Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

GCSE CHEMISTRY

H

Higher Tier Paper 1

Thursday 16 May 2019 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.
- 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.
- 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	

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

Do not write outside the box

0 1 This question is about the periodic table.

In the 19th century, some scientists tried to classify the elements by arranging them in order of their atomic weights.

Figure 1 shows the periodic table Mendeleev produced in 1869.

His periodic table was more widely accepted than previous versions.

Figure 1

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Period 1	H						
Period 2	Li	Be	B	C	N	O	F
Period 3	Na	Mg	Al	Si	P	S	Cl
Period 4	K Cu	Ca Zn	* *	Ti *	V As	Cr Se	Mn Br
Period 5	Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	* I

0 1 . 1 The atomic weight of tellurium (Te) is 128 and that of iodine (I) is 127

Why did Mendeleev reverse the order of these two elements?

[1 mark]

so elements / iodine / tellurium were in groups with similar properties

Do not write outside the box

0 1 . 2 Mendeleev left spaces marked with an asterisk *

He left these spaces because he thought missing elements belonged there.

Why did Mendeleev's periodic table become more widely accepted than previous versions?

[3 marks]

Mendeleev had predicted properties of missing elements

elements were discovered (that filled the spaces / gaps)

properties (of these elements) matched Mendeleev's predictions

0 1 . 3 Mendeleev arranged the elements in order of their atomic weight.

What is the modern name for atomic weight?

[1 mark]

Tick (✓) **one** box.

Atomic number	
Mass number	
Relative atomic mass	✓
Relative formula mass	

0 1 . 4 Complete the sentence.

[1 mark]

In the modern periodic table, the elements are arranged in order of

(increasing) atomic / proton number .

Do not write outside the box

Chlorine, iodine and astatine are in Group 7 of the modern periodic table.

0 1 . 5 Astatine (At) is below iodine in Group 7.

Predict:

- the formula of an astatine molecule
- the state of astatine at room temperature.

[2 marks]

Formula of astatine molecule At2

State at room temperature solid

0 1 . 6 Sodium is in Group 1 of the modern periodic table.

Describe what you would see when sodium reacts with chlorine.

[2 marks]

(white) solid forms

• colour of gas / chlorine disappears / fades

10

Do not write outside the box

0 2 This question is about acids and alkalis.

0 2 . 1 Which ion do all acids produce in aqueous solution?

[1 mark]

Tick (✓) **one** box.

H^+ ☑

H^- ☐

O^{2-} ☐

OH^- ☐

0 2 . 2 Calcium hydroxide solution reacts with an acid to form calcium chloride.

Complete the word equation for the reaction.

[2 marks]

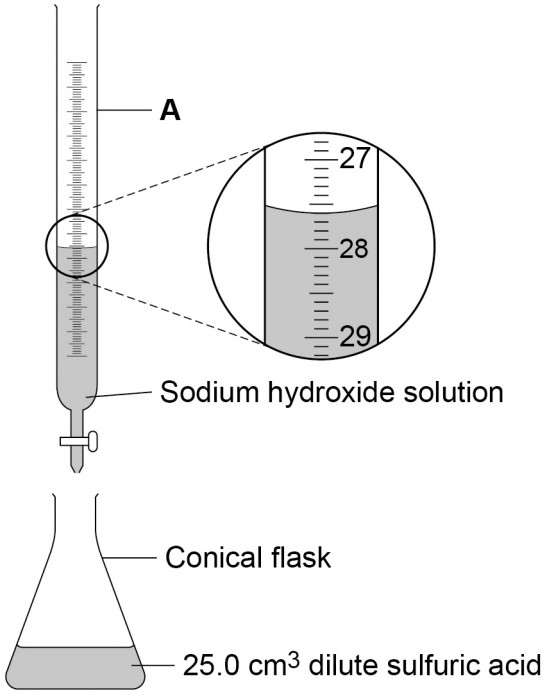
calcium hydroxide + hydrochloric (acid) acid → calcium chloride + water

Question 2 continues on the next page

A student investigates the volume of sodium hydroxide solution that reacts with 25.0 cm^3 of dilute sulfuric acid.

Figure 2 shows the apparatus the student uses.

Figure 2



Use **Figure 2** to answer Questions **02.3** and **02.4**

0 2 . 3 Name apparatus **A**.

[1 mark]

burette

0 2 . 4 What is the reading on apparatus **A**?

[1 mark]

27.6 (cm3) cm^3

Do not write outside the box

0 2 . 5 The higher the concentration of a sample of dilute sulfuric acid, the greater the volume of sodium hydroxide needed to neutralise the acid.

The student tested two samples of dilute sulfuric acid, **P** and **Q**.

Describe how the student could use titrations to find which sample, **P** or **Q**, is more concentrated.

[6 marks]

Indicative content

allow converse using acid added to alkali

Key steps

- measure the volume of acid
- add indicator to the acid
- add sodium hydroxide solution
- until the colour changes
- record volume of sodium hydroxide solution added
- repeat procedure with the other acid

Use of results

- compare the two volumes of sodium hydroxide solution to find which sample P or Q is more concentrated

Other points

- pipette to measure volume of acid
- use a few drops of indicator
- swirl
- use a white tile
- rough titration to find approximate end point
- add dropwise near the endpoint
- read volume from bottom of meniscus
- repeat and take a mean

11

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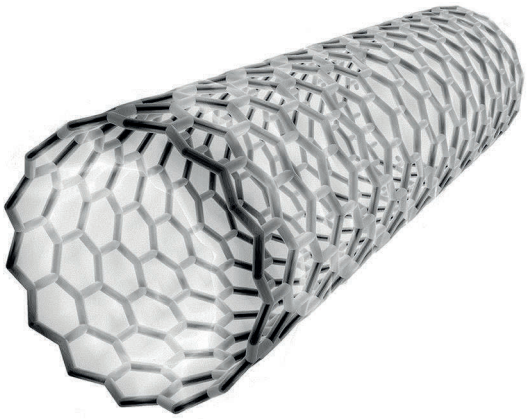
0 3 This question is about materials and their properties.

0 3 . 1 **Figure 3** shows a carbon nanotube.

Figure 3



The structure and bonding in a carbon nanotube are similar to graphene.

Carbon nanotubes are used in electronics because they conduct electricity.

Explain why carbon nanotubes conduct electricity.

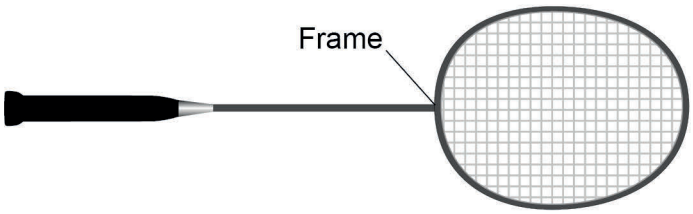
[2 marks]

contain delocalised electrons

(so) electrons can move through the structure / nanotube

0 3 . 2 **Figure 4** shows a badminton racket.

Figure 4



Do not write outside the box

Table 1 shows some properties of materials.

The materials could be used to make badminton racket frames.

Table 1

Material	Density in g/cm^3	Relative strength	Relative stiffness
Aluminium	2.7	0.3	69
Carbon nanotube	1.5	60	1000
Wood	0.71	0.1	10

Evaluate the use of the materials to make badminton racket frames.

Use **Table 1**.

[4 marks]

Indicative content

- wood is the least dense so lightest to use
- aluminium is the most dense so will make the racket too heavy
- carbon nanotube is the strongest so least likely to break
- wood / aluminium are too weak so the racket will break more easily
- carbon nanotube is the stiffest so least likely to bend out of shape
- wood / aluminium are not very stiff so could bend out of shape
- justified conclusion

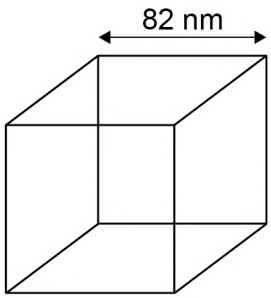
Do not write outside the box

Zinc oxide can be produced as nanoparticles and as fine particles.

0 3 . 3 A nanoparticle of zinc oxide is a cube of side 82 nm

Figure 5 represents a nanoparticle of zinc oxide.

Figure 5



Calculate the surface area of a nanoparticle of zinc oxide.

Give your answer in standard form.

[3 marks]

$(82)^2 = 6724$ (nm2)

(6 x 6724) = 40344 (nm2)

Surface area = 4.0×10^4(nm2) nm^2

0 3 . 4 Some suncreams contain zinc oxide as nanoparticles or as fine particles.

Suggest **one** reason why it costs less to use nanoparticles rather than fine particles in suncreams.

[1 mark]

less can be used (for the same effect)

10

Do not write outside the box

0 4 This question is about atomic structure.

0 4 . 1 Atoms contain subatomic particles.

Table 2 shows properties of two subatomic particles.

Complete **Table 2**.

[2 marks]

Table 2

Name of particle	Relative mass	Relative charge
neutron	1	0
proton	1	+1

An element **X** has two isotopes.

The isotopes have different mass numbers.

0 4 . 2 Define mass number.

[1 mark]

number of protons plus neutrons

0 4 . 3 Why is the mass number different in the two isotopes?

[1 mark]

(the isotopes contain) different numbers of neutrons

Question 4 continues on the next page

Do not write outside the box

0 4 . 4 The model of the atom changed as new evidence was discovered.

The plum pudding model suggested that the atom was a ball of positive charge with electrons embedded in it.

Evidence from the alpha particle scattering experiment led to a change in the model of the atom from the plum pudding model.

Explain how.

[4 marks]

most (alpha) particles passed (straight) through (the gold foil)

(so) the mass of the atom is concentrated in the nucleus / centre

or

(so) most of the atom is empty space

some (alpha) particles were deflected / reflected

(so) the atom has a (positively) charged nucleus / centre

8

Do not write outside the box

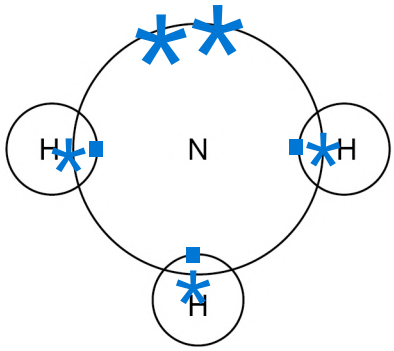
0 5 This question is about ammonia, NH_3

0 5 . 1 Complete the dot and cross diagram for the ammonia molecule shown in **Figure 6**.

Show only the electrons in the outer shell of each atom.

[2 marks]

Figure 6



0 5 . 2 Give **one** limitation of using a dot and cross diagram to represent an ammonia molecule.

[1 mark]

does not show the shape
or
only two-dimensional

0 5 . 3 Explain why ammonia has a low boiling point.

You should refer to structure and bonding in your answer.

[3 marks]

(ammonia has) small molecules

(ammonia has) weak intermolecular forces

(so) little energy is needed to overcome the intermolecular forces

Turn over ►

Do not write outside the box

Ammonia reacts with oxygen in the presence of a metal oxide catalyst to produce nitrogen and water.

0 5 . 4 Which metal oxide is most likely to be a catalyst for this reaction?

[1 mark]

Tick (✓) **one** box.

CaO ☐

Cr_2O_3 ☑

MgO ☐

Na_2O ☐

Figure 7 shows the displayed formula equation for the reaction.

Figure 7

Table 3 shows some bond energies.

Table 3

Bond	N — H	O = O	N ≡ N	O — H
Bond energy in kJ/mol	391	498	945	464

Do not write outside the box

0 5 . 5 Calculate the overall energy change for the reaction.

Use **Figure 7** and **Table 3**.

[3 marks]

(for bonds broken)
((12 x 391) + (3 x 498) =) 6186

(for bonds made)
((2 x 945) + (12 x 464) =) 7458

(overall energy change = 6186
7458 =) (-)1272 (kJ)

Overall energy change = (-)1272 kJ

0 5 . 6 Explain why the reaction between ammonia and oxygen is exothermic.

Use values from your calculation in Question **05.5**

[2 marks]

7458 (kJ) (released in making bonds) is greater than 6186 (kJ)

(used in breaking bonds) or

the products have 1272 (kJ) less energy than the reactants

(so) energy is released (to the surroundings)

Question 5 continues on the next page

Do not write outside the box

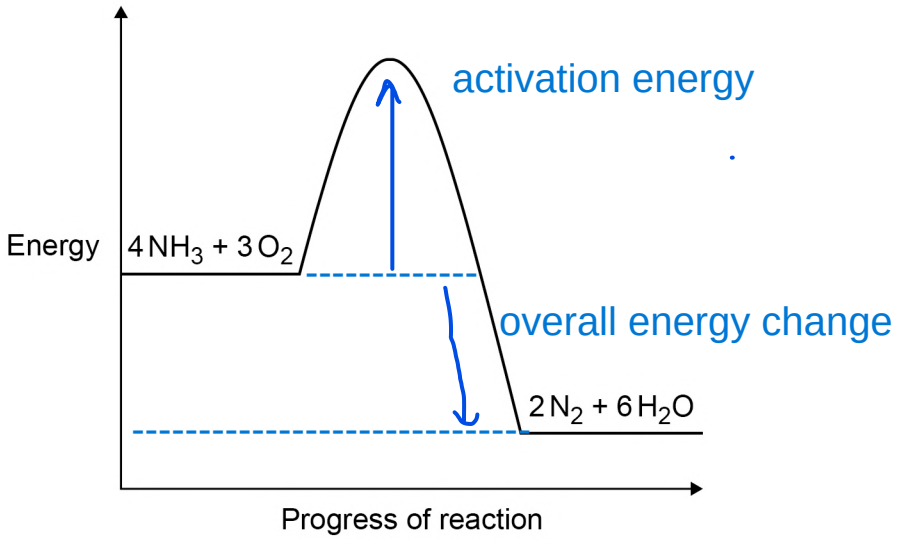
0 5 . 7 **Figure 8** shows the reaction profile for the reaction between ammonia and oxygen.

Complete **Figure 8** by labelling the:

- activation energy
- overall energy change.

[2 marks]

Figure 8



14

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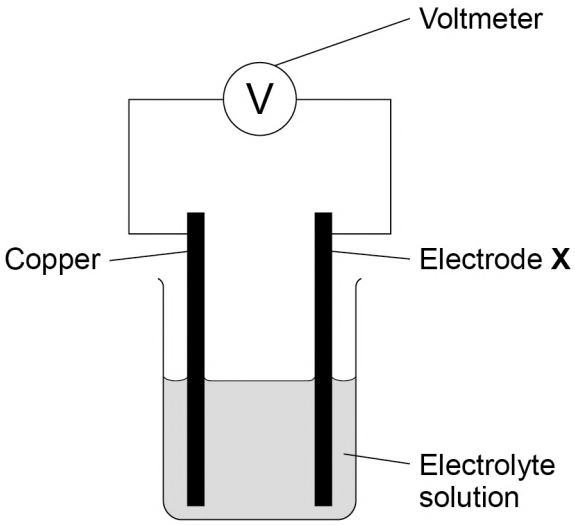
0 6 This question is about chemical cells.

A student investigated the voltage produced by different chemical cells.

Figure 9 shows the apparatus.

Figure 9



This is the method used.

1. Use cobalt as electrode **X**.

2. Record the cell voltage.

3. Repeat steps 1 and 2 using different metals as electrode **X**.

0 6 . 1 Suggest **two** control variables used in this investigation.

[2 marks]

1 temperature (of solution)

2 • concentration of electrolyte / solution

Turn over ►

Do not write outside the box

Table 4 shows the student's results.

Table 4

Electrode X	Voltage of cell in volts
cobalt	+0.62
copper	0.00
magnesium	+2.71
nickel	+0.59
silver	–0.46
tin	+0.48

0 6 . 2 Write the six metals used for electrode **X** in order of reactivity.

Use **Table 4**.

Justify your order of reactivity.

[4 marks]

Most reactive magnesium

cobalt

nickel

tin

copper

Least reactive silver

Justification the higher the (positive) voltage, the more reactive (the metal) silver has a negative voltage because silver is less reactive than copper

Do not write outside the box

0 6 . 3 Which of the following pairs of metals would produce the greatest voltage when used as the electrodes in the cell?

Use **Table 4**.

[1 mark]

Tick (✓) **one** box.

Magnesium and cobalt	☐
Magnesium and tin	✓
Nickel and cobalt	☐
Nickel and tin	☐

0 6 . 4 Hydrogen fuel cells can be used to power different forms of transport.

Some diesel trains are being converted to run on hydrogen fuel cells.

A newspaper article referred to the converted trains as the new 'steam trains'.

Suggest why.

[2 marks]

(in a fuel cell) hydrogen is oxidised (to produce water)

06.4

water is produced / released as gas / vapour / steam

9

Do not write outside the box

0 7 This question is about electrolysis.

Aluminium is produced by electrolysing a molten mixture of aluminium oxide and cryolite.

0 7 . 1 Explain why a mixture is used as the electrolyte instead of using only aluminium oxide.

[2 marks]

mixture has a lower melting point (than aluminium oxide)

(so) less energy needed

0 7 . 2 What happens at the negative electrode during the production of aluminium?

[1 mark]

Tick (✓) **one** box.

- Aluminium atoms gain electrons. ☐
- Aluminium atoms lose electrons. ☐
- Aluminium ions gain electrons. ☑
- Aluminium ions lose electrons. ☐

0 7 . 3 Oxygen is produced at the positive electrode.

Complete the balanced half-equation for the process at the positive electrode.

[2 marks]

$2\ O^{-2} \rightarrow O_2 + 4\ e^-$

Do not write outside the box

0 7 . 4 Explain why the positive electrode must be continually replaced.

[3 marks]

the electrode reacts with oxygen

the electrode is carbon / graphite

(so) carbon dioxide is produced

0 7 . 5 The overall equation for the electrolysis of aluminium oxide is:

$$2\,Al_2O_3 \rightarrow 4\,Al + 3\,O_2$$

Calculate the mass of oxygen produced when 2000 kg of aluminium oxide is completely electrolysed.

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

[4 marks]

(Mr of Al2O3 =) 102

$\frac{2\,000\,000}{102}$ =19 608 (mol Al2O3)

19 608 × $\frac{3}{2}$

= 29 412 (mol O2)

$\frac{29\,412 \times 32}{1000}$

Mass of oxygen = 941 kg

Do not write outside the box

Sodium metal and chlorine gas are produced by the electrolysis of molten sodium chloride.

0 7 . 6 Explain why sodium chloride solution **cannot** be used as the electrolyte to produce sodium metal.

[2 marks]

hydrogen (gas) would be produced (instead of sodium)

(because) sodium is more reactive than hydrogen

0 7 . 7 Calculate the volume of 150 kg of chlorine gas at room temperature and pressure.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3

Relative formula mass (M_r): $Cl_2 = 71$

[2 marks]

(volume of 1 g of Cl2 = $\frac{24}{71}$

=0.34 (dm3)

$\frac{(150\ 000)}{71}$ x 24

Volume = 50700 dm^3

16

Do not write outside the box

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

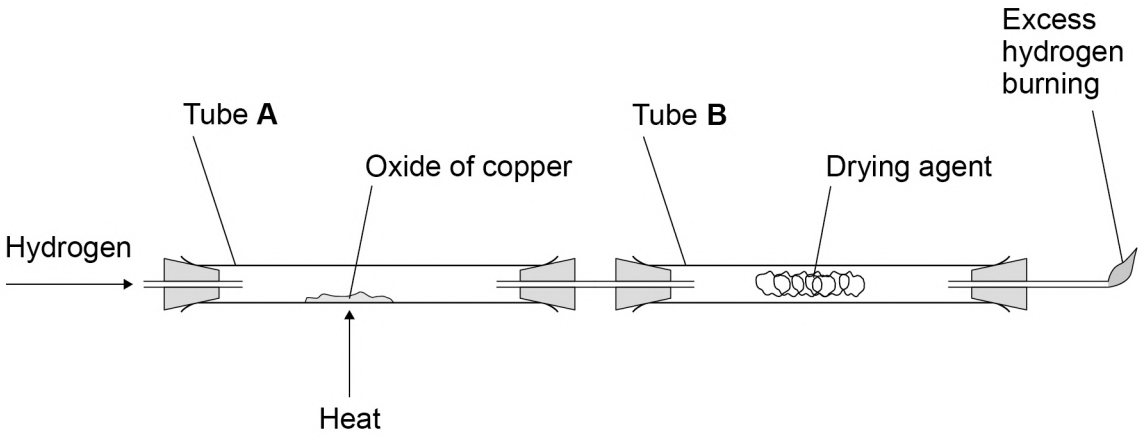
Do not write outside the box

0 8 Copper forms two oxides, Cu_2O and CuO

A teacher investigated an oxide of copper.

Figure 10 shows the apparatus.

Figure 10



This is the method used.

1. Weigh empty tube **A**.
2. Add some of the oxide of copper to tube **A**.
3. Weigh tube **A** and the oxide of copper.
4. Weigh tube **B** and drying agent.
5. Pass hydrogen through the apparatus and light the flame at the end.
6. Heat tube **A** for 2 minutes.
7. Reweigh tube **A** and contents.
8. Repeat steps 5 to 7 until the mass no longer changes.
9. Reweigh tube **B** and contents.
10. Repeat steps 1 to 9 with different masses of the oxide of copper.

Do not write outside the box

0 8 . 1 Suggest **one** reason why step 8 is needed.

[1 mark]

to make sure all of the oxide (of copper) has reacted

0 8 . 2 Explain why the excess hydrogen must be burned off.

[2 marks]

to prevent hydrogen escaping (into the air)

(because) hydrogen is explosive

Question 8 continues on the next page

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Figure 10 is repeated here.

Figure 10

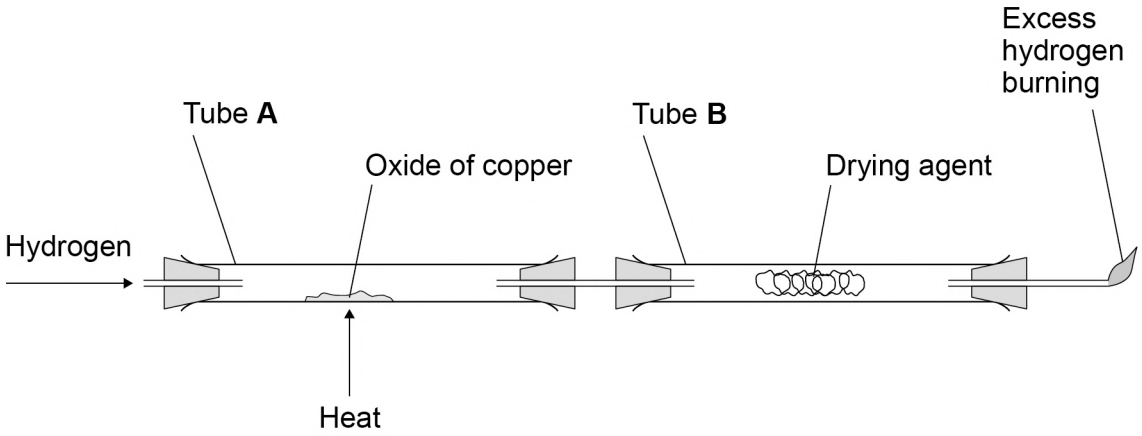

Table 5 shows the teacher's results.

Table 5

	Mass in g
Tube **A** empty	105.72
Tube **A** and oxide of copper before heating	115.47
Tube **A** and contents after 2 minutes	114.62
Tube **A** and contents after 4 minutes	114.38
Tube **A** and contents after 6 minutes	114.38
Tube **B** and contents at start	120.93
Tube **B** and contents at end	123.38

When an oxide of copper is heated in a stream of hydrogen, the word equation for the reaction is:

copper oxide + hydrogen → copper + water

Do not write outside the box

0 8 . 3 Determine the mass of copper and the mass of water produced in this experiment.

Use **Table 5**.

[2 marks]

Mass of copper = 8.66 g

Mass of water = 2.45 g

0 8 . 4 The teacher repeated the experiment with a different sample of the oxide of copper.

The teacher found that the oxide of copper produced 2.54 g of copper and 0.72 g of water.

Two possible equations for the reaction are:

Equation 1: $Cu_2O + H_2 \rightarrow 2Cu + H_2O$

Equation 2: $CuO + H_2 \rightarrow Cu + H_2O$

Determine which is the correct equation for the reaction in the teacher's experiment.

Relative atomic masses (A_r): H = 1 O = 16 Cu = 63.5

[3 marks]

moles Cu = 0.04 or $\frac{2.54}{63.5} = 0.04$

moles H2O = 0.04 or $\frac{0.72}{18} = 0.04$

ratio = 1:1 so equation 2 is correct

8

Turn over for the next question

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There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED

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0 9 A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

This is the method used.

1. Measure 25.0 cm^3 potassium hydroxide solution into a polystyrene cup.

2. Record the temperature of the solution.

3. Add 2.0 cm^3 dilute sulfuric acid.

4. Stir the solution.

5. Record the temperature of the solution.

6. Repeat steps 3 to 5 until a total of 20.0 cm^3 dilute sulfuric acid has been added.

0 9 . 1 Suggest why the student used a polystyrene cup rather than a glass beaker for the reaction.

[2 marks]

polystyrene is a better (thermal) insulator

(so) reduces energy exchange
(with the surroundings)

Question 9 continues on the next page

Do not write outside the box

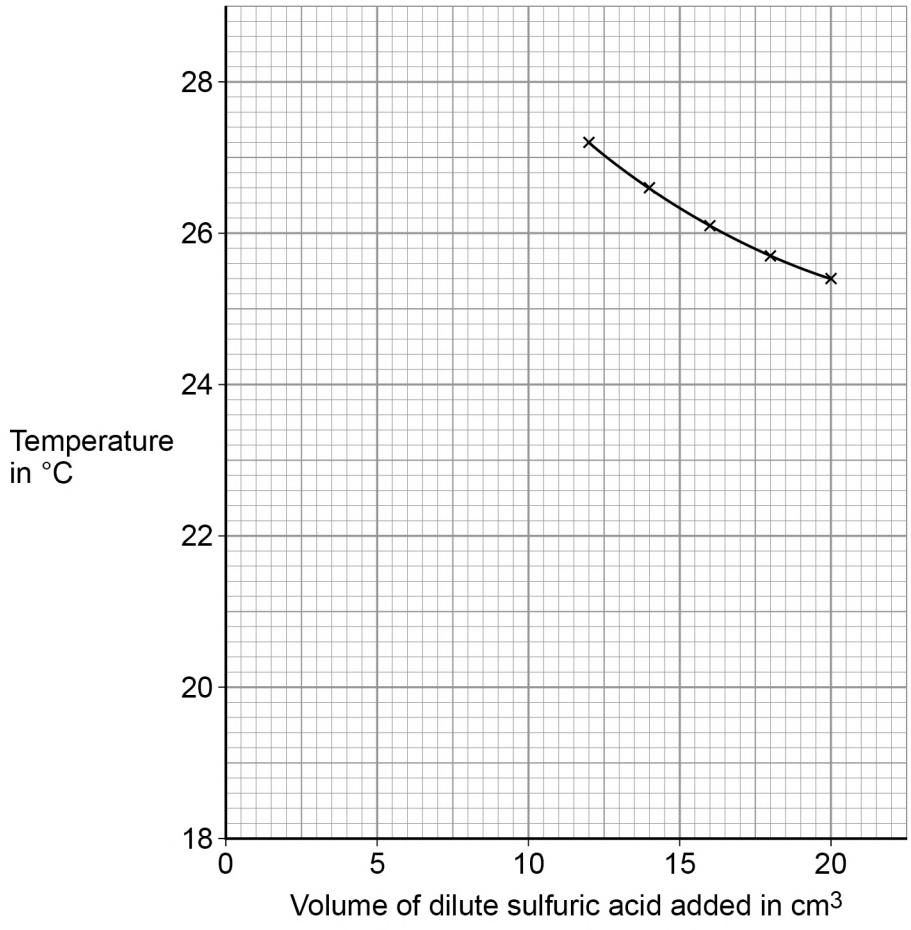
Table 6 shows some of the student's results.

Table 6

Volume of dilute sulfuric acid added in cm^3	Temperature in °C
0.0	18.9
2.0	21.7
4.0	23.6
6.0	25.0
8.0	26.1
10.0	27.1

Figure 11 shows some of the data from the investigation.

Figure 11



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0 9 . 2 Complete **Figure 11**:

all six points plotted correctly
line of best fit through points plotted from Table 6

- plot the data from **Table 6** both lines of best fit extrapolated correctly until they cross
- draw a line of best fit through these points
- extend the lines of best fit until they cross.

[4 marks]

0 9 . 3 Determine the volume of dilute sulfuric acid needed to react completely with 25.0 cm^3 of the potassium hydroxide solution.

Use **Figure 11**.

[1 mark]

Volume of dilute sulfuric acid to react completely = 11 cm^3

0 9 . 4 Determine the overall temperature change when the reaction is complete.

Use **Figure 11**.

[1 mark]

(27.5 – 18.9)

Overall temperature change = 8.6 °C

Question 9 continues on the next page

Do not write outside the box

0 9 . 5 The student repeated the investigation.

The student used solutions that had different concentrations from the first investigation.

The student found that 15.5 cm^3 of 0.500 mol/dm^3 dilute sulfuric acid completely reacted with 25.0 cm^3 of potassium hydroxide solution.

The equation for the reaction is:

$$2\,KOH + H_2SO_4 \rightarrow K_2SO_4 + 2\,H_2O$$

Calculate the concentration of the potassium hydroxide solution in mol/dm^3 and in g/dm^3

Relative atomic masses (A_r): H = 1 O = 16 K = 39

[6 marks]

(moles H_2SO_4 = 0.500 × $\frac{15.5}{1000}$
= 0.00775

(moles KOH = 2 x moles H_2SO_4
= 2 x 0.00775) = 0.0155

(conc KOH = moles KOH x $\frac{1000}{25.0}$
= 0.0155 x $\frac{1000}{25.0}$

= 0.62 (mol/dm^3)

(Mr KOH =) 56

(conc = Mr x conc in mol/dm^3 =
56 x 0.62)
= 34.7 (g/dm^3)

Concentration in mol/dm^3 = 0.62 mol/dm^3

Concentration in g/dm^3 = 34.7 g/dm^3

14

END OF QUESTIONS