOTAL	

Do not write outside the box

0 1 This question is about structure and bonding.

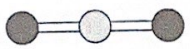
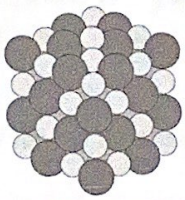
0 1 . 1 Which **two** substances have intermolecular forces between particles? **[2 marks]**

Tick (✓) **two** boxes.

- Diamond ☐
- Magnesium ☐
- Poly(ethene) ☑
- Sodium chloride ☐
- Water ☑

0 1 . 2 **Table 1** shows the structures of three compounds.

Table 1 **Diagrams not to scale**

Compound	Structure
Carbon dioxide	
Magnesium oxide	
Silicon dioxide	

Do not write outside the box

Compare the structure and bonding of the three compounds:

- carbon dioxide
- magnesium oxide
- silicon dioxide.

[6 marks]

carbon dioxide and silicon dioxide are both made of atoms but magnesium oxide is made up of ions. Silicon dioxide and magnesium oxide are giant structures but carbon dioxide is small molecules with weak intermolecular forces. All 3 compounds have strong bonds but both carbon dioxide and silicon dioxide are made from non-metals so the bonds are covalent and so share electrons between atoms. Magnesium oxide is formed from a metal and a non-metal so its bonds are ionic, magnesium donates 2 electrons to oxygen. In silicon dioxide each silicon forms 4 single bonds and each oxygen forms 2 single bonds but in carbon dioxide each carbon forms 2 double bonds and each oxygen forms one double bond.

8

Turn over for the next question

Do not write outside the box

0 2 This question is about metals and the reactivity series.

0 2 . 1 Which **two** statements are properties of most transition metals?

[2 marks]

Tick (✓) **two** boxes.

They are soft metals. ☐

They form colourless compounds. ☐

They form ions with different charges. ☑

They have high melting points. ☑

They have low densities. ☐

0 2 . 2 A student added copper metal to colourless silver nitrate solution.

The student observed:

- pale grey crystals forming
- the solution turning blue.

Explain how these observations show that silver is less reactive than copper.

[3 marks]

The grey crystals are silver and the copper ions produced are blue because the copper displaces the silver forming copper nitrate and silver.

Do not write outside the box

0 2 . 3 A student is given three metals, **X**, **Y** and **Z** to identify.

The metals are magnesium, iron and copper.

Plan an investigation to identify the three metals by comparing their reactions with dilute hydrochloric acid.

Your plan should give valid results.

[4 marks]

Start by measuring out the same concentration and volume of hydrochloric acid into 3 separate beakers. Then add the same mass and particle size of each metal into the beakers (1 metal per beaker). Measure the temperature ~~change~~ before and after the metal is added and calculate the ~~energy~~ temperature change for each metal. Copper will not react with the hydrochloric acid so there will be no temperature change. Magnesium and iron will both increase the temperature but magnesium will increase it more than iron.

Question 2 continues on the next page

Do not write outside the box

0 2 . 4 Metal **M** has two isotopes.

Table 2 shows the mass numbers and percentage abundances of the isotopes.

Table 2

Mass number	Percentage abundance (%)
203	30
205	70

Calculate the relative atomic mass (A_r) of metal **M**.

Give your answer to 1 decimal place.

[2 marks]

$\frac{(203 \times 30) + (205 \times 70)}{100} = 204.4$

Relative atomic mass (1 decimal place) = 204.4

11

Do not write outside the box

0 3 This question is about silver iodide.

Silver iodide is produced in the reaction between silver nitrate solution and sodium iodide solution.

The equation for the reaction is:

$$AgNO_3(aq) + NaI(aq) \rightarrow AgI(s) + NaNO_3(aq)$$

0 3 . 1 A student investigated the law of conservation of mass.

This is the method used.

1. Pour silver nitrate solution into a beaker labelled **A**.
2. Pour sodium iodide solution into a beaker labelled **B**.
3. Measure the masses of both beakers and their contents.
4. Pour the solution from beaker **B** into beaker **A**.
5. Measure the masses of both beakers and their contents again.

Table 3 shows the student's results.

Table 3

	Mass before mixing in g	**Mass after mixing in g**
Beaker **A** and contents	78.26	108.22
Beaker **B** and contents	78.50	48.54

Explain how the results demonstrate the law of conservation of mass.

You should use data from **Table 3** in your answer.

[2 marks]

78.26+78.5 = 156.76 = total mass before
108.22 + 48.54 = 156.76 = total mass after
The mass of the products equals the mass of the reactants

Do not write outside the box

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the mass of the products equals the mass of the reactants

Do not write outside the box

0 3 . 2 Suggest how the student could separate the insoluble silver iodide from the mixture at the end of the reaction.

[1 mark]

Filtration

The student purified the separated silver iodide.

This is the method used.

1. Rinse the silver iodide with distilled water.

2. Warm the silver iodide.

0 3 . 3 Suggest **one** impurity that was removed by rinsing with water.

[1 mark]

Sodium nitrate solution

0 3 . 4 Suggest why the student warmed the silver iodide.

[1 mark]

To remove water from it.

Question 3 continues on the next page

Do not write outside the box

0 3 . 5 Calculate the percentage atom economy for the production of silver iodide in this reaction.

The equation for the reaction is:

$$AgNO_3(aq) + NaI(aq) \rightarrow AgI(s) + NaNO_3(aq)$$

Give your answer to 3 significant figures.

Relative formula masses (M_r): $AgNO_3 = 170$ $NaI = 150$ $AgI = 235$ $NaNO_3 = 85$

[4 marks]

atom economy = $\frac{\text{Mr desired products}}{\text{Mr all reactants}} \times 100$

atom economy = $\frac{235}{170 + 150} \times 100$

$= \frac{235}{320} \times 100$

$= 73.4375$

Percentage atom economy (3 significant figures) = 73.4 %

0 3 . 6 Give **one** reason why reactions with a high atom economy are used in industry.

[1 mark]

For sustainable development

10

0 4 This question is about electrolysis.

A student investigated the electrolysis of copper chromate solution.

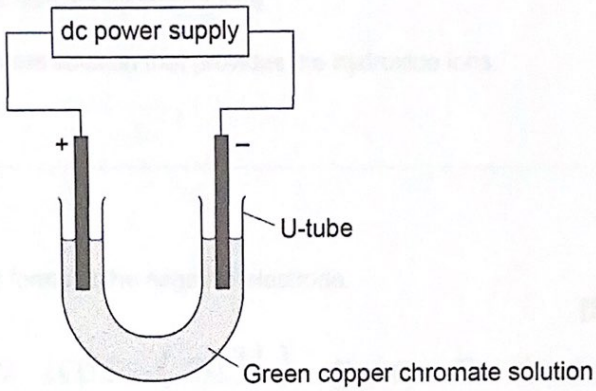
Copper chromate solution is green.

Copper chromate contains:

- blue coloured Cu^{2+} ions
- yellow coloured CrO_4^{2-} ions.

Figure 1 shows the apparatus used.

Figure 1



The student switched the power supply on.

The student observed the changes at each electrode.

Table 4 shows the student's observations.

Table 4

Changes at positive electrode	Changes at negative electrode
Solution turned yellow Bubbles formed at the electrode	Solution turned blue Solid formed on the electrode

Do not write outside the box

0 4 . 1 Explain why the colour changed at the positive electrode.

[2 marks]

The chromate ions (CrO_4^{2-}) moved to the positive electrode because they are negatively charged and opposite charges attract.

0 4 . 2 The gas produced at the positive electrode was oxygen.

The oxygen was produced from hydroxide ions.

Name the substance in the solution that provides the hydroxide ions.

[1 mark]

Water

0 4 . 3 Describe how the solid forms at the negative electrode.

[3 marks]

The copper ions (Cu^{2+}) gain 2 electrons to form copper atoms.

0 4 . 4 The student repeated the investigation using potassium iodide solution instead of copper chromate solution.

Name the product at each electrode when potassium iodide solution is electrolysed.

[2 marks]

Negative electrode Hydrogen

Positive electrode Iodine

8

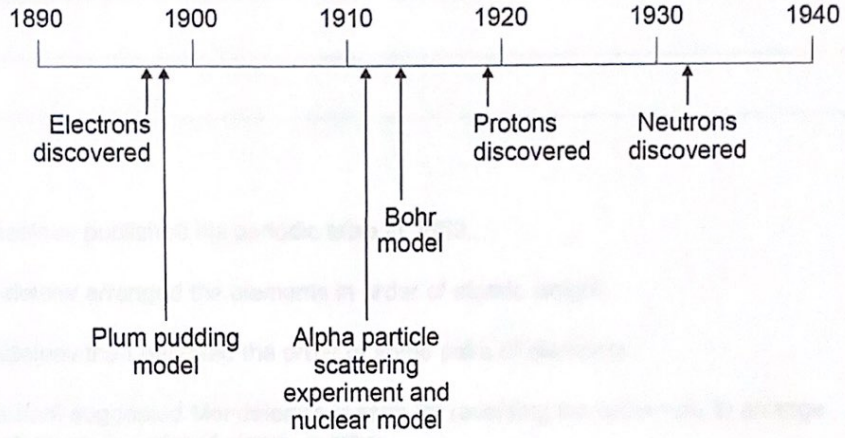
Turn over ▶

Do not write outside the box

0 5 This question is about the development of scientific theories.

Figure 2 shows a timeline of some important steps in the development of the model of the atom.

Figure 2



0 5 . 1 The plum pudding model did not have a nucleus.

Describe **three** other differences between the nuclear model of the atom and the plum pudding model.

[3 marks]

1 The nuclear model is mostly empty space but the plum pudding model has no empty space.

2 In the nuclear model, mass is concentrated in the nucleus but in the plum pudding model mass is spread out.

3 In the nuclear model the electrons are in orbits around the nucleus but in the plum pudding model electrons are embedded

Do not write outside the box

0 5 . 2 Niels Bohr adapted the nuclear model.

Describe the change that Bohr made to the nuclear model.

[2 marks]

Electrons orbit the nucleus at specific distances from the nucleus.

0 5 . 3 Mendeleev published his periodic table in 1869.

Mendeleev arranged the elements in order of atomic weight.

Mendeleev then reversed the order of some pairs of elements.

A student suggested Mendeleev's reason for reversing the order was to arrange the elements in order of atomic number.

Explain why the student's suggestion **cannot** be correct.

Use **Figure 2**.

[2 marks]

Atomic number is the number of protons but protons were not discovered until later

0 5 . 4 Give the correct reason why Mendeleev reversed the order of some pairs of elements.

[1 mark]

So their properties matched the rest of the group

8

Do not write outside the box

0 6 This question is about displacement reactions.

0 6 . 1 The displacement reaction between aluminium and iron oxide has a high activation energy.

What is meant by 'activation energy'?

[1 mark]

The minimum energy needed for a reaction to occur.

0 6 . 2 A mixture contains 1.00 kg of aluminium and 3.00 kg of iron oxide.

The equation for the reaction is:

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

Show that aluminium is the limiting reactant.

Relative atomic masses (A_r): O = 16 Al = 27 Fe = 56

[4 marks]

$\text{moles} = \frac{\text{mass}}{M_r}$

moles of $Fe_2O_3 = \frac{3000}{56+56+16+16+16} = 18.75$

moles of Al $= \frac{1000}{27} = 37$

$37 \div 2 = 18.5$

Iron oxide is in excess because 18.75 mol is more than the 18.5 mol. ~~am~~ needed.

Do not write outside the box

Magnesium displaces zinc from zinc sulfate solution.

0 6 . 3 Complete the ionic equation for the reaction.

You should include state symbols.

[2 marks]

$$Mg(s) + Zn^{2+}(aq) \rightarrow \underline{Mg^{2+}(aq)} + \underline{Zn(s)}$$

0 6 . 4 Explain why the reaction between magnesium atoms and zinc ions is both oxidation and reduction.

[2 marks]

Magnesium atoms are oxidised because they lose electrons and zinc ions are reduced because they gain electrons

9

Turn over for the next question

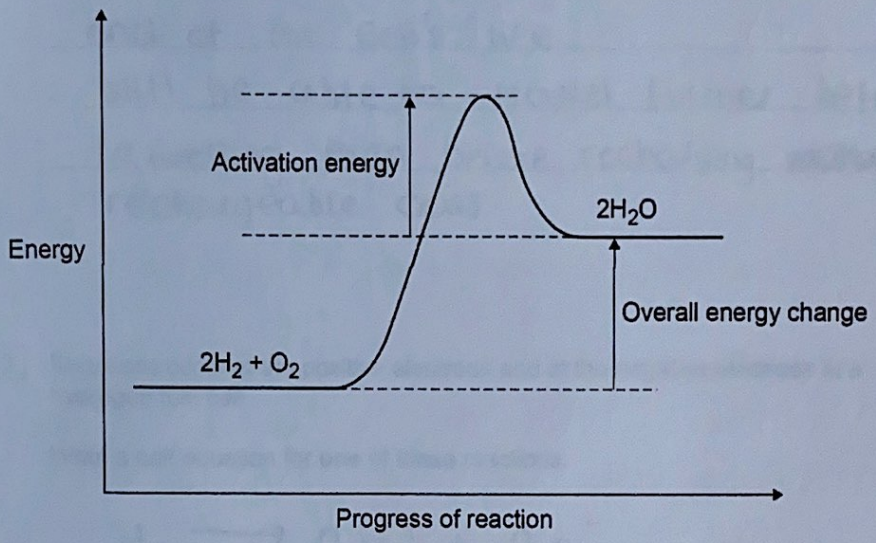
Do not write outside the box

0 7 The reaction between hydrogen and oxygen releases energy.

0 7 . 1 A student drew a reaction profile for the reaction between hydrogen and oxygen.

Figure 3 shows the student's reaction profile.

Figure 3



The student made **two** errors when drawing the reaction profile.

Describe the **two** errors.

[2 marks]

1 The activation energy line should be from the reactants line to the peak.

2 The products line should be below the reactants line

Do not write outside the box

0 7 . 2 The reaction between hydrogen and oxygen in a hydrogen fuel cell is used to produce electricity.

Hydrogen fuel cells and rechargeable cells are used to power some cars.

Give **two** advantages of using hydrogen fuel cells instead of using rechargeable cells to power cars.

[2 marks]

1 no toxic chemicals to dispose of at the end of the cell's life

2 will be able to travel further before refuelling than before recharging ~~rechargeable~~ rechargeable cells.

0 7 . 3 Reactions occur at the positive electrode and at the negative electrode in a hydrogen fuel cell.

Write a half equation for **one** of these reactions.

[1 mark]

$H_2 \longrightarrow 2H^+ + 2e^-$

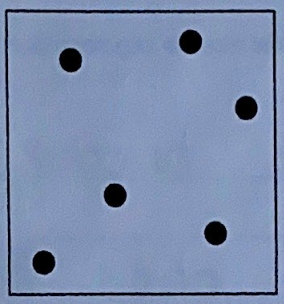
Question 7 continues on the next page

Do not write outside the box

0 7 . 4 The three states of matter can be represented by a simple particle model.

Figure 4 shows a simple particle model for hydrogen gas.

Figure 4



Give **two** limitations of this simple particle model for hydrogen gas.

[2 marks]

1 Hydrogen is not shown as H_2 molecules

2 Does not show the weak forces in between particles.

0 7 . 5 The hydrogen gas needed to power a car for 400 km would occupy a large volume.

Suggest **one** way that this volume can be reduced.

[1 mark]

Under higher pressure

Do not write outside the box

0 7 . 6 The energy needed for a car powered by a hydrogen fuel cell to travel 100 km is 58 megajoules (MJ).

The energy released when 1 mole of hydrogen gas reacts with oxygen is 290 kJ

The volume of 1 mole of a gas at room temperature and pressure is 24 dm^3

Calculate the volume of hydrogen gas at room temperature and pressure needed for the car to travel 100 km

[4 marks]

58 MJ = 58000 KJ

moles = $\frac{58000}{290}$ = 200

Volume of gas = moles of gas x 24

= 200 x 24

= 4800

Volume of hydrogen gas = 4800 dm^3

12

Turn over for the next question

Do not write outside the box

0 8 This question is about the halogens.

Table 5 shows the melting points and boiling points of some halogens.

Table 5

Element	Melting point in °C	Boiling point in °C
Fluorine	–220	–188
Chlorine	–101	–35
Bromine	–7	59

0 8 . 1 What is the state of bromine at 0 °C **and** at 100 °C?

[1 mark]

Tick (✓) **one** box.

State at 0 °C	State at 100 °C	
Gas	Gas	☐
Gas	Liquid	☐
Liquid	Gas	☑
Liquid	Liquid	☐
Solid	Gas	☐
Solid	Liquid	☐

Do not write outside the box

0 8 . 2 Explain the trend in boiling points of the halogens shown in **Table 5.**

[4 marks]

The boiling point increases down the group because the relative formula mass increases and the size of the molecule increases. This means the intermolecular forces increase in strength and so more energy is needed to overcome the intermolecular forces.

0 8 . 3 Why is it **not** correct to say that the boiling point of a single bromine molecule is 59 °C?

[1 mark]

Boiling point is a bulk property.

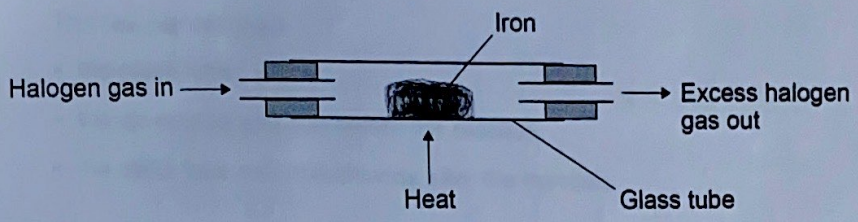
Question 8 continues on the next page

Do not write outside the box

Iron reacts with each of the halogens in their gaseous form.

Figure 5 shows the apparatus used.

Figure 5



0 8 . 4 Give **one** reason why this experiment should be done in a fume cupboard.

[1 mark]

The halogen is toxic

0 8 . 5 Explain why the reactivity of the halogens decreases going down the group.

[3 marks]

Going down the group the outer electrons become further from the nucleus due to more shells so the nucleus has less attraction for the outer electrons and an electron is gained less easily.

Do not write outside the box

0 8 . 6 A teacher investigated the reaction of iron with chlorine using the apparatus in **Figure 5**.

The word equation for the reaction is:

iron + chlorine → iron chloride

The teacher weighed:

- the glass tube
- the glass tube and iron before the reaction
- the glass tube and iron chloride after the reaction.

Table 6 shows the teacher's results.

Table 6

	Mass in g
Glass tube	51.56
Glass tube and iron	56.04
Glass tube and iron chloride	64.56

Calculate the simplest whole number ratio of:

moles of iron atoms : moles of chlorine atoms

Determine the balanced equation for the reaction.

Relative atomic masses (A_r): Cl = 35.5 Fe = 56

[6 marks]

mass of iron = 56.04 - 51.56 = 4.48 g

mass of ~~iron chloride~~ chlorine = ~~64.56 - 51.56~~ 64.56 - 51.56 = 8.52 g

moles = $\frac{\text{mass}}{\text{Mr}}$ moles Fe = $\frac{4.48}{56}$ = 0.08

moles of Cl = $\frac{8.52}{35.5}$ = 0.24

0.08 : 0.24

1 : 3

Moles of iron atoms : moles of chlorine atoms = 1 : 3

Equation for the reaction 2Fe + 3 Cl_2 → 2 $FeCl_3$

16

Do not write outside the box

0 9 This question is about citric acid ($C_6H_8O_7$).

Citric acid is a solid.

A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

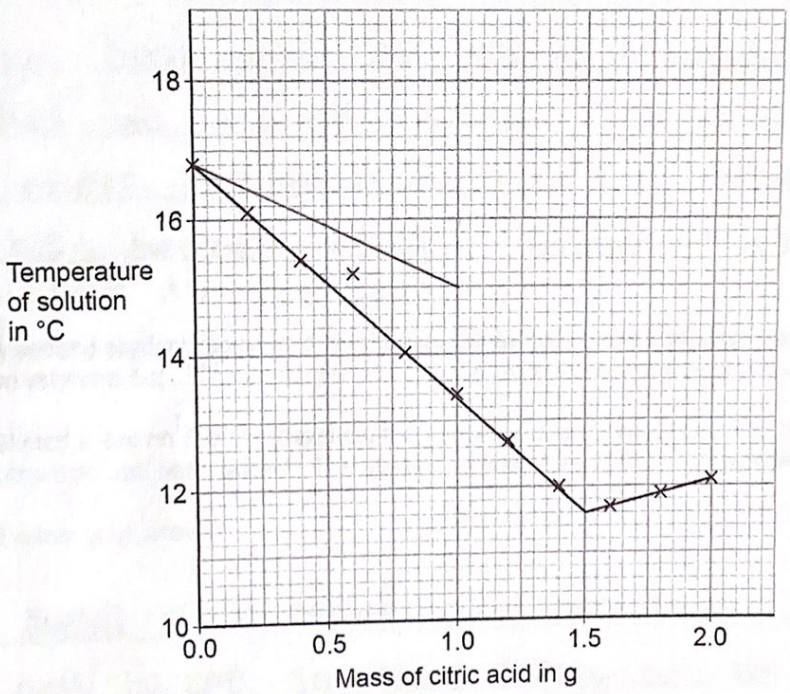
This is the method used.

1. Pour 25 cm^3 of sodium hydrogencarbonate solution into a polystyrene cup.
2. Measure the temperature of the sodium hydrogencarbonate solution.
3. Add 0.20 g of citric acid to the polystyrene cup.
4. Stir the solution.
5. Measure the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 2.00 g of citric acid has been added.

The student plotted the results on a graph.

Figure 6 shows the student's graph.

Figure 6



Do not write outside the box

0 9 . 1 **Figure 6** shows an anomalous point when 0.60 g of citric acid was added. This was caused by the student making an error.

The student correctly:

- measured the mass of the citric acid
- read the thermometer
- plotted the point.

Suggest **one** reason for the anomalous point.

[1 mark]

Didn't stir the solution enough

0 9 . 2 Explain the shape of the graph in terms of the energy transfers taking place.

You should use data from **Figure 6** in your answer.

[3 marks]

Initially the temperature decreases because energy is taken in by the reaction. After 1.5g of citric acid has been added the sodium hydrogen carbonate has all reacted so the citric acid is in excess. The temperature starts to increase after 1.5g because energy is transferred from the room to the solution.

0 9 . 3 A second student repeated the investigation using a metal container instead of the polystyrene cup. The container and the cup were the same size and shape.

Sketch a line on **Figure 6** to show the second student's results until 1.00 g of citric acid had been added. The starting temperature of the solution was the same.

Explain your answer.

[3 marks]

Metal is a better conductor than polystyrene so more energy will be absorbed from the surroundings and the solution will cool less.

Do not write outside the box

The student used a solution of citric acid to determine the concentration of a solution of sodium hydroxide by titration.

0 9 . 4 The student made 250 cm^3 of a solution of citric acid of concentration 0.0500 mol/dm^3

Calculate the mass of citric acid ($C_6H_8O_7$) required.

Relative atomic masses (A_r): H = 1 C = 12 O = 16

[3 marks]

Mr citric acid = ~~[illegible]~~ $(12 \times 6) + (1 \times 8) + (7 \times 16)$

$= 192$

moles = concentration x volume $= 0.05 \times \frac{250}{1000}$

$= 0.0125$

mass = moles x mr $= 0.0125 \times 192 = 2.4$ g

Mass = 2.4 g

This is part of the method the student used for the titration.

1. Measure 25.0 cm^3 of the sodium hydroxide solution into a conical flask using a pipette.
2. Add a few drops of indicator to the flask.
3. Fill a burette with citric acid solution.

0 9 . 5 Describe how the student would complete the titration.

[3 marks]

The student should add the citric acid to the flask of sodium hydroxide dropwise, swirling the flask after every drop to mix the solution. Stop when you a colour change is noticed in the flask and ~~measure~~ measure how much has been added (volume of citric acid needed for colour change)

Do not write outside the box

0 9 . 6 Give **two** reasons why a burette is used for the citric acid solution.

[2 marks]

1 so the citric acid can be added in small increments

2 Burettes are more accurate than measuring cylinders

0 9 . 7 13.3 cm^3 of 0.0500 mol/dm^3 citric acid solution was needed to neutralise 25.0 cm^3 of sodium hydroxide solution.

The equation for the reaction is:

$$3NaOH + C_6H_8O_7 \rightarrow C_6H_5O_7Na_3 + 3H_2O$$

Calculate the concentration of the sodium hydroxide solution in mol/dm^3

[3 marks]

moles = concn. x volume

moles of $C_6H_8O_7 = \frac{13.3}{1000} \times 0.05 = 0.000665$

3:1 ratio in equation so,

moles of NaOH $= 0.000665 \times 3 = 0.001995$

concentration of NaOH $= \frac{\text{moles}}{\text{volume}} = \frac{0.001995}{25 \div 1000} = \frac{0.001995}{0.025}$

$= 0.0798$

Concentration = 0.0798 mol/dm^3

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END OF QUESTIONS