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.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
TOTAL	

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.

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) ☑

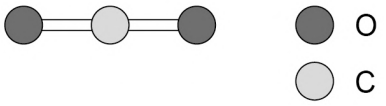
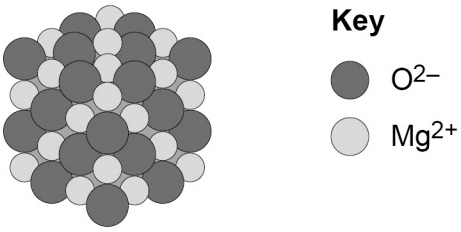
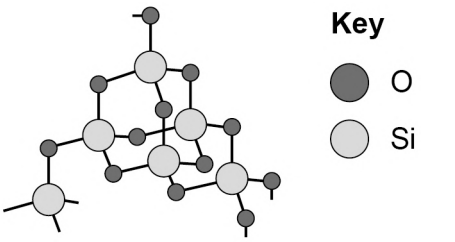
Sodium chloride ☐

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]

Indicative content

- (both) carbon dioxide and silicon dioxide are made up of atoms
- (but) magnesium oxide is made up of ions

- (both) silicon dioxide and magnesium oxide are giant structures
- (but) carbon dioxide is small molecules
- with weak intermolecular forces

- all three compounds have strong bonds
- (both) carbon dioxide and silicon dioxide are formed from two non-metals
- (so) bonds formed are covalent

- (so) electron (pairs) are shared (between atoms)

- (but) magnesium oxide is formed from a metal and a non-metal
- (so) bonds in magnesium oxide are ionic
- (so) electrons are transferred
- from magnesium to oxygen
- two electrons are transferred

- bonds in silicon dioxide are single bonds
- (where) each silicon forms four bonds

- (and) each oxygen forms two bonds

- (but) in carbon dioxide the bonds are double bonds
- (where) carbon forms two double bonds
- (and) 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

the copper ions (produced) are blue

(because) copper displaces 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]

Indicative content

Key steps
• add the metals to (dilute) hydrochloric acid
• measure temperature change or compare rate of bubbling or compare colour of resulting solution for copper:
• no reaction
• shown by no temperature change or shown by no bubbles

for magnesium and iron:

• magnesium increases in temperature more than iron
or
magnesium bubbles faster than iron
or
magnesium forms a colourless solution and iron forms a coloured solution

Control variables
• same concentration / volume of hydrochloric acid
• same mass / moles of metal
• same particle size of metal
• same temperature (of acid if comparing rate of bubbling)

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]

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

or

$$\frac{6090 + 14\,350}{100}$$

Relative atomic mass (1 decimal place) = 204.4

11

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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]

(total) mass before = 156.76 (g) and
(total) mass after = 156.76 (g)
(so) the mass of 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]

filter / 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 / evaporate the water

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]

(total Mr = 170 + 150) = 320

(% atom economy =)

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

= 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

Do not write outside the box

Turn over for the next question

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0 4 This question is about electrolysis.

A student investigated the electrolysis of copper chromate solution.

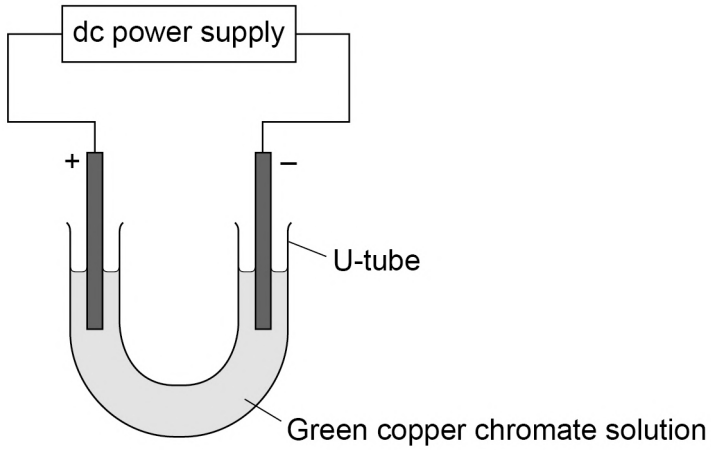
Copper chromate solution is green.

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]

CrO42- / chromate ions moved to the positive electrode

(because) 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]

copper ions gain two 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

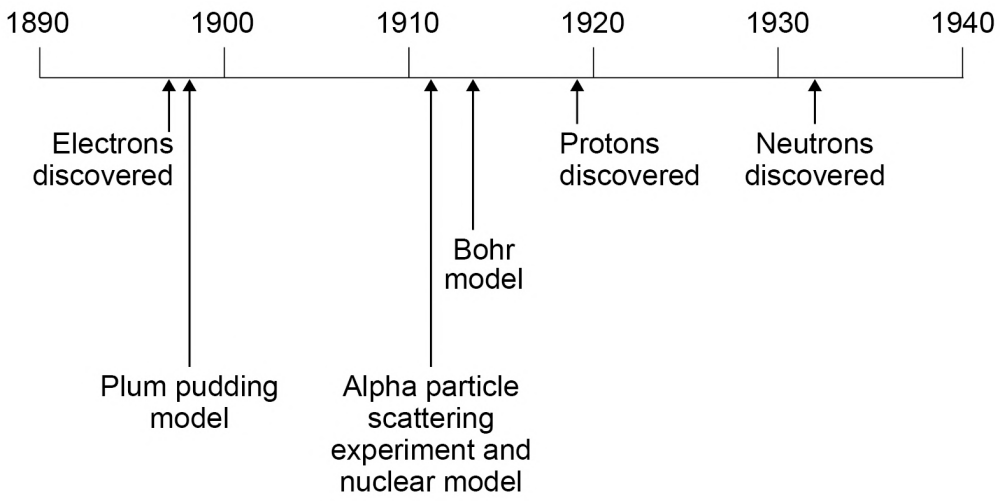
Turn over ►

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 positive charge is (all) in the nucleus

2 • the mass is concentrated in the nucleus

3 • the electrons and the nucleus are separate

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

electrons are 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

(and) 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 particles to react

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

The equation for the reaction is:

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

Show that aluminium is the limiting reactant.

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

[4 marks]

(Mr of Fe2O3 =) 160

(moles Fe2O3 = $\frac{3000}{160}$

= 18.75 (mol)

(moles Al = $\frac{1000}{27}$

= 37.0 (mol)

(aluminium is limiting because) 37.0 mol is less than the (2 x 18.75 =) 37.5 mol (aluminium 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]

$$Mg(s) + Zn^{2+}(aq) \rightarrow \underline{Mg2+(aq)} + \underline{Zn(s)}$$

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

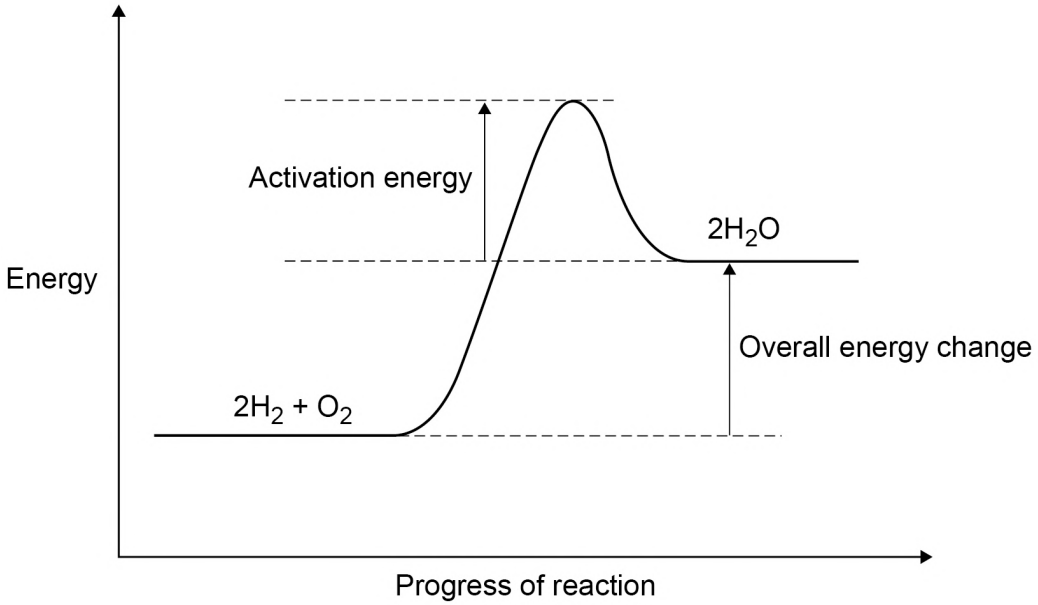
Do not write outside the box

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 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 take less time to refuel (than to recharge 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]

$H_2 \text{ -----> } 2H^+ + 2e^-$

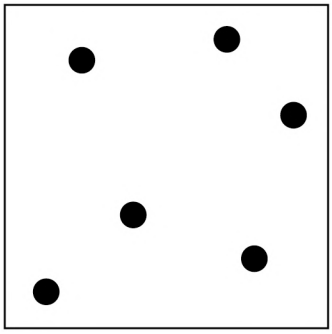
Question 7 continues on the next page

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 H2 / molecules

2 • particles are shown as spheres

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 =) 58 000 kJ or (290 kJ =) 0.290 MJ

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

or $\frac{58}{0.290}$

= 200

(volume =) 200 × 24

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]

(boiling point) increases (down the table / group)

(because) the relative formula / molecular mass increases
or
(because) the size of the molecule increases

(so) the intermolecular forces increase (in strength)

(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]

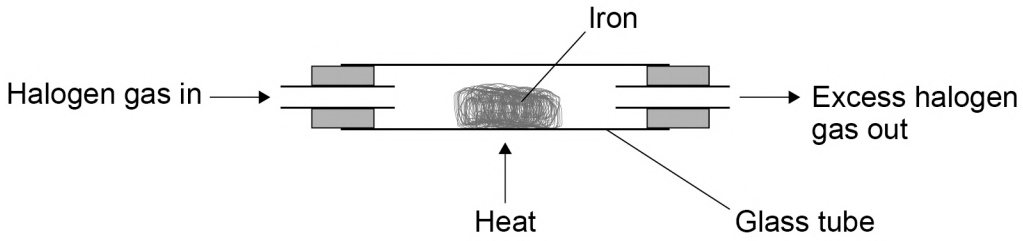
boiling point is a bulk property

Question 8 continues on the next page

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 gas / 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 / shell
become further from the nucleus

(so) the nucleus has less
attraction for the outer electrons
/ shell

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]

4.48 (g iron) and 8.52 (g chlorine)

(moles Fe = $\frac{4.48}{56}$ = 0.08

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

(Fe : Cl = 0.08 : 0.24 =) 1 : 3

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

Equation for the reaction 2 Fe + 3 Cl2------>2 FeCl3

16

Turn over ►

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.

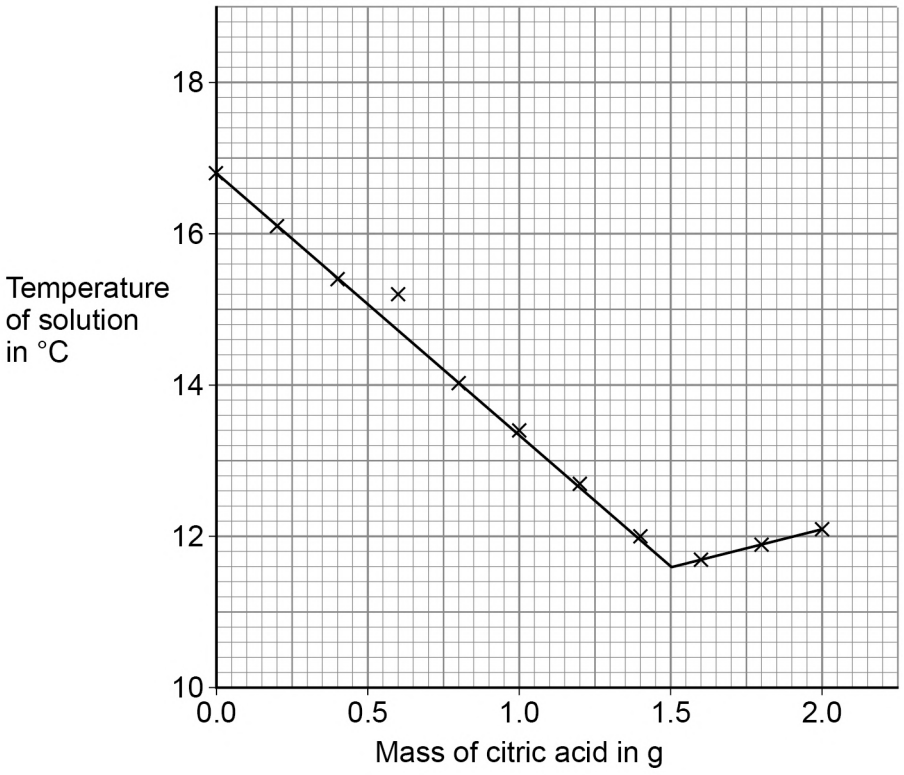
5. Measure the temperature of the solution.

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]

the temperature decreases (initially) because energy is taken in (by the reaction from the solution)

when 1.5 g (of citric acid) is added the sodium hydrogencarbonate has all reacted

so) the temperature increases

as 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]

less steep line starting at 16.8 °C and reaching 1.00 g (of citric acid)

(as) metal is a better conductor

(so) more energy is absorbed (from the surroundings)

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 =) 192

(moles = $\frac{250}{1000}$ × 0.0500)

= 0.0125

(mass = 0.0125 × 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]

add the citric acid (to the flask) until there is a (permanent) colour change

measure / record the volume (of citric acid) added

any one from:
- swirl
- use a white tile

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 can measure variable volumes

2 • more accurate than a measuring cylinder

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:

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

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

[3 marks]

(moles citric acid = $\frac{13.3}{1000} \times 0.0500 = 0.000665$

(moles NaOH = 3 × 0.000665) = 0.001995

(conc = $\frac{1000}{25} \times 0.001995$

Concentration = 0.0798 mol/dm^3

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END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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