

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 1

Friday 17 May 2024

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.

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.
- In all calculations, show clearly how you work out your answer.
- 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	



0 1

A student produced a salt by reacting copper carbonate with sulfuric acid.

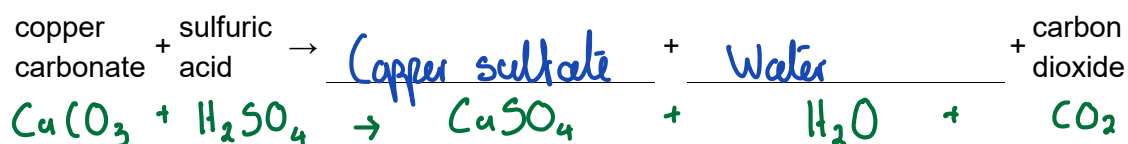
This is the method used.

1. Measure 50 cm³ of sulfuric acid into a beaker.
2. Add copper carbonate powder.
3. Stir the mixture.
4. Repeat steps 2 and 3 until copper carbonate is in excess.
5. Filter the mixture.
6. Warm the filtrate gently until crystals start to appear.
7. Leave the solution to cool and crystallise.

0 1 . 1

Complete the word equation for the reaction.

[2 marks]



0 1 . 2

Give **one** observation the student could make during **Step 4** which shows that the copper carbonate is in excess.

[1 mark]

Solid remains in the mixture.
(or no more effervescence)

0 1 . 3

Give **one** reason for filtering the mixture in **Step 5**.

[1 mark]

To remove the excess copper carbonate
 CuCO_3



- 0 1 . 4** Name the equipment that can be used to warm the filtrate **gently** in **Step 6**. [1 mark]

Water bath
(or electric heater)

- 0 1 . 5** The maximum theoretical mass of the salt that could be produced using 50 cm³ of the sulfuric acid is 12.5 g.

The percentage yield of the salt is 92.8%.

Calculate the mass of salt actually produced.

Use the equation:

$$\% \text{ yield} = \frac{\text{mass of salt actually produced}}{\text{maximum theoretical mass of salt that could be produced}} \times 100$$

(Handwritten: 92.8, x, 12.5)

[3 marks]

$$92.8 = \frac{x}{12.5} \times 100$$

$$\frac{92.8}{100} = \frac{x}{12.5}$$

$$0.928 \times 12.5 = x$$

$$x = 11.6 \text{ g} \quad \text{Mass of salt actually produced} = 11.6 \text{ g}$$

Question 1 continues on the next page

Turn over ►



0 1 . 6

Some salts can be produced by reacting sulfuric acid with a metal.

Neither copper nor sodium is used to produce a salt with sulfuric acid.

Give **one** reason why each metal is **not** used.

[2 marks]

Copper does not react with sulfuric acid
(Cu is unreactive, below H in reactivity series)

Sodium is too reactive with sulfuric acid and
could explode. The reaction is dangerous.

10

K Most reactive
Na
Li
Ca
Mg
C
Zn
Fe
H
Cu Least reactive



0 2

This question is about the periodic table.

Sodium and potassium are in Group 1 of the periodic table.

0 2 . 1

Give **one similarity** and **one difference** between the **electronic structures** of sodium and potassium.

[2 marks]

Similarity They both have one outer shell electron.
(as they are both in Group 1)

Difference Sodium has 3 shells
Potassium has 4 shells

Group 1 elements react with water.

0 2 . 2

Give **two** observations made when potassium reacts with water.

[2 marks]

1 Flame

2 Effervescence, fizzing

0 2 . 3

Potassium hydroxide solution is produced when **potassium** reacts with water.

What is the colour of **universal indicator** when added to potassium **hydroxide** solution?

Give **one** reason for your answer.

OH⁻

[2 marks]

Colour of universal indicator blue/purple

Reason The solution is alkaline

Turn over ►



Table 1 shows the densities of some of the elements in Group 0 of the periodic table.

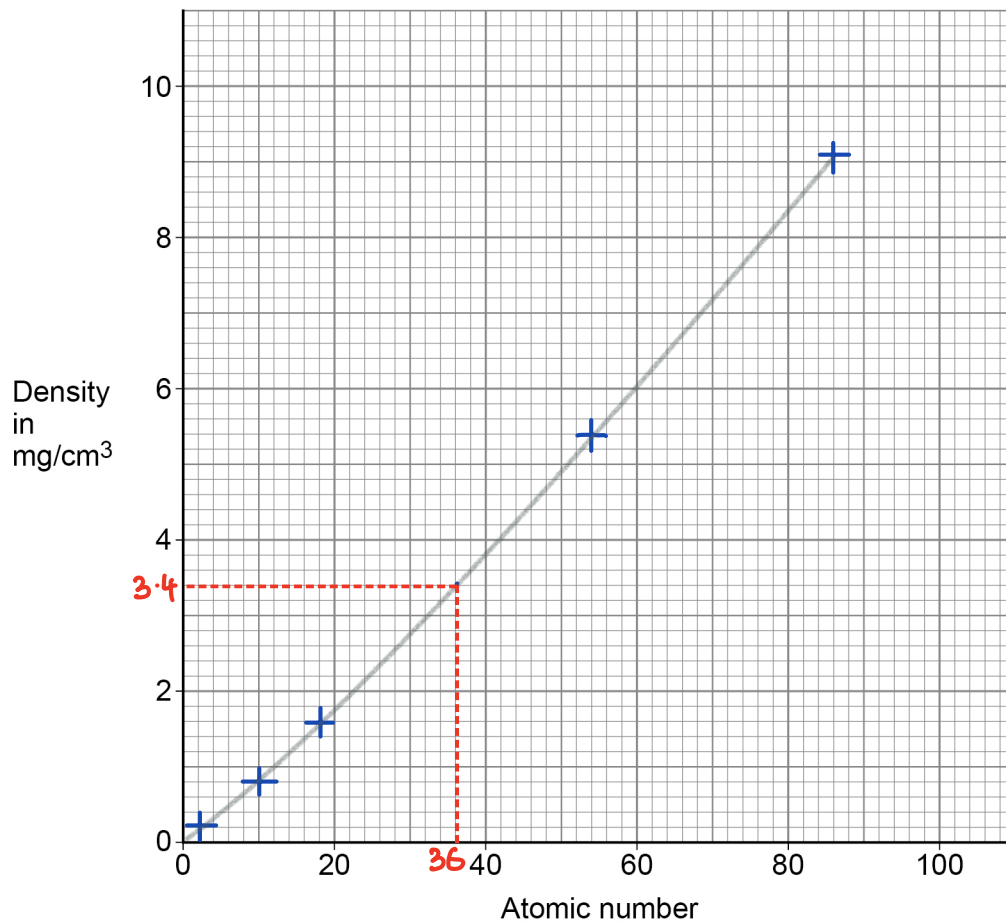
Table 1

Element	Atomic number	Density in mg/cm^3
Helium	2	0.2
Neon	10	0.8
Argon	18	1.6
Krypton	36	X
Xenon	54	5.4
Radon	86	9.1

0 2 . 4 Plot the data from **Table 1** on **Figure 1**.

[2 marks]

Figure 1



0 2 . 5 Estimate the density (X) of krypton.

Use **Figure 1** and **Table 1**.

[1 mark]

Plotting line of best fit through data.
Interpolate to find X

Density = 3.4 mg/cm³

0 2 . 6 The elements in Group 7 are called the halogens.

A more reactive halogen can displace a less reactive halogen from a solution of its salt.

Which combination of solutions will produce a reaction when mixed?

[1 mark]

Tick (✓) **one** box.

Cl_2 and potassium fluoride KF \times

F
Cl
Br
I
↑
Reactivity

$\text{Cl}_2 + 2\text{KBr} \rightarrow \text{Br}_2 + 2\text{KCl}$
Chlorine and potassium bromide ✓

Br_2 and potassium fluoride KF \times

Br_2 and potassium chloride KCl \times

0 2 . 7 Which of the following describes the trends going down Group 7?

[1 mark]

Tick (✓) **one** box.

Relative molecular mass decreases \times and boiling point decreases \times .

Relative molecular mass decreases \times and boiling point increases ✓.

Relative molecular mass increases ✓ and boiling point decreases \times .

Relative molecular mass increases ✓ and boiling point increases ✓.

11

Mr ↓
gas
F
Cl
Br
I
solid
↓ B.P.

Turn over ►

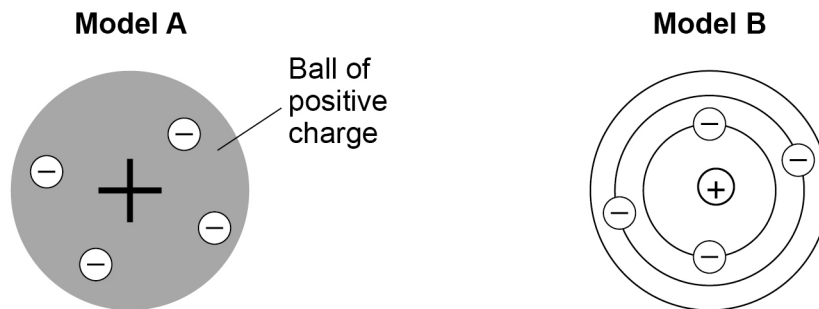


0 3

This question is about models of the atom.

Figure 2 shows two early models of the atom.

Figure 2



0 3 . 1

Name the models of the atom shown in Figure 2.

[2 marks]

Model A Plum pudding

Model B Bohr

0 3 . 2

Compare model A with the model of the atom used today.

Use Figure 2.

[4 marks]

Similarities: Both contain electrons

Both are neutral overall

Differences: Model A has no nucleus and no protons

" " has positive charge spread

throughout the atom.

Model B: has the positive charge in the centre

Electrons are distributed randomly in A,

in B they occupy shells

Mass is distributed throughout atom in A



0 3 . 3

Chadwick's experiments showed the existence of neutrons in an atom.

This led to an understanding of isotopes.

Define the term 'isotopes'.

Refer to subatomic particles in your answer.

[2 marks]

Isotopes are atoms with:
the same number of protons
and with different numbers of neutrons

8

Turn over for the next question

Turn over ►



0 4

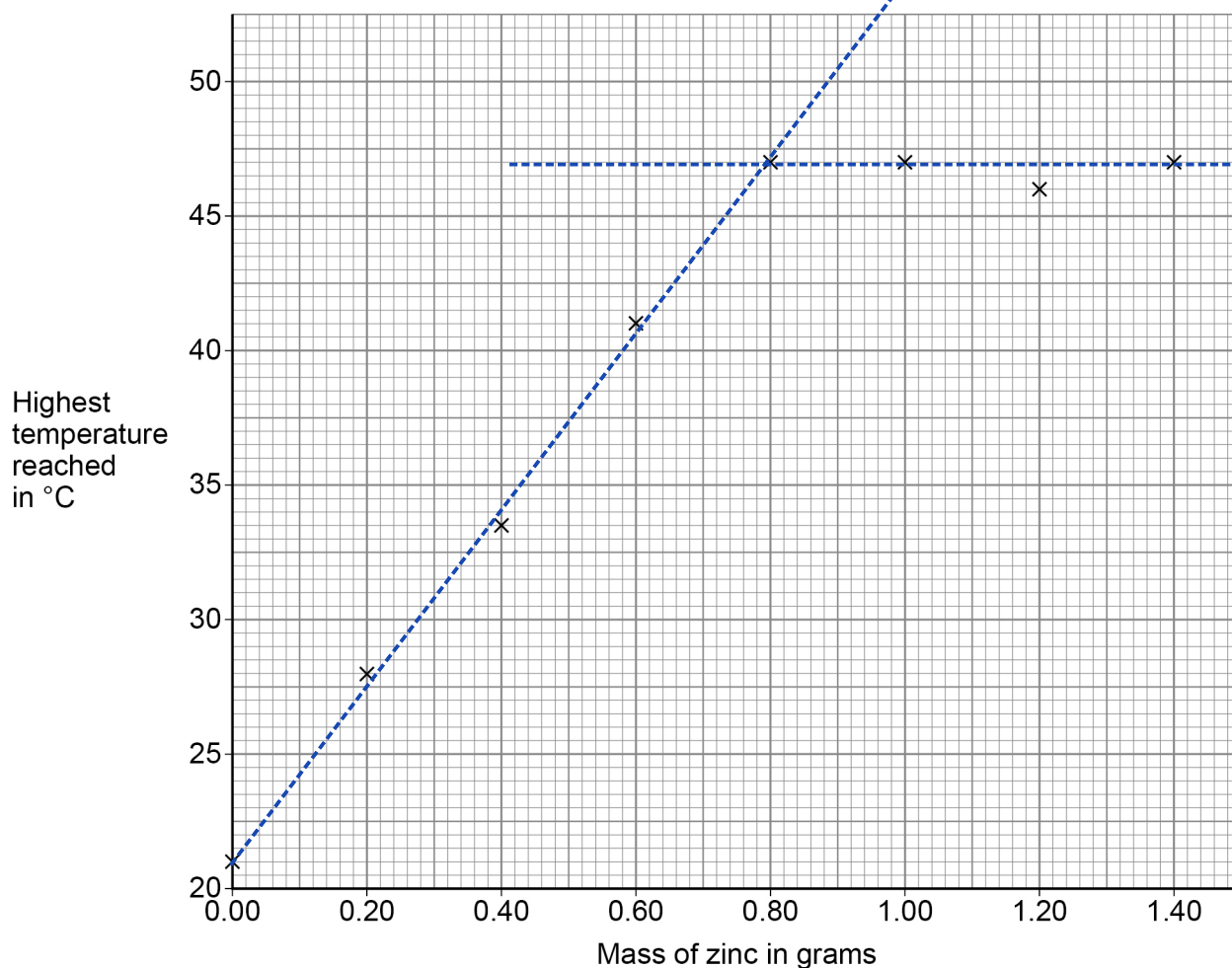
A student investigated the energy change of the reaction between zinc and copper sulfate solution.

This is the method used.

1. Measure 25 cm³ of copper sulfate solution into a polystyrene cup.
2. Measure the temperature of the copper sulfate solution.
3. Add 0.20 g of zinc powder to the copper sulfate solution.
4. Stir the reaction mixture.
5. Record the highest temperature reached.
6. Repeat steps 1 to 5 with different masses of zinc powder.

Figure 3 shows the results.

Figure 3



0 4 . 1 Draw **two** lines of best fit on **Figure 3**.

The lines should cross.

[2 marks]

0 4 . 2 Explain the results shown in **Figure 3**.

Do **not** refer to anomalous points.

Use data from **Figure 3**.

[4 marks]

The temperature rises because the reaction is exothermic.

Until 0.8g of zinc is added.

There is no additional reaction because zinc is in excess and the copper sulfate has been used up.

0 4 . 3 Explain why using a polystyrene cup gives more accurate results than using a glass beaker.

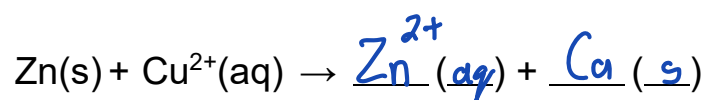
[2 marks]

Polystyrene is a better thermal insulator, so there is less energy transfer to the surroundings.

0 4 . 4 Complete the ionic equation for the reaction between zinc and copper sulfate solution.

Include state symbols.

[2 marks]



Turn over ►



A different student repeated steps 1 to 5 of the method four times using 0.50 g of zinc powder.

Table 2 shows the results.

Table 2

	Trial 1	Trial 2	Trial 3	Trial 4
Highest temperature reached in °C	37.6	37.2	37.8	37.4

$$\text{Range} = \text{Highest} - \text{Lowest}$$

$$\text{Uncertainty} = \frac{\text{Range}}{2}$$

0 4 . 5 Calculate the mean highest temperature reached.

Include the uncertainty in your answer.

[3 marks]

$$\text{Mean} = \frac{37.6 + 37.2 + 37.8 + 37.4}{4} = 37.5$$

$$\text{Uncertainty} = \frac{\text{Range}}{2} = \frac{37.8 - 37.2}{2} = 0.3$$

$$\text{Mean highest temperature reached} = 37.5 \pm 0.3 \text{ } ^\circ\text{C}$$

0 4 . 6 The results show random errors.

The student did not make any measuring errors.

Suggest **one** reason for the random errors in this experiment.

[1 mark]

Inconsistent stirring.



Turn over for the next question

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outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



0 5

This question is about ionic compounds and electrolysis.

Calcium chloride is an ionic compound.

0 5 . 1

Calcium and chlorine react to produce calcium chloride.

Describe what happens to calcium atoms and chlorine atoms when the ionic compound calcium chloride is formed.

[4 marks]

Calcium atoms (Group 2) lose two outer electrons
from the neutral atom to form Ca^{2+} ions

Chlorine atoms (Group 7) gain an electron to
attain a full outer shell and form Cl^- ions

Opposite electrostatic forces attract and Ca^{2+} ions
form ionic bonds with two Cl^- ions.

0 5 . 2

Solid calcium chloride **cannot** be electrolysed.

Give **one** reason why.

[1 mark]

Ca^{2+} and Cl^- ions cannot carry electric charge
in solid phase as they cannot move.

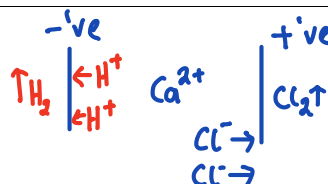
0 5 . 3

Name the product formed at the negative electrode when aqueous calcium chloride solution is electrolysed.

[1 mark]

Hydrogen

Ca more reactive than H

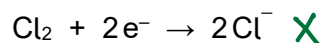


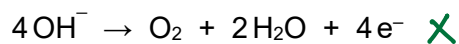
0 5 . 4

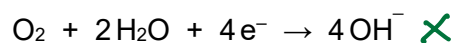
What is the **half equation** for the reaction at the **positive electrode** when **aqueous calcium chloride** solution is electrolysed?

[1 mark]

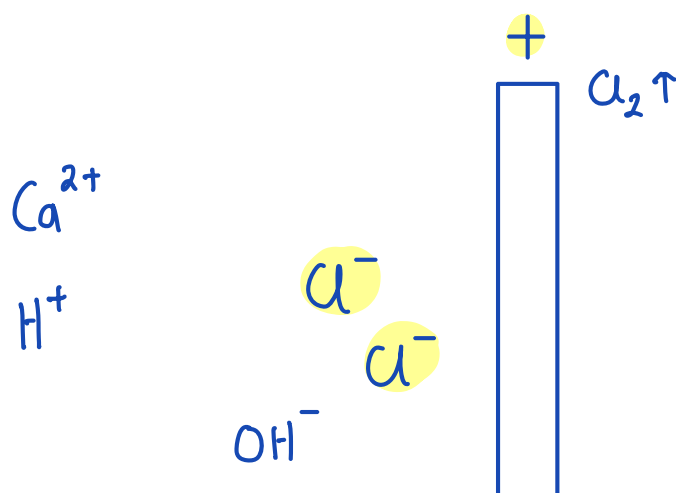
Tick (✓) **one** box.







Question 5 continues on the next page



Cl^- ions lose e^- to form Cl atoms
 2 Cl atoms bond to form 1 molecule of Cl_2



Turn over ►



0 5 . 5 A student investigated the electrolysis of green copper chromate solution.

Figure 4 shows the apparatus.

Figure 4

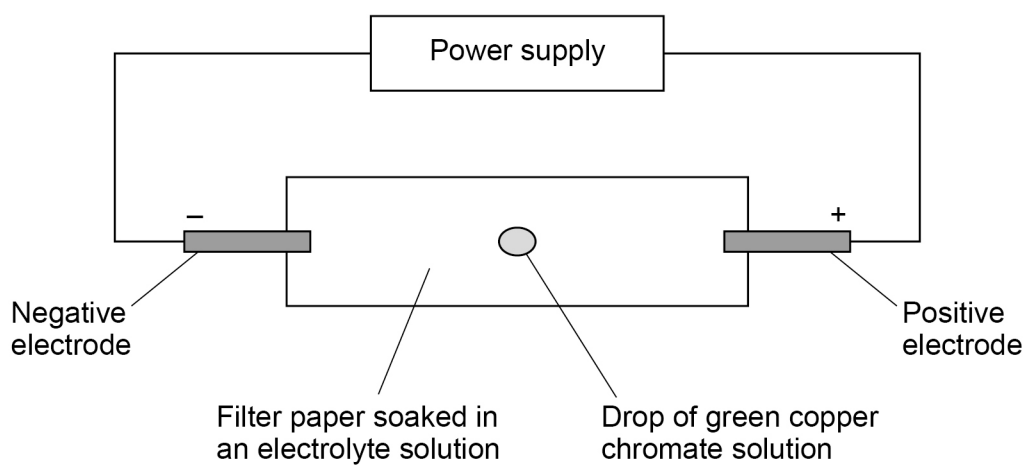
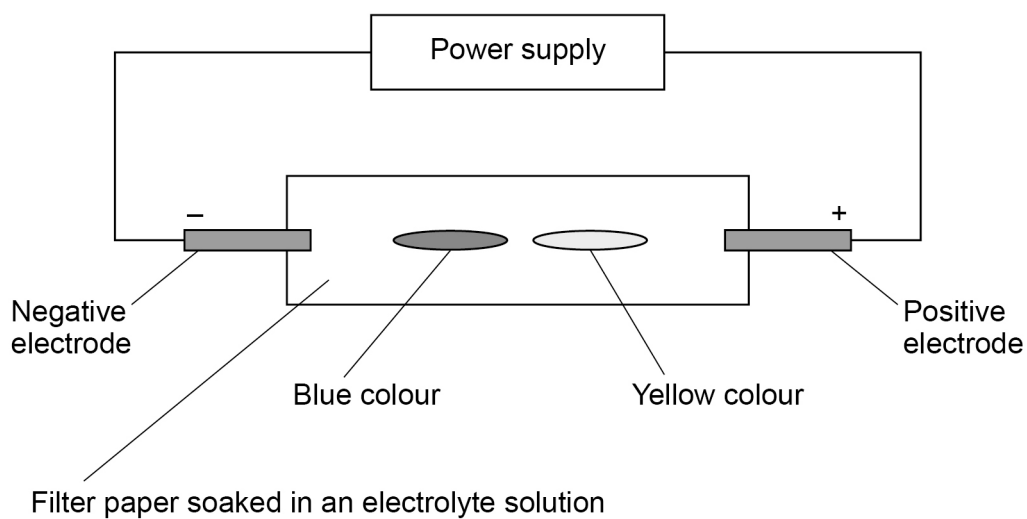


Figure 5 shows the results.

Figure 5



Copper chromate solution contains the ions Cu^{2+} and CrO_4^{2-}

Do not write
outside the
box

Explain the results shown in **Figure 5**.

[3 marks]

Cu^{2+} ions are blue, CrO_4^{2-} ions are yellow

Because Cu^{2+} ions move to the negative electrode
and also CrO_4^{2-} ions move to the positive electrode

The green mixture separates.

10

Turn over for the next question

Turn over ►



0 6

A student investigated the voltage produced by different pairs of metal electrodes in a chemical cell.

Figure 6 shows the apparatus.

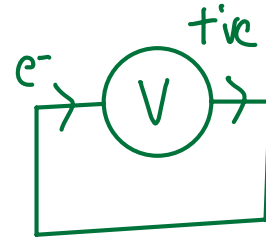
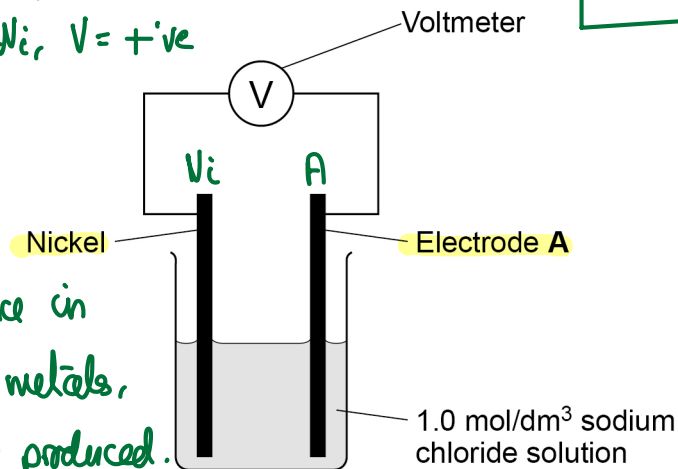


Figure 6

Ni More Reactive than A, V = -ive
A " " " Ni, V = +ive



The bigger the difference in reactivity of the two metals, the larger the voltage produced.

This is the method used.

1. Place a nickel electrode and an electrode made from a different metal (electrode A) in 1.0 mol/dm^3 sodium chloride solution.
2. Measure the voltage produced.
3. Repeat using different metals for electrode A.

If Electrode A is more reactive than Ni, Voltage = +ive

Table 3 shows the results.

Table 3

Electrode A	Symbol of metal	Voltage in volts
Copper	Cu	-0.59 5
Magnesium	Mg	2.12 1
Nickel	Ni	0.00 3
Silver	Ag	-1.05 4
Zinc	Zn	0.51 2

Most +ive



0 6 . 1 Write the symbols of the five metals in **Table 3** in order of reactivity.

Justify your answer.

[3 marks]

Most reactive Mg Zn Ni Cu Ag Least reactive

Justification The higher the positive voltage,
the more reactive the metal.

0 6 . 2 The voltage produced by a chemical cell depends on the concentration of the electrolyte solution.

Plan an experiment to investigate how the voltage produced by a chemical cell varies with the **concentration** of the electrolyte solution.

The following substances are available:

- the metal electrodes in **Table 3**
- 1.0 mol/dm³ sodium chloride solution
- pure water.

[6 marks]

Set up cell with NaCl solution as electrolyte

Use two different metals as electrodes

Measure the voltage

Repeat at different concentrations of electrolyte solution, by diluting the NaCl solution with water.

Using measured volumes of NaCl solution and water.
Measured with a measuring cylinder (or pipette)

Use the same two metals each time

Use the same volume of electrolyte each time

Turn over ►



0 6 . 3

Describe how a hydrogen fuel cell produces a potential difference.

[2 marks]

Hydrogen is oxidised (electrochemically) to
produce water.

11

A fuel cell is an electrical cell supplied with fuel (H_2) and O_2 .
Energy from reaction produces electrical energy.
When fuel enters the cell it becomes oxidised and sets up
a potential difference within the cell.



0 7

This question is about iron.

0 7 . 1

Iron is a metal.

Describe how iron conducts thermal energy.

[2 marks]

Thermal energy is transferred by delocalised electrons.

0 7 . 2

Pure iron is too soft for many uses.

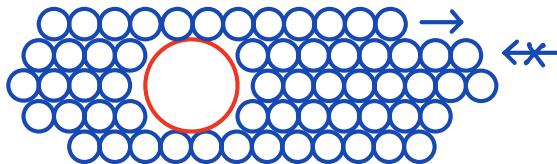
Explain why mixing iron with other metals makes alloys which are harder than pure iron.

[3 marks]

The alloy mixture has different sized atoms,

so the layers are distorted

and cannot easily slide over one another.



Question 7 continues on the next page

Turn over ►

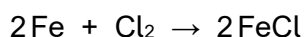
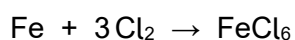
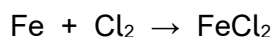


0 7 . 3 When iron reacts with chlorine, 0.12 mol of iron reacts with 0.18 mol of chlorine (Cl_2).

Which is the correct equation for the reaction?

[1 mark]

Tick (✓) **one** box.



Divide by
smallest

x 2 to get
whole numbers

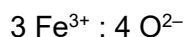
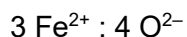
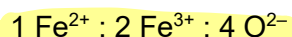
$$\begin{array}{l} \text{Fe} : \text{Cl}_2 \\ 0.12 : 0.18 \\ \hline 0.12 : 0.12 \\ 1 : 1.5 \\ 2 : 3 \end{array}$$



The most common oxides of iron are Fe_2O_3 and Fe_3O_4

0 7 . 4 What is the ratio of the numbers of ions in Fe_3O_4 ?

Tick (✓) **one** box.



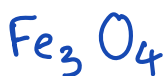
Fe is a Transition Metal

and can form

either Fe^{2+} or Fe^{3+}

O forms O^{2-}

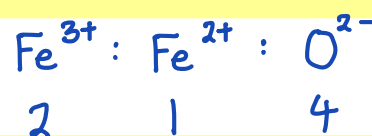
Charges must balance as
compound is overall neutral.



$\rightarrow 4 \times \text{O}^{2-} = 8-$

So 3 Fe ions
must add up to $8+$
 $\text{Fe}^{3+} \quad \text{Fe}^{3+} \quad \text{Fe}^{2+}$

$3+3+2 = 8+$



0 7 5 Calculate the percentage (%) by mass of iron in Fe_3O_4

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

[3 marks]

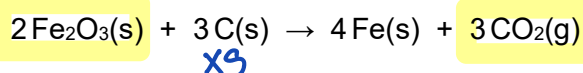
$$M_r(\text{Fe}_3\text{O}_4) = (56 \times 3) + (16 \times 4) = 232$$

$$\begin{aligned} \% \text{ by mass} &= \frac{\text{Fe}_3}{M_r(\text{Fe}_3\text{O}_4)} = \frac{(56 \times 3)}{232} \times 100\% \\ &= 72.4\% \end{aligned}$$

Percentage by mass of iron = 72.4 %

0 7 6 Fe_2O_3 reacts with carbon to produce carbon dioxide.

The equation for the reaction is: 2 moles Fe_2O_3 produce 3 moles CO_2



Calculate the volume of carbon dioxide gas at room temperature and pressure that is produced from 40.0 kg of Fe_2O_3 using excess carbon.

Relative formula mass (M_r): $\text{Fe}_2\text{O}_3 = 160$

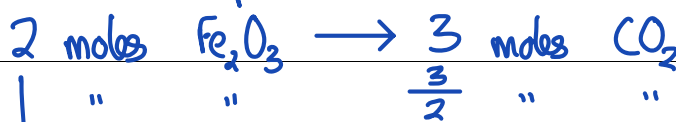
$$40 \text{ kg} = 40000 \text{ g}$$

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

[5 marks]

$$\text{No moles } \text{Fe}_2\text{O}_3 = \frac{40000 \text{ g}}{160 \text{ g/mol}} = 250 \text{ moles.}$$

How much CO_2 does this produce?



$$250 \text{ " " } \frac{3}{2} \times 250 \text{ " "}$$

$$= 375 \text{ moles } \text{CO}_2$$

$$\text{Volume of } \text{CO}_2 = 375 \text{ mol} \times 24 \text{ dm}^3/\text{mol} = 9000 \text{ dm}^3$$

Volume of carbon dioxide = 9000 dm^3

15

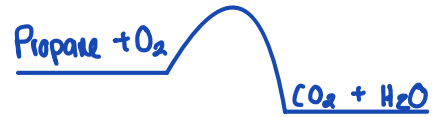
1 mole gas @ RTP = 24 dm^3

Turn over ►



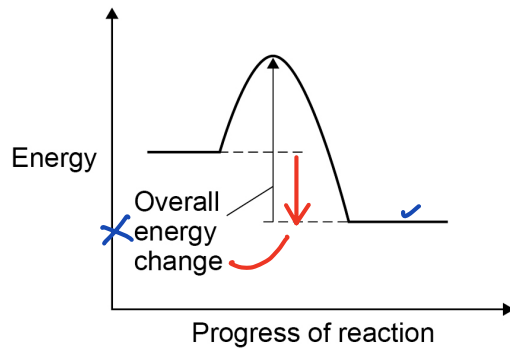
Propane reacts with oxygen to produce carbon dioxide and water.

The reaction is exothermic. \therefore Products lower energy than Reactants

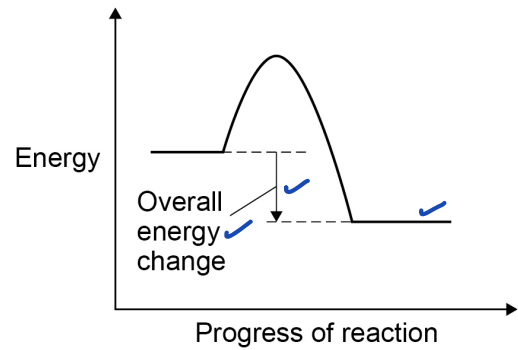


0 8 . 2 Figure 8 shows four reaction profiles.

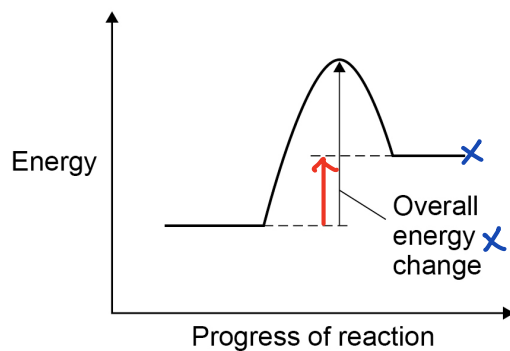
Figure 8



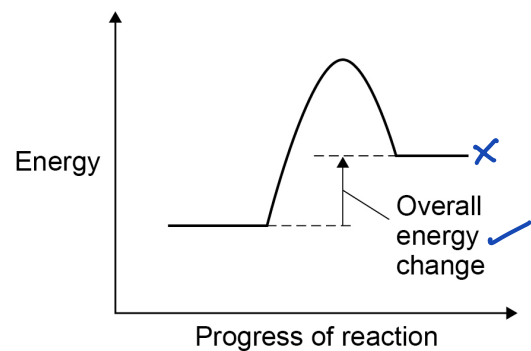
A



B



C



D

Which is the correct reaction profile and labels for the reaction between propane and oxygen?

Tick (✓) **one** box.

[1 mark]

A

B

C

D

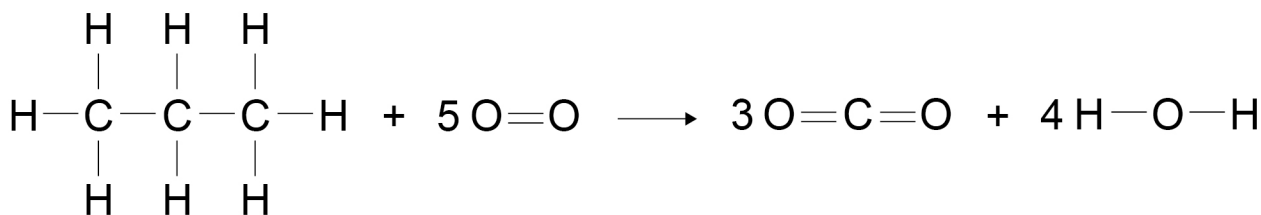
Question 8 continues on the next page

Turn over ►



0 8 . 3 Figure 9 shows the displayed formula equation for the reaction between propane and oxygen.

Figure 9



The overall energy change of this exothermic reaction is 2219 kJ/mol.

Table 4 shows the bond energies of the bonds in the reaction.

Table 4

	C—C	C—H	O=O	C=O	O—H
Energy in kJ/mol	347	X	498	805	464

Calculate the bond energy of the C—H bond (X).

[5 marks]

$$\Delta H = \text{Sum of Bonds Broken} - \text{Sum of Bonds Formed}$$

$$= [8(\text{C}-\text{H}) + 2(\text{C}-\text{C}) + 5(\text{O}=\text{O})] - [6(\text{C}=\text{O}) + 8(\text{O}-\text{H})]$$

$$= [8(\text{C}-\text{H}) + (2 \times 347) + (5 \times 498)] - [(6 \times 805) + (8 \times 464)]$$

$$= [8(\text{C}-\text{H}) + 694 + 2490] - [4830 + 3712]$$

$$= [8(\text{C}-\text{H}) + 3184] - [8542]$$

$$-2219 = 8(\text{C}-\text{H}) + 3184 - 8542$$

$$8(\text{C}-\text{H}) + 3184 - 8542 = -2219$$

$$8(\text{C}-\text{H}) - 5358 = -2219$$

$$8(\text{C}-\text{H}) = -2219 + 5358$$

$$8(\text{C}-\text{H}) = 3139$$

$$\text{C}-\text{H} = \frac{3139}{8} = 392.4 \text{ kJ/mol}$$

Bond energy of the C—H bond (X) = 392 kJ/mol



0 9

This question is about acids and their reactions.

Acids can be either weak or strong.

0 9 . 1

What is meant by 'a **weak acid**'?

[2 marks]

An acid which is partially ionised in aqueous solution



0 9 . 2

Explain what happens to the pH of an acid as the acid is diluted with water.

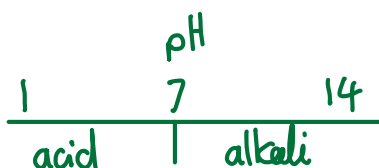
[2 marks]

As an acid is diluted, the concentration of H^+ ions decreases.

As $[\text{H}^+]$ decreases, pH increases

$$\text{pH} = \log[\text{H}^+]$$

Question 9 continues on the next page



Turn over ►



0 9 . 3 A student does a titration to find the volume of acid needed to neutralise an alkali.

The student fills a burette with the acid.

Give **three** more steps the student must do before adding the acid to the alkali from the burette.

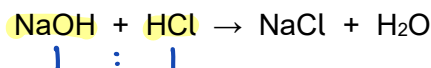
You should name any equipment used.

[3 marks]

- 1 Use a volumetric pipette to add the alkali into a conical flask.
- 2 Add an indicator to the alkali
- 3 Take the initial burette reading.

0 9 . 4 The student titrated a solution containing 0.0045 moles of sodium hydroxide with 0.15 mol/dm³ hydrochloric acid.

The equation for the reaction is:



Calculate the volume of hydrochloric acid in cm³ needed in the titration.

[2 marks]

1 mole NaOH reacts with 1 mole HCl
 0.0045 mol " " " 0.0045 mol HCl

$$\text{Volume of HCl} = \frac{\text{no moles}}{\text{Concentration}}$$

$$V(\text{dm}^3) = \frac{0.0045 \text{ mol}}{0.15 \text{ mol/dm}^3}$$

$$V(\text{dm}^3) = 0.03 \text{ dm}^3$$

$$V(\text{dm}^3) = 0.03 \times 1000 = 30 \text{ cm}^3$$

$$\text{Volume of acid} = 30 \text{ cm}^3$$

$$1 \text{ dm} = 10 \text{ cm}$$

$$1^3 \text{ dm}^3 = 10^3 \text{ cm}^3$$

$$1 \text{ dm}^3 = 1000 \text{ cm}^3$$



0 9 . 5

A calcium atom is larger than a magnesium atom.

Explain why calcium reacts more vigorously than magnesium with hydrochloric acid of the same concentration.

[3 marks]

2

The electrons in the outer shell of Ca
are further from the nucleus

So the outer electrons are less strongly attracted
to the nucleus.

So positive ions are formed more easily

(2)

9.0 Be beryllium 4
24.3 Mg magnesium 12
40.1 Ca calcium 20
87.6 Sr strontium 38
137.3 Ba barium 56
[226] Ra radium 88

END OF QUESTIONS

12



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ANSWER IN THE SPACES PROVIDED**



