Cardinal Newman Catholic School

Holy Cross Catholic Multi Academy Company

YEAR 11

CHEMISTRY PAPER 1

Summer 2024

Separate Science practice question booklet

HIGHER TIER ONLY

Name:

"Knowledge through the light of faith"

CARDINAL NEWMAN CATHOLIC SCHOOL

For each Topic in Paper 1 there are 4/5 practice questions.

Remember they can ask you questions linked to all five topics.

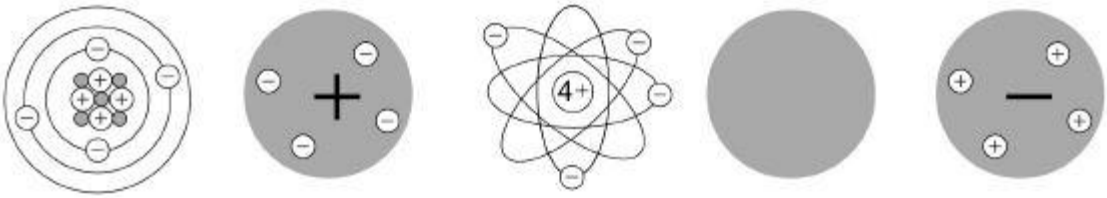
How to use this booklet:

1. Complete revision for each topic
2. Put away your notes/resources and try to answer the questions in the best way possible.
3. Look at the mark scheme at the back of the booklet and compare it to your answer – add anything you have missed off in green pen.
4. Go back to the revision guide/your resources to go over anything you are unsure of.

Contents

C1 Atomic Structure and the Periodic table

Q1. The diagram below represents different models of the atom.



A B C D E

(a) Which diagram shows the plum pudding model of the atom?
Tick **one** box.

A ☐ B ☐ C ☐ D ☐ E ☐

(1)

(b) Which diagram shows the model of the atom developed from the alpha particle scattering experiment?
Tick **one** box.

A ☐ B ☐ C ☐ D ☐ E ☐

(1)

(c) Which diagram shows the model of the atom resulting from Bohr's work?
Tick **one** box.

A ☐ B ☐ C ☐ D ☐ E ☐

(1)

(d) Define the mass number of an atom.

_____

_____

(1)

(e) Element **X** has two isotopes. Their mass numbers are 69 and 71
The percentage abundance of each isotope is:

- 60% of ^{69}**X**
- 40% of ^{71}**X**

Estimate the relative atomic mass of element **X**.
Tick **one** box.

< 69.5 ☐

Between 69.5 and 70.0 ☐

Between 70.0 and 70.5 ☐

> 70.5 ☐

(1)

(f) Chadwick's experimental work on the atom led to a better understanding of isotopes.

Explain how his work led to this understanding.

_____

_____

_____

_____

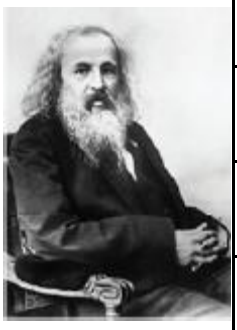
_____

_____ **(3)**

(Total 8 marks)

Q2. By 1869, about 60 elements had been discovered.
Mendeleev arranged these elements in a table, in order of their atomic weight.
He also put elements with similar chemical properties in the same columns.

Mendeleev and part of his table are shown below.



	Group							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
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	Fe Co Ni

(a) (i) Name **one** element in Group 1 of Mendeleev's table that is not in Group 1 of the periodic table on the Data Sheet.
Give a reason why this element should not be in Group 1.

Name of element _____

Reason _____

_____

(2)

(ii) Which group of the periodic table on the Data Sheet is missing from Mendeleev's table?

_____

(1)

(b) The gaps (–) in Mendeleev's table were for elements that had not been discovered.

(i) Compare Mendeleev's table with the periodic table on the Data Sheet.

Name **one** of the elements in Period 4 that had not been discovered by 1869.

_____

(1)

(ii) Mendeleev was able to make predictions about the undiscovered elements. This eventually led most scientists to accept his table.

Suggest what predictions Mendeleev was able to make about these undiscovered elements.

_____

_____

_____

_____

_____

(2)

(c) In terms of their electronic structure:

(i) state why lithium and sodium are both in Group 1

_____

_____

_____

(1)

(ii) explain why sodium is more reactive than lithium.

_____

_____

_____

_____

_____

_____

_____

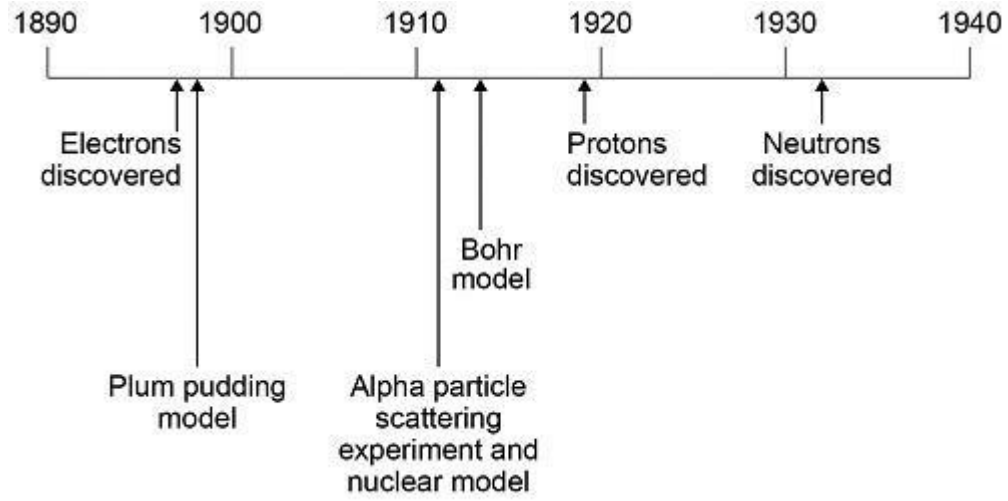
_____

(3)

(Total 10 marks)

Q3. This question is about the development of scientific theories.

The diagram below shows a timeline of some important steps in the development of the model of the atom.



(a) 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.

1 _____

_____

_____

2 _____

_____

_____

3 _____

_____

_____ **(3)**

(b) Niels Bohr adapted the nuclear model.

Describe the change that Bohr made to the nuclear model.

_____

_____

_____

_____

(2)

(c) 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 the diagram above.

_____

_____

_____

_____

(2)

(d) Give the correct reason why Mendeleev reversed the order of some pairs of elements.

_____

_____

(1)

(Total 8 marks)

Q4. This question is about Group 7 elements.

Chlorine is more reactive than iodine.

(a) Name the products formed when chlorine solution reacts with potassium iodide solution.

_____

_____

(1)

(b) Explain why chlorine is more reactive than iodine.

_____

_____

_____

_____

_____

_____

(3)

(c) Chlorine reacts with hydrogen to form hydrogen chloride.

Explain why hydrogen chloride is a gas at room temperature.
Answer in terms of structure and bonding.

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q5. This question is about the halogens.

Table 1 shows the melting points and boiling points of some halogens.

Table 1

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

(a) What is the state of bromine at 0 °C **and** at 100 °C?

Tick (✓) **one** box.

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

(1)

(b) Explain the trend in boiling points of the halogens shown in **Table 1**.

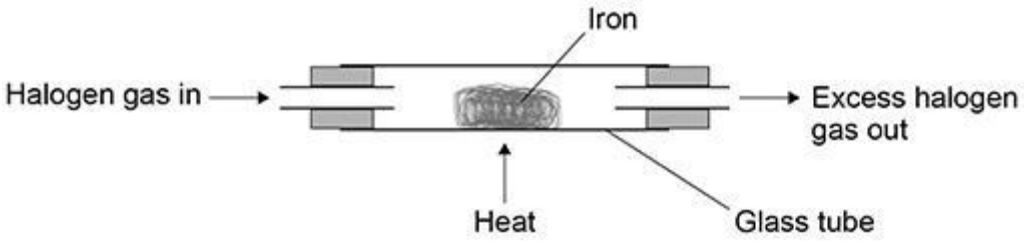
(4)

(c) Why is it **not** correct to say that the boiling point of a single bromine molecule is 59 °C?

(1)

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

The diagram below shows the apparatus used.



(d) Give **one** reason why this experiment should be done in a fume cupboard.

(1)

(e) Explain why the reactivity of the halogens decreases going down the group.

(3)

(Total 10 marks)

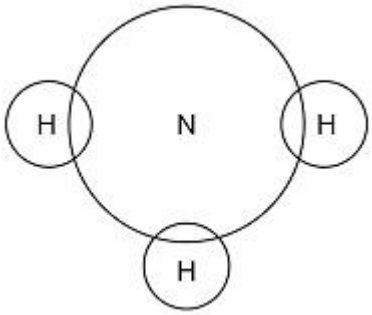
C2 Bonding, structure and the properties of matter

Q1. This question is about ammonia, NH_3

(a) Complete the dot and cross diagram for the ammonia molecule shown in **Figure 1**.

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

Figure 1



(2)

(b) Give **one** limitation of using a dot and cross diagram to represent an ammonia molecule.

_____

_____

(1)

(c) Explain why ammonia has a low boiling point.
You should refer to structure and bonding in your answer.

_____

_____

_____

_____

_____

_____

(3)

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

(d) Which metal oxide is most likely to be a catalyst for this reaction?

Tick (✓) **one** box.

CaO ☐

Cr_2O_3 ☐

MgO ☐

Na_2O ☐

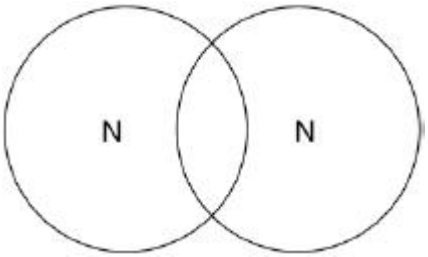
(1)

(Total 7 marks)

Q2. This question is about structure and bonding.

(a) Complete the dot and cross diagram to show the covalent bonding in a nitrogen molecule, N_2

Show only the electrons in the outer shell.



(2)

(b) Explain why nitrogen is a gas at room temperature.

Answer in terms of nitrogen's structure.

_____

_____

_____

_____

_____

_____

(3)

(c) Graphite and fullerenes are forms of carbon.

Graphite is soft and is a good conductor of electricity.

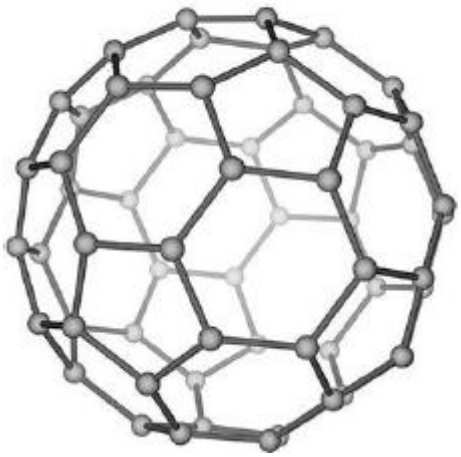
Explain why graphite has these properties.

Answer in terms of structure and bonding.

(4)

(d) **Figure 1** shows a model of a Buckminsterfullerene molecule.

Figure 1



A lubricant is a substance that allows materials to move over each other easily.

Suggest why Buckminsterfullerene is a good lubricant.

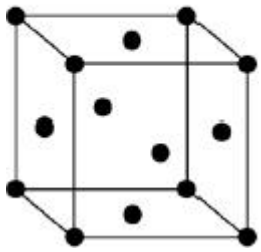
Use **Figure 1**.

(2)

Silver can form cubic nanocrystals.

Figure 2 represents a silver nanocrystal.

Figure 2



(e) A silver nanocrystal is a cube of side 20 nm

Calculate the surface area to volume ratio of the nanocrystal.

Surface area to volume ratio = _____

(3)

(f) Silver nanoparticles are sometimes used in socks to prevent foot odour.

Suggest why it is cheaper to use nanoparticles of silver rather than coarse particles of silver.

(2)

(Total 16 marks)

Q3. This question is about magnesium and magnesium chloride.

(a) Magnesium chloride contains magnesium ions (Mg^{2+}) and chloride ions (Cl^{-}).

Describe, in terms of electrons, what happens when a magnesium atom reacts with chlorine atoms to produce magnesium chloride.

(4)

(b) Magnesium is a metal.

Explain why metals can be bent and shaped.

(2)

(Total 6 marks)

Q4. This question is about the properties and uses of materials.

Use your knowledge of structure and bonding to answer the questions.

(a) Explain how copper conducts electricity.

(2)

(b) Explain why diamond is hard.

(2)

(c) Explain why thermosetting polymers are better than thermosoftening polymers for saucepan handles.

(2)

(Total 6 marks)

C3 Quantitive Chemistry

Q1. This question is about salts.

(a) Name the salt produced by the neutralisation of hydrochloric acid with potassium hydroxide.

_____

(1)

(b) Write an ionic equation for the neutralisation of hydrochloric acid with potassium hydroxide.

_____ + _____ → _____

(1)

(c) Iron chloride is produced by heating iron in chlorine gas.

The equation for the reaction is:

$$2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$$

Calculate the volume of chlorine needed to react with 14 g of iron.

You should calculate:

- the number of moles of iron used
- the number of moles of chlorine that react with 14 g of iron
- the volume of chlorine needed.

Relative atomic mass (A_r): Fe = 56

The volume of 1 mole of gas = 24 dm^3

_____

_____

_____

_____

Volume of chlorine = _____ dm^3

(3)

(Total 5 marks)

Q2. This question is about acids.

(a) Ethanedioic acid is a solid at room temperature.

Calculate the mass of ethanedioic acid ($H_2C_2O_4$) needed to make 250 cm^3 of a solution with concentration 0.0480 mol/dm^3

Relative formula mass (M_r): $H_2C_2O_4$ = 90

_____

_____

_____

Mass = _____ g **(2)**

(b) The student found that 25.0 cm^3 of the sodium hydroxide solution was neutralised by 15.00 cm^3 of the 0.0480 mol/dm^3 ethanedioic acid solution.

The equation for the reaction is:

$$H_2C_2O_4 + 2\ NaOH \rightarrow Na_2C_2O_4 + 2\ H_2O$$

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

Concentration = _____ mol/dm^3

(3)

(Total 5 marks)

Q3. This question is about displacement reactions.

(a) The displacement reaction between aluminium and iron oxide has a high activation energy.
What is meant by 'activation energy'?

(1)

(b) 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)

Magnesium displaces zinc from zinc sulfate solution.

(c) Complete the ionic equation for the reaction.

You should include state symbols.

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

(2)

(d) Explain why the reaction between magnesium atoms and zinc ions is both oxidation and reduction.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q4. This question is about the halogens.

(a) A teacher investigated the reaction of iron with chlorine using the apparatus in the above diagram.

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 2 shows the teacher's results.

Table 2

	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

Moles of iron atoms : moles of chlorine atoms = _____ **:** _____

Equation for the reaction

_____

(6)

(Total 6 marks)

Q5. This question is about electrolysis.

(a) 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

Mass of oxygen = _____ kg

(4)

(b) 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

Volume = _____ dm^3

(2)

(Total 6 marks)

Q6. 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.

(a) Suggest why the student used a polystyrene cup rather than a glass beaker for the reaction.

_____

_____

_____

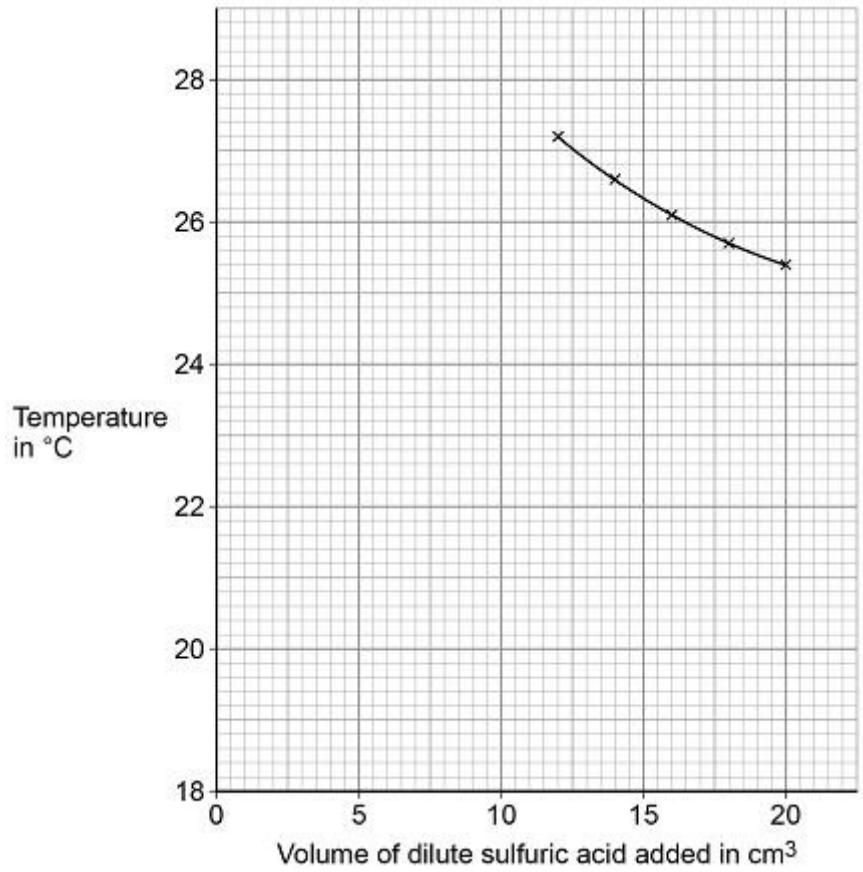
_____

(2)

The following table shows some of the student's results.

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

The figure below shows some of the data from the investigation.



(b) Complete the figure:

- plot the data from the table
- draw a line of best fit through these points
- extend the lines of best fit until they cross.

(4)

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

Use the figure above.

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

(1)

(d) Determine the overall temperature change when the reaction is complete.

Use the figure above.

_____

_____

Overall temperature change = _____ °C

(1)

(e) 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

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

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

(6)

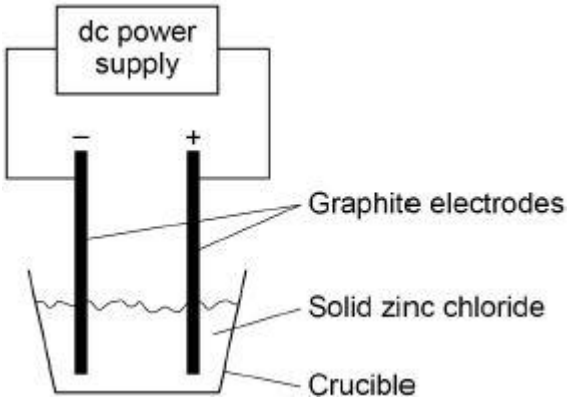
(Total 14 marks)

C4 Chemical changes

Q1. A student investigated the electrolysis of different substances.

Figure 1 shows the apparatus.

Figure 1



(a) Explain why electrolysis would not take place in the apparatus shown in **Figure 1**.

_____

_____

_____

_____

(2)

(b) Explain why graphite conducts electricity.

Answer in terms of the structure and bonding in graphite.

_____

_____

_____

_____

_____

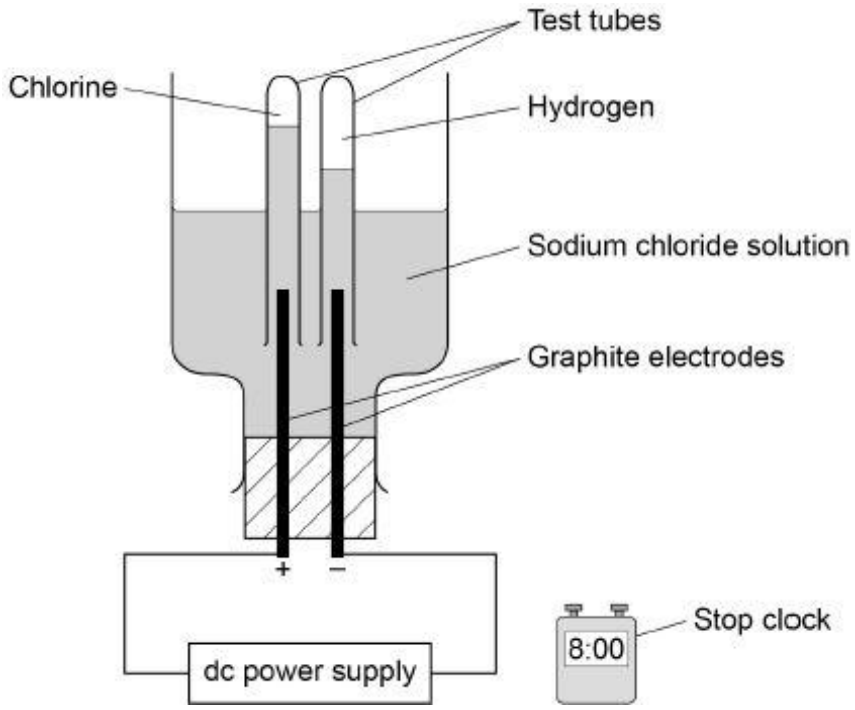
_____

(3)

The student investigated how the volume of gases produced changes with time in the electrolysis of sodium chloride solution.

Figure 2 shows the apparatus.

Figure 2



(c) The student made an error in selecting the apparatus for this investigation.

How should the apparatus be changed?

Give **one** reason for your answer.

_____

_____

_____

_____

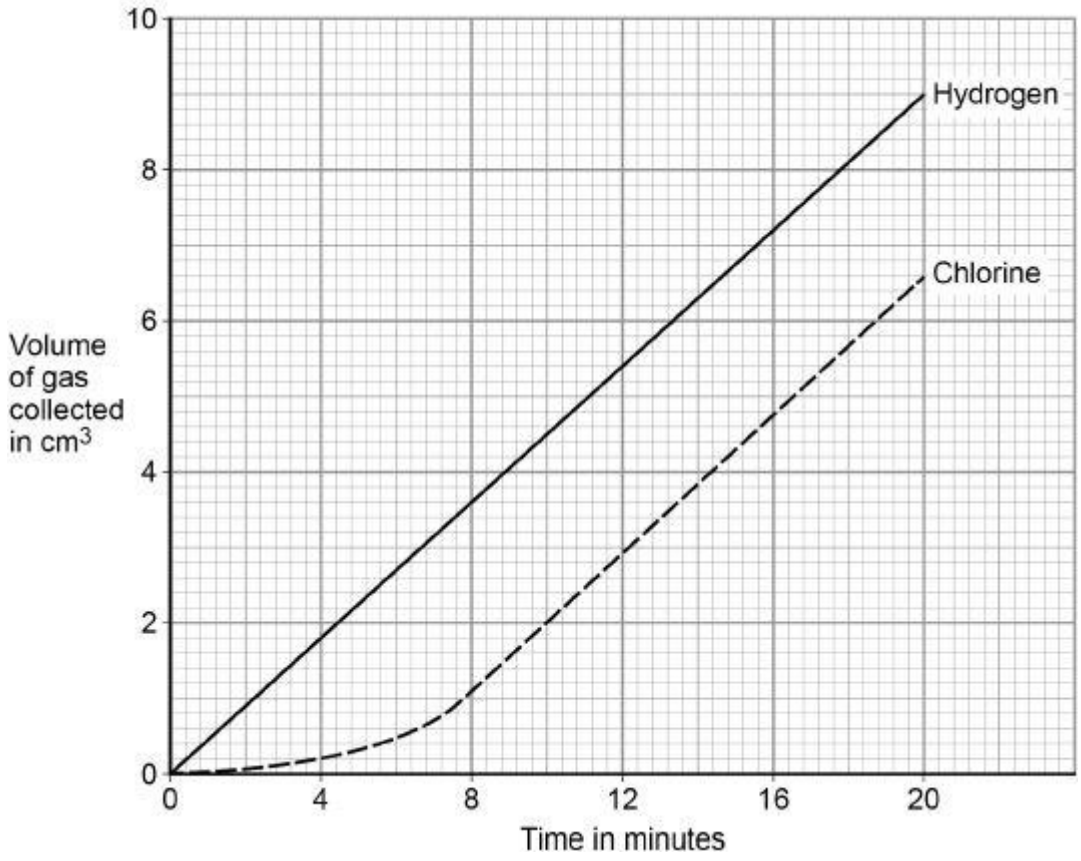
(2)

Another student used the correct apparatus.

This student measured the volumes of gases collected every minute for 20 minutes.

Figure 3 shows the student's results.

Figure 3



(d) Describe the trends shown in the results.

Use values from **Figure 3**.

(3)

(e) The number of moles of each gas produced at the electrodes is the same.

No gas escapes from the apparatus.

Suggest **one** reason for the difference in volume of each gas collected.

_____

_____

(1)

(f) Calculate the amount in moles of chlorine collected after 20 minutes.

Use **Figure 3**.

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

Give your answer in standard form.

_____

_____

_____

_____

Moles of chlorine = _____ mol

(3)

(Total 14 marks)

Q2. This question is about acids and alkalis.

(a) Dilute hydrochloric acid is a strong acid.

Explain why an acid can be described as both strong and dilute.

_____

_____

_____

_____

(2)

(b) A 1.0×10^{-3} mol/dm^3 solution of hydrochloric acid has a pH of 3.0

What is the pH of a 1.0×10^{-5} mol/dm^3 solution of hydrochloric acid?

pH = _____

(1)

A student titrated 25.0 cm^3 portions of dilute sulfuric acid with a 0.105 mol/dm^3 sodium hydroxide solution.

(c) The table below shows the student's results.

	Titration 1	**Titration 2**	**Titration 3**	**Titration 4**	**Titration 5**
Volume of sodium hydroxide solution in cm^3	23.50	21.10	22.10	22.15	22.15

The equation for the reaction is:

$$2\ NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2\ H_2O$$

Calculate the concentration of the sulfuric acid in mol/dm^3

Use only the student's concordant results.

Concordant results are those within 0.10 cm^3 of each other.

Concentration of sulfuric acid = _____ mol/dm^3

(5)

(d) Explain why the student should use a pipette to measure the dilute sulfuric acid and a burette to measure the sodium hydroxide solution.

(2)

(e) Calculate the mass of sodium hydroxide in 30.0 cm^3 of a 0.105 mol/dm^3 solution.

Relative formula mass (M_r): NaOH = 40

_____

_____

_____

_____

Mass of sodium hydroxide = _____ g

(2)

(Total 12 marks)

Q3. This question is about acids.

Hydrogen chloride and ethanoic acid both dissolve in water.

All hydrogen chloride molecules ionise in water.

Approximately 1% of ethanoic acid molecules ionise in water.

(a) A solution is made by dissolving 1 g of hydrogen chloride in 1 dm^3 of water.

Which is the correct description of this solution? Tick (✓) **one** box.

A concentrated solution of a strong acid	☐
A concentrated solution of a weak acid	☐
A dilute solution of a strong acid	☐
A dilute solution of a weak acid	☐

(1)

(b) Which solution would have the lowest pH? Tick (✓) **one** box.

0.1 mol/dm^3 ethanoic acid solution	☐
0.1 mol/dm^3 hydrogen chloride solution	☐
1.0 mol/dm^3 ethanoic acid solution	☐
1.0 mol/dm^3 hydrogen chloride solution	☐

(1)

A student investigated the concentration of a solution of sodium hydroxide by titration with a 0.0480 mol/dm^3 ethanedioic acid solution.

This is the method used.

1. Measure 25.0 cm^3 of the sodium hydroxide solution into a conical flask using a 25.0 cm^3 pipette.

2. Add two drops of indicator to the sodium hydroxide solution.

3. Fill a burette with the 0.0480 mol/dm^3 ethanedioic acid solution to the 0.00 cm^3 mark.

4. Add the ethanedioic acid solution to the sodium hydroxide solution until the indicator changes colour.

5. Read the burette to find the volume of the ethanedioic acid solution used.

(c) Suggest **two** improvements to the method that would increase the accuracy of the result.

1 _____

_____

2 _____

_____

(2)

(d) Ethanedioic acid is a solid at room temperature.

Calculate the mass of ethanedioic acid ($H_2C_2O_4$) needed to make 250 cm^3 of a solution with concentration 0.0480 mol/dm^3

Relative formula mass (M_r): $H_2C_2O_4$ = 90

_____

_____

_____

_____

Mass = _____ g

(2)

(Total 6 marks)

Q4. This question is about chemical reactions and electricity.

(a) Electrolysis and chemical cells both involve chemical reactions and electricity.

Explain the difference between the processes in electrolysis and in a chemical cell.

_____

_____

_____

_____

(2)

(b) A teacher demonstrates the electrolysis of molten lead bromide.

Bromine is produced at the positive electrode.

Complete the half equation for the production of bromine.

You should balance the half equation.

$$Br^- \rightarrow \quad + \quad$$

(2)

(c) Two aqueous salt solutions are electrolysed using inert electrodes.

Complete the table below to show the product at each electrode.

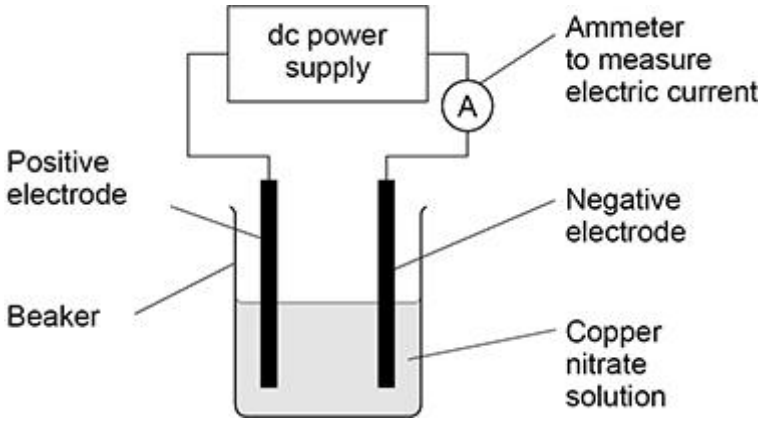
Salt solution	**Product at positive electrode**	**Product at negative electrode**
Copper nitrate		copper
Potassium iodide		

(3)

Some students investigated the electrolysis of copper nitrate solution using inert electrodes.

Figure 1 shows the apparatus.

Figure 1



The students investigated how the mass of copper produced at the negative electrode varied with:

- time
- current.

This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in **Figure 1**.
3. Adjust the power supply until the ammeter shows a current of 0.3 A
4. Switch off the power supply after 5 minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.
8. Repeat steps 1 to 7 at different currents.

(d) Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker.

Suggest how the students could find the total mass of copper produced.

_____

_____

_____

_____

_____

_____

(4)

(Total 11 marks)

Q5. This question is about salts.

(a) Name the salt produced by the neutralisation of hydrochloric acid with potassium hydroxide.

_____

(1)

(b) Write an ionic equation for the neutralisation of hydrochloric acid with potassium hydroxide.

_____ + _____ → _____

(1)

(c) Soluble salts can be produced by reacting dilute hydrochloric acid with an insoluble solid.

Copper, copper carbonate and copper oxide are insoluble solids.

Which of these insoluble solids can be used to make a copper salt by reacting the solid with dilute hydrochloric acid?

Tick (✓) **one** box.

Copper and copper carbonate only	☐
Copper and copper oxide only	☐
Copper carbonate and copper oxide only	☐
Copper, copper carbonate and copper oxide	☐

(1)

A student makes crystals of magnesium sulfate.

This is the method used.

1. Add sulfuric acid to a beaker.
2. Warm the sulfuric acid.
3. Add a spatula of magnesium oxide to the beaker.
4. Stir the mixture.
5. Repeat steps 3 and 4 until there is magnesium oxide remaining in the beaker.
6. Filter the mixture.
7. Evaporate the filtrate gently until crystals start to form.
8. Leave the solution to finish crystallising.

(d) Give **one** reason for:

- step 2
- step 5
- step 6.

Step 2 _____

_____

Step 5 _____

_____

Step 6 _____

_____

(3)

(e) How should the filtrate be evaporated gently in **step 7**?

_____

_____

(1)

(Total 7 marks)

C5 Energy changes

Q1. This question is about metals.

(a) The table below shows information about four substances.

Substance	Melting point in °C	Boiling point in °C	Does it conduct electricity in the solid state?	Does it conduct electricity in the liquid state?
A	–117	79	No	No
B	801	1413	No	Yes
C	1535	2750	Yes	Yes
D	1610	2230	No	No

Which substance could be a metal?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(b) Explain why alloys are harder than pure metals.

_____

_____

_____

_____

_____

_____

(3)

(c) A student wants to compare the reactivity of an unknown metal, **Q**, with that of zinc.

Both metals are more reactive than silver.

The student is provided with:

- silver nitrate solution
- metal **Q** powder
- zinc powder
- a thermometer
- normal laboratory equipment.

No other chemicals are available.

Describe a method the student could use to compare the reactivity of metal **Q** with that of zinc.

Your method should give valid results.

(4)

(Total 8 marks)

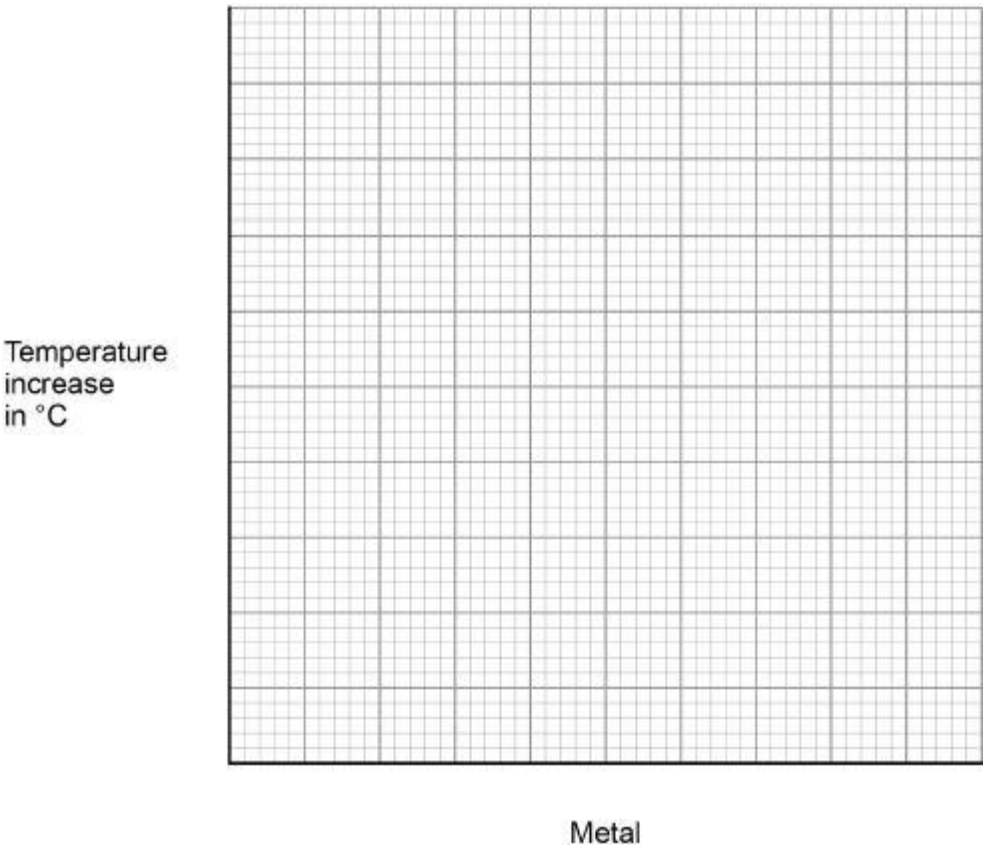
Q2. A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

The table below shows the student's results.

Metal	**Temperature increase in °C**
Copper	0
Iron	13
Magnesium	43
Zinc	17

(a) Plot the data from the table above on **Figure 1** as a bar chart.

Figure 1



(2)

(b) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

_____

_____

(1)

(c) The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(d) Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 2**.

Figure 2

(3)

(Total 10 marks)

Q3. This question is about the reaction between hydrogen sulfide (H_2S) and oxygen.

The equation for the reaction is:

$$2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ H_2O(g) + 2\ SO_2(g)$$

(a) What does $H_2O(g)$ represent?

_____ **(1)**

(b) Calculate the volume of oxygen required to react with 50 cm^3 of hydrogen sulfide.

_____

_____

Volume = _____ cm^3

(1)

(c) **Figure 1** shows part of the reaction profile for the reaction.

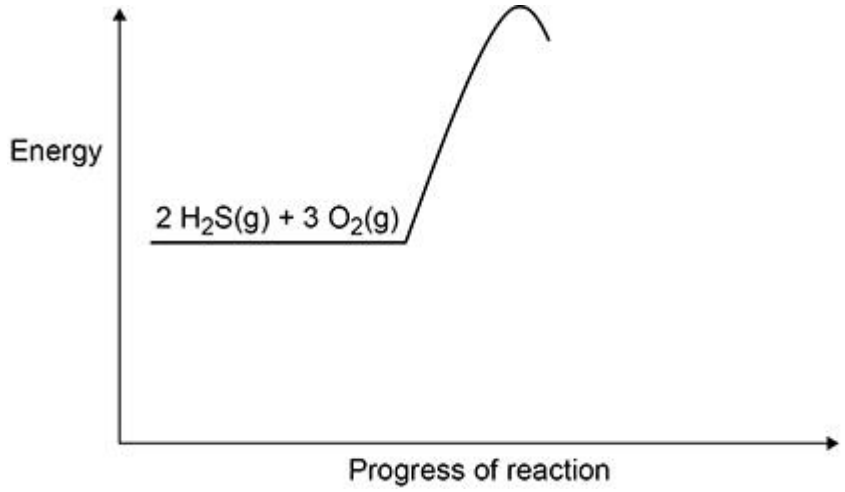
The reaction is exothermic.

Complete **Figure 1**.

You should:

- complete the profile line
- label the activation energy
- label the overall energy change.

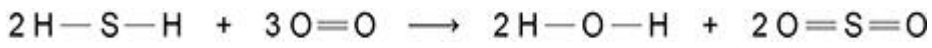
Figure 1



(3)

(d) **Figure 2** shows the displayed formula equation for the reaction of hydrogen sulfide with oxygen.

Figure 2



The table below shows some of the bond energies.

Bond	H — S	O = O	H — O	S = O
Energy in kJ/mol	364	498	464	**X**

In the reaction the energy released forming new bonds is 1034 kJ/mol greater than the energy needed to break existing bonds.

Calculate the bond energy **X** for the bond.

Use **Figure 2** and the table above.

X = _____kJ/mol

(5)

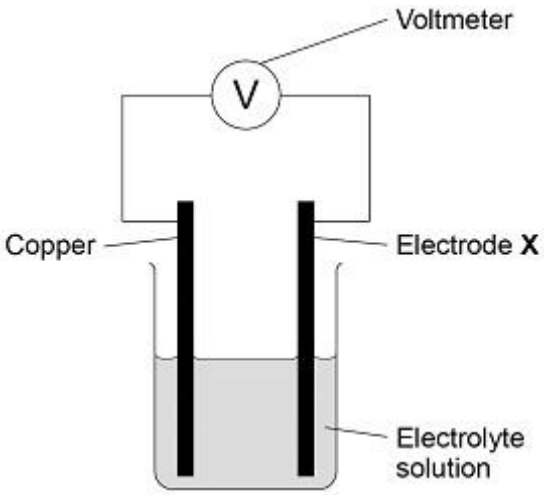
(Total 10 marks)

Q4. This question is about chemical cells.

A student investigated the voltage produced by different chemical cells.

Figure 1 shows the apparatus.

Figure 1



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**.

(a) Suggest **two** control variables used in this investigation.

1 _____

_____

2 _____

_____

(2)

The following table shows the student's results.

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

(b) Write the six metals used for electrode **X** in order of reactivity.

Use the table above.

Justify your order of reactivity.

Most reactive _____

_____

_____

_____

_____

Least reactive _____

Justification _____

_____

_____

_____

_____

(4)

(c) Which of the following pairs of metals would produce the greatest voltage when used as the electrodes in the cell?

Use the table above.

Tick (✓) **one** box.

Magnesium and cobalt ☐

Magnesium and tin ☐

Nickel and cobalt ☐

Nickel and tin ☐

(1)

(d) 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)

(Total 9 marks)

Mark schemes

C1 Atomic Structure

Q1.

(a) B

1

(b) C

1

(c) A

1

(d) sum of protons and neutrons

allow number of protons and neutrons

1

(e) between 69.5 and 70.0

1

(f) Chadwick provided the evidence to show the existence of neutrons

allow Chadwick discovered neutrons

1

(this was necessary because) isotopes have the same number of protons

allow (this was necessary because) isotopes have the same atomic number

or

(this was necessary because) isotopes are atoms of the same element

ignore isotopes have the same number of electrons

1

but with different numbers of neutrons

allow but with different mass (numbers)

1

[8]

Q2.

(a) (i) *incorrect or no element = **0** marks*

hydrogen

allow H / H_2

1

all the other elements are metals

allow hydrogen is a not an (alkali / group 1) metal

ignore hydrogen is a gas

OR

copper (1)

allow Cu

(copper) is not an alkali metal (1)

allow Cu is a transition element / metal

allow any valid specific chemical property eg Cu does not react with water

ignore references to electronic structure

ignore physical properties

1

(ii) Group 0 / noble gases

ignore Group 8

1

(b) (i) scandium / gallium / germanium

accept Sc / Ga / Ge

allow Krypton / Kr

1

(ii) predicted they were metals

allow atomic mass / weight

ignore atomic structure

1

predicted their (chemical/physical) properties / reactivity
accept any chemical / physical property
allow similar properties if mentioned in context of a group

1

(c) (i) (both) have <u>one</u> / <u>an</u> electron in the outer energy level / shell
ignore form single plus ions

1

(ii) *accept shell for energy level*
accept converse explanation for lithium
if 'outer' not mentioned, max 2 marks
ignore sodium reacts more easily
sodium loses one outer electron <u>more</u> easily (than lithium)

1

because outer electrons/energy level furth<u>er</u> from the nucleus in sodium **or** because sodium has <u>more</u> shells (than lithium)
*do **not** accept 'more outer shells'*
allow sodium (atom) is larger

1

because forces/attraction to hold outer electron are weak<u>er</u> in sodium (than lithium)
accept more shielding in sodium (than lithium)

1

[10]

Q3. (a) any **three** from: (nuclear model)

- mostly empty space
  allow the plum pudding model has no empty space
  allow the plum pudding model is solid
- the positive charge is (all) in the nucleus
  allow in the plum pudding model the atom is a ball of positive charge (with embedded electrons)
  *do **not** accept reference to protons*
- the mass is concentrated in the nucleus
  allow in the plum pudding model the mass is spread out
  *do **not** accept reference to neutrons*
- the electrons and the nucleus are separate
  allow in the plum pudding model the electrons are embedded
  allow in the nuclear model the electrons are in orbits

3

(b) electrons orbit the nucleus
*do **not** accept reference to protons / neutrons*
allow electrons are in energy levels around the nucleus
or
allow electrons are in shells around the nucleus

1

electrons are at specific distances from the nucleus

1

(c) atomic number is the number of protons

1

(and) protons were not discovered until later
ignore electrons / neutrons were not discovered until later

1

(d) so their properties matched the rest of the group
allow converse

1

[8]

Q4. (a) potassium chloride **and** iodine

either order

allow KCl for potassium chloride and I_2 for iodine

1

(b) (chlorine's) outer electrons / shell closer to the nucleus

allow chlorine has fewer shells

allow chlorine atom is smaller than iodine atom

ignore chlorine has fewer outer shells

1

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

allow chlorine has less shielding

*do **not** accept incorrect types of attraction*

1

(so) chlorine gains an electron more easily

1

***max 2** marks can be awarded if the answer refers to chloride / iodide instead of chlorine / iodine*

allow converse statements

allow energy levels for shells throughout

(c) hydrogen chloride is made of small molecules

allow hydrogen chloride is simple molecular

1

(so hydrogen chloride) has weak intermolecular forces*

1

(intermolecular forces) require little energy to overcome*

1

do **not accept reference to bonds breaking unless applied to intermolecular bonds*

(d) (bonds broken = 4(412) + 193 =)1841

1

(bonds formed = 3(412) + 366 + **X** =) 1602 + **X**

1

−51 = 1841 − (1602 + **X**)

allow use of incorrectly calculated values of bonds broken and / or bonds formed from steps 1 and 2 for steps 3 and 4

1

(**X** =) 290 (kJ/mol)

allow a correctly calculated answer from use of −51 = bonds formed − bonds broken

1

OR

alternative method ignoring the 3 unchanged C−H bonds

(412 + 193 =) 605 (1)

366 + **X** (1)

−51 = 605 − (366 + **X**) (1)

(**X** =) 290 (kJ/mol) (1)

*an answer of 290 (kJ/mol) scores **4** marks*

*an answer of 188 (kJ/mol) scores **3** marks*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[11]

Q5.(a) liquid gas

1

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

1

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

1

(so) the intermolecular forces increase (in strength)
allow (so) the forces between molecules increase (in strength)

1

(so) more energy is needed to overcome the intermolecular forces
allow (so) more energy is needed to separate the molecules
*do **not** accept a reference to breaking bonds unless specifically between molecules*

1

(c) boiling point is a bulk property
allow boiling point is related to intermolecular forces (so more than one molecule is involved)

1

(d) the gas / halogen is toxic
allow the gas / halogen is poisonous / harmful allow to prevent inhalation of the gas / halogen
ignore deadly / lethal

1

(e) (going down the group) the outer electrons / shell become further from the nucleus
allow energy level for shell throughout
allow the atoms become larger
allow the number of shells increases
ignore the number of outer shells increases

1

(so) the nucleus has less attraction for the outer electrons / shell
allow (so) the nucleus has less attraction for the incoming electron
allow (so) increased shielding between the nucleus and the outer electrons / shell
allow (so) increased shielding between the nucleus and the incoming electron

1

(so) an electron is gained less easily

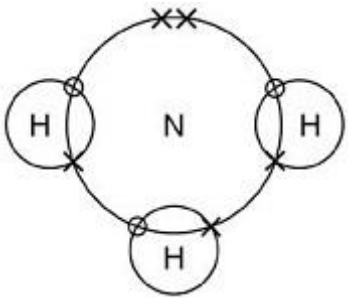
1

[10]

C2 Bonding, structure and the properties of matter

Q1.

(a)



*scores **2** marks*
allow dots, crosses, circles or $e^{(-)}$ for electrons

1 bonding pair of electrons in each overlap

1

2 non-bonding electrons on nitrogen

*do **not** accept non-bonding electrons on hydrogen*
ignore inner shell electrons drawn on nitrogen

1

(b) does not show the shape
or
only two-dimensional

allow is not three-dimensional

1

(c) (ammonia has) small molecules

allow (ammonia has) a simple molecular (structure)

1

(ammonia has) weak intermolecular forces

allow (ammonia has) weak intermolecular bonds
*do **not** accept weak covalent bonds*

1

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

allow (so) little energy is needed to break the intermolecular bonds
allow (so) little energy is needed to separate the molecules
*do **not** accept references to breaking covalent bonds*

1

(d) Cr_2O_3

1

[7]

Q2.

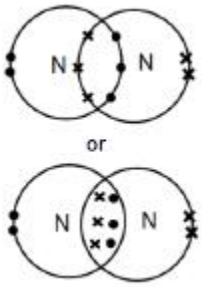
(a) six electrons in the overlap

allow dots, crosses or $e^{(-)}$ for electrons

1

2 non-bonding electrons on each nitrogen atom

***2** marks for an answer of:*



1

(b) weak forces

1

between molecules
or
intermolecular

do not allow references to covalent bonding between molecules

1

(which) need little energy to overcome

1

(c) each (carbon) atom forms three covalent bonds

1

forming layers (of hexagonal rings)

1

(soft)
(because) layers can slide over each other

1

(conducts electricity)
(because of) delocalised electrons

1

(d) molecules are spherical

1

(so molecules) will roll

1

(e) surface area (= 20 × 20 × 6) = 2400 (nm^2)

1

volume (= 20^3) = 8000 (nm^3)

1

ratio = 0.3 (nm^3): 1 (nm^3)
ratio = 0.3 (nm^3): 1 (nm^3)
or
1 (nm^3): 3.33 (nm^3)

1

(f) (nanoparticles) have a larger surface area to volume ratio

1

so less can be used for the same effect

1

[16]

Q3.

(a) magnesium loses two electrons **and** chlorine gains one electron
*accept magnesium loses electrons **and** chlorine gains electrons for 1 mark*
ignore oxidation and reduction

2

one magnesium and two chlorines
accept $MgCl_2$

1

noble gas structure
or
eight electrons in the outer shell
accept full outer shell (of electrons)
or
(electrostatic) attraction between ions
or
forms ionic bonds
*do **not** accept covalent bonds*

1

*reference to incorrect particles **or** incorrect bonding **or** incorrect structure = **max 3***

(b) layers (of particles/atoms/ions)

1

(particles/atoms/ions/layers) can slide

1

*any mention of intermolecular / weak bonds/forces = **max 1***

[6]

Q4.

(a) has delocalised electrons
accept free (moving) electrons

1

(so electrons) can move through the structure/metal
accept (so electrons) can carry charge through the structure/metal

accept (so electrons) can form a current

1

*reference to incorrect particles **or** incorrect bonding **or** incorrect structure = **max 1***

(b) giant structure

accept lattice
accept each atom forms four bonds (with other carbon atoms)
ignore macromolecular

1

strong bonds

accept covalent
*do **not** accept ionic*

1

*reference to intermolecular forces/bonds **or** incorrect particles = **max 1***

(c) thermosetting polymers do not melt (when heated)

accept thermosetting polymers do not change shape (when heated)
accept thermosetting polymers have high(er) melting points
ignore thermosetting polymers do not soften (when heated)

1

due to cross-links (between chains)

accept due to bonds between chains

1

*reference to smart polymers = **max 1***
accept converse argument

[6]

C3 Quantitive Chemistry

Q1.

(a) potassium chloride

allow KCl

1

(b) $H^+ + OH^- \rightarrow H_2O$

ignore state symbols

1

(c) (moles Fe = $\frac{14}{56}$ =) 0.25 (mol)

1

(moles Cl_2 = $\frac{3}{2}$ $_2$ × 0.25 =) 0.375 (mol)

allow correct use of an incorrectly calculated number of moles of Fe

1

(volume Cl_2 = 24 × 0.375) = 9.0 (dm^3)

allow correct use of an incorrectly calculated number of moles of Cl_2

1

[10]

Q2. (a) (concentration = 90 × 0.0480 =) 4.32 (g/dm^3)

1

(mass = 4.32 × $\frac{250}{1000}$) = 1.08 (g)

allow correct use of an incorrectly calculated value of concentration in g/dm^3

1

alternative approach:
(moles = 0.0480 × $\frac{250}{1000}$ =)
0.012 (mol) (1)
(mass = 0.012 × 90)
= 1.08 (g) (1)
allow correct use of an incorrectly calculated value of number of moles

(b) (moles $H_2C_2O_4$ = $\frac{15.0}{1000}$ × 0.0480)
= 0.00072 (mol)

1

(moles NaOH =
moles $H_2C_2O_4$ × 2 =)
0.00144 (mol)
allow correct use of an incorrectly calculated value of number of moles of $H_2C_2O_4$

1

(concentration= $\frac{0.00144}{25.0}$ × 1000)
= 0.0576 (mol/dm^3)
allow 0.058 (mol/dm^3)
allow correct use of an incorrectly calculated value of number of moles of NaOH

1

alternative approach:
$\frac{\text{volume} \times \text{conc (acid)}}{\text{volume} \times \text{conc (NaOH)}} = \frac{1}{2}$ (1)
allow inverse
(conc NaOH =)
$2 \times \frac{15.0 \times 0.0480}{25.0}$ (1)
allow correct use of incorrect mole ratio
= 0.0576 (mol/dm^3) (1)

[9]

Q3.

(a) the (minimum) energy needed for particles to react
or
the (minimum) energy needed for a reaction to occur
allow the (minimum) energy needed to start a reaction

1

(b) (M_r of Fe_2O_3 =) 160

1

(moles Fe_2O_3 = $\frac{3000}{160}$ =)
18.75 (mol)
allow correct use of incorrectly calculated M_r

1

(moles Al = $\frac{1000}{27}$ =) 37.0 (mol)
allow 37.037037 (mol) correctly rounded to at least 2 significant figures
*if both MP2 and MP3 are not awarded allow **1** mark for 0.01875 mol Fe_2O_3 **and** 0.037 mol Al*

1

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

or

iron oxide is in excess because 18.75 mol is more than the ($\frac{37.0}{2}$ =) 18.5 mol (iron oxide needed)

allow correct use of incorrect number of moles from steps 2 and/or 3

alternative approaches:

approach 1:

(finding required mass of aluminium by moles method)

(M_r of Fe_2O_3 =) 160 (1)

(moles Fe_2O_3 = $\frac{3000}{160}$ =)

18.75 (mol) (1)

allow correct use of incorrectly calculated M_r

(moles Al needed =18.75 × 2 =) 37.5 (mol)

and

(mass Al needed = 37.5 × 27 =) 1012.5 (g) **or** 1.0125 kg (1)

allow correct use of incorrectly calculated moles of iron oxide

allow correct use of incorrectly calculated moles of aluminium needed

(so) 1.00 kg of aluminium is not enough (1)

dependent on calculated mass of aluminium needed being greater than 1.00 (kg)

approach 2:

(finding required mass of aluminium by proportion method)

(M_r of Fe_2O_3 =) 160 (1)

(3.00 kg Fe_2O_3 needs)

$\frac{3.00}{160}$ × 2 × 27 (kg Al) (1)

allow correct use of incorrectly calculated M_r

(=) 1.0125 (kg) (1)

(so) 1.00 kg of aluminium is not enough (1)

dependent on calculated mass of aluminium needed being greater than 1.00 (kg)

alternative approaches:

approach 3:

(finding required mass of iron oxide by moles method)

M_r of Fe_2O_3 =) 160 (1)

(moles Al = $\frac{1000}{27}$ =) 37.0 (mol) (1)

allow 37.037037 (mol) correctly rounded to at least 2 significant figures

(moles Fe_2O_3 needed) = $\frac{37.0}{2}$) = 18.5 (mol)

and

(mass Fe_2O_3 needed = 18.5 × 160 =) 2960 (g) **or** 2.96 (kg) (1)

allow correct use of incorrectly calculated moles of aluminium

allow correct use of incorrectly calculated moles of iron oxide needed

allow correct use of incorrectly calculated M_r

(so) 3.00 kg of iron oxide is an excess (1)

dependent on calculated mass of iron oxide needed being less than 3.00 (kg)

approach 4:
(finding required mass of iron oxide by proportion method)
(M_r of Fe_2O_3 =) 160 (1)

(1.00 kg Al needs) $\frac{1.00}{2 \times 27}$ (kg Fe_2O_3) (1)

allow correct use of incorrectly calculated M_r

(=) 2.96 (kg) (1)

(so) 3.00 kg of iron oxide is an excess (1)

dependent on calculated mass of iron oxide needed being less than 3.00 (kg)

1

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

allow multiples

*allow **1** mark for $Mg^{2+} + Zn$ with missing or incorrect state symbols*

2

(d) magnesium (atoms) are oxidised because they lose electrons

1

(and) zinc (ions) are reduced because they gain electrons

*if no other marks awarded allow **1** mark for magnesium (atoms) lose electrons and zinc (ions) gain electrons 1*

1

[9]

Q4. (a) 4.48 (g iron) **and** 8.52 (g chlorine)

1

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

allow correct calculation using incorrectly calculated mass of iron

1

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

allow correct calculation using incorrectly calculated mass of chlorine

allow (moles Cl_2 = $\frac{8.52}{71}$ =) 0.12

1

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

allow correct calculation using incorrectly calculated moles of iron and / or chlorine

$2 Fe + 3 Cl_2 \rightarrow 2 FeCl_3$

allow multiples / fractions

allow a correctly balanced equation including Fe and Cl_2 from an incorrect ratio of Fe : Cl

*allow **1** mark for Fe **and** Cl_2 (reactants) **and** $FeCl_3$ (product)*

or

*allow **1** mark for Fe **and** Cl_2 (reactants) **and** a formula for iron chloride correctly derived from an incorrect ratio of Fe : Cl (product)*

2

[6]

Q5. (a)

*an answer of 941 (kg) scores **4** marks*

(M_r of Al_2O_3 =) 102

$\left(\frac{2\,000\,000}{102} =\right)$ 19 608 (mol Al_2O_3)

allow correct calculation using incorrectly calculated value of M_r of Al_2O_3

1

$\left(19\,608 \times \frac{3}{2} =\right)$ 29 412 (mol O_2)

allow correct calculation using incorrectly calculated value of moles of Al_2O_3

1

$\left(\frac{29\,412 \times 32}{1000} =\right)$ 941 (kg)

allow 941.1764706 (kg) correctly rounded to at least 2 significant figures
allow correct answer using incorrectly calculated value of moles of O_2

1

alternative approach:
(2 M_r of Al_2O_3 =) 204 (1)
204 (kg of Al_2O_3) gives 96 (kg of O_2) (1)
(2000 kg of Al_2O_3 gives)
$\frac{2000}{204}$ x 96 (kg of O_2)
or
$\frac{2000000}{204}$ x 96 (g of O_2) (1)
= 941 (kg) (1)

(b)

*an answer of 50700 (dm^3) scores **2** marks*
*an answer of 50.7 (dm^3) scores **1** mark*
$\left(\frac{150\,000}{71} =\right)$ 2113 (mol of Cl_2)

1

or

(volume of 1 g of Cl_2 = $\frac{24}{71}$ =) 0.34 (dm^3)
$(\frac{150\,000}{71}$ x 24) = 50700 (dm^3)

allow 50704.22535 (dm^3) correctly rounded to at least 2 significant figures
allow correct calculation using their calculated number of moles and/or calculated volume of 1 g

1

[16]

Q6.

(a) polystyrene is a better (thermal) insulator
allow polystyrene is a poorer (thermal) conductor

1

(so) reduces energy exchange (with the surroundings)
allow (so) reduces energy / heat loss (to the surroundings)

1

(b) all six points plotted correctly
allow a tolerance of ± ½ a small square
*allow **1** mark for at least 3 points plotted correctly*

2

line of best fit through points plotted from the table

1

both lines of best fit extrapolated correctly until they cross

1

(c) 11 (cm^3)

allow ecf from part (b)
allow answers in the range 10.75 to 11.25 (cm^3)
allow a tolerance of ± ½ a small square

1

(d) (27.5 − 18.9) = 8.6 (°C)

allow ecf from part (b)
allow answers in the range 8.5 to 8.7 (°C)
allow a tolerance of ± ½ a small square

1

(e)

*an answer of 0.62 (mol/dm^3) for concentration in mol/dm^3 scores **4** marks*
*an answer of 0.31 (mol/dm^3) for concentration in mol/dm^3 scores **3** marks*

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

1

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

allow correct calculation using incorrectly calculated value of moles of H_2SO_4

1

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

allow correct calculation using incorrectly calculated value of moles of KOH

1

= 0.62 (mol/dm^3)

allow correct answer using incorrectly calculated value of moles of KOH

1

(M_r KOH =) 56

1

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

allow 35 or 34.72 (g/dm^3)
allow correct answer using incorrectly calculated value of concentration in mol/dm^3 and/or incorrect M_r

1

alternative approach for step 1 to step 4

$\frac{2}{1} = \frac{25 \times \text{conc KOH}}{15.5 \times 0.500}$ (2)

$(\text{conc KOH}) = \frac{2 \times 15.5 \times 0.500}{25.0}$ (1)

= 0.62 (mol/dm^3) (1)

allow 1 mark if mole ratio is incorrect

1

[14]

C4 Chemical changes

Q1. (a) solid (zinc chloride) does not conduct (electricity)

or

zinc chloride needs to be in solution **or** molten

allow liquid / aqueous

1

(because) ions cannot move in the solid

or

(as) ions can (only) move in liquid / solution

*do **not** accept references to movement of electrons in zinc chloride*

1

(b) each carbon / atom forms 3 (covalent) bonds

1

one electron per carbon / atom is delocalised

1

(so) these electrons carry charge through the graphite

or

(so) these electrons move through the structure

ignore carry current / electricity

1

*if no other mark scored, allow **1** mark for delocalised / free electrons*

allow free electrons for delocalised electrons

(c) use measuring cylinders (instead of test tubes)

allow use burettes

allow use (gas) syringes

allow Hoffmann voltameter

1

(because) test tubes cannot measure volume

or

(because) test tubes have no graduations / scale

allow (so that) volume can be measured **1**

(d) any **three** from:

- the volume of hydrogen collected is directly proportional to the time

  allow the (volume of) hydrogen is collected at a constant / steady rate
- the rate of collection of hydrogen is 0.45 (cm^3/min)
- up to 8 minutes chlorine is collected at an increasing rate

  allow any value from 6 to 8 minutes

  allow initially chlorine is collected at an increasing rate
- after 8 minutes the rate of collection of chlorine is the same as that of hydrogen

  allow any value from 6 to 8 minutes

  or

  after 8 minutes the rate of collection of chlorine is 0.45 (cm^3/min)

  allow after 8 minutes the (volume of) chlorine is collected at a constant / steady rate

  if neither bullet point 3 nor bullet point 4 is awarded

  *allow **1** mark for chlorine is collected slowly up to 8 minutes and then more quickly*

  allow any value from 6 to 8 minutes

3

(e) chlorine reacts with water

or

chlorine dissolves (in the solution).

1

(f) $(\text{volume} =) \frac{6.6}{1000}\ (dm^3)$

or 0.0066 (dm^3)

allow 6.5 (cm^3) for 6.6 (cm^3)

1

$(\text{moles} =) \frac{0.0066}{24}$

allow use of incorrect volume from step 1

1

$= 2.75 \times 10^{-4}$ (mol)

allow 2.8×10^{-4} *(mol)*
allow answer from incorrect calculation given in standard form
alternative approach for marking points 1 and 2
24 dm^3 *= 24 000* cm^3 *(1)*

$(moles =) \frac{6.6}{24\,000}$ *(1)*

1

an answer of 2.75×10^{-4} *(mol) or* 2.8×10^{-4} *(mol) scores **3** marks*
an answer of 0.000275 / 0.00028 / 2.75×10^{-1} */* 2.8×10^{-1} *(mol) / scores **2** marks*
*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[10]

Q2.

(a) (strong because) completely ionised (in aqueous solution)

ignore pH
allow dissociated for ionised
*do **not** accept hydrogen is ionising*
*do **not** accept* H^+ *are ionised*

1

(dilute because) small amount of acid per unit volume

ignore low concentration

1

(b) 5.0

allow 5

1

(c) (titre):
chooses titrations 3, 4, 5

1

average titre = 22.13 (cm^3)

allow average titre = 22.13(3…) (cm^3*)*
allow a correctly calculated average from an incorrect choice of titrations

1

(calculation):
(moles NaOH =
$\frac{22.13}{1000} \times 0.105 = 0.002324$)

allow use of incorrect average titre from step 2

1

(moles H_2SO_4 =
½ × 0.002324 =) 0.001162

allow use of incorrect number of moles from step 3

1

(concentration =

$\frac{0.001162}{25} \times 1000)$

= 0.0465 (mol/dm^3)

allow use of incorrect number of moles from step 4

1

alternative approach for step 3, step 4 and step 5

$\frac{2}{1} = \frac{22.13 \times 0.105}{25.0 \times conc.\ H_2SO_4}$ *(1)*

(concentration H_2SO_4 =)

$\frac{22.13 \times 0.105}{25.0 \times 2}$

= 0.0465 (mol/dm^3) (1)

an answer of 0.046473 ***or*** *0.04648 correctly rounded to at least 2 sig figs scores marking points 3, 4 and 5*

an answer of 0.092946 ***or*** *0.09296* ***or*** *0.185892* ***or*** *0.18592 correctly rounded to at least 2 sig figs scores marking points 3 and 5*

an incorrect answer for one step does ***not*** *prevent allocation of marks for subsequent steps*

(d) pipette measures a fixed volume (accurately)

1

(but) burette measures variable volume

allow can measure drop by drop

1

(e) $(moles =) \frac{30}{1000} \times 0.105$

or 0.00315 (mol)

or

(mass per dm^3 =) 0.105 × 40

or 4.2 (g)

1

$(mass = \frac{30}{1000} \times 0.105 \times 40)$

= 0.126 (g)

1

an answer of 0.126 (g) scores ***2*** *marks*

an answer of 126(g) scores ***1*** *mark*

an incorrect answer for one step does ***not*** *prevent allocation of marks for subsequent steps*

[12]

Q3.

(a) a dilute solution of a strong acid

1

(b) 1.0 mol/dm^3 hydrogen chloride solution

1

(c) any **two** from:

- swirl (the solution)
- white tile (under the flask)
- add (ethanedioic) acid dropwise (near the endpoint)
- repeat **and** calculate mean

2

(d) (concentration = 90 × 0.0480 =)
4.32 (g/dm^3)

1

(mass = 4.32 × $\frac{250}{1000}$) = 1.08 (g)

allow correct use of an incorrectly calculated value of concentration in g/dm³

1

alternative approach:

(moles = 0.0480 × $\frac{250}{1000}$ =)

0.012 (mol) (1)

(mass = 0.012 × 90)

= 1.08 (g) (1)

allow correct use of an incorrectly calculated value of number of moles

[6]

Q4.

(a) electrolysis uses electricity to produce a chemical reaction

allow voltage for electricity
allow potential difference for electricity
allow (electrical) current for electricity
allow electrolysis uses electricity to decompose a compound / electrolyte

1

(but) cells use a chemical reaction to produce electricity

1

(b) $2Br^- \rightarrow Br_2 + 2e^-$

allow multiples
*allow **1** mark for Br_2 **and** e^-*

2

(c)

Salt solution	Product at positive electrode	Product at negative electrode
(copper nitrate)	oxygen (1)	(copper)
(potassium iodide)	iodine (1)	hydrogen (1)

1
2

(d) filter the mixture

1

wash and dry the copper / residue

1

weigh the copper collected

1

add to the increase in mass of the electrode

1

[11]

Q5.

(a) potassium chloride

allow KCl

1

(b) $H^+ + OH^- \rightarrow H_2O$

ignore state symbols

1

(c) copper carbonate and copper oxide only

1

(d) (Step 2) to speed up the reaction

1

(Step 5) to make sure all the (hydrochloric) acid reacts

1

(Step 6) to remove the excess magnesium oxide

ignore to remove impurities

1

(e) using a (boiling) water bath

or

using an electric heater

1

[7]

C5 Energy changes

Q1.

(a) C

1

(b) (in an alloy) the atoms are of different sizes

1

(so) the layers (of atoms in an alloy) are distorted

1

(so in an alloy) the layers slide over each other less easily (than in a pure metal)

1

(c) measure temperature change

*allow measure the temperature before **and** after the reaction*

1

when each metal is added to silver nitrate solution

1

same concentration / volume of solution

or

same mass / moles of metal

allow same initial temperature (of silver nitrate solution)

1

the greater the temperature change the more reactive

1

[8]

Q2.

(a) all 4 metals labelled and suitable scale on *y*-axis

magnesium value must be at least half the height of the grid

1

all bars correctly plotted

allow a tolerance of ±½ a small square
ignore width and spacing of bars
*allow **1** mark if copper not included and other 3 bars plotted correctly*

1

(b) temperature increases

allow (because) energy / 'heat' is transferred to the surroundings
allow energy / 'heat' is given out

or

temperature does not decrease

allow energy / 'heat' is not taken in (from the surroundings)
allow the energy of the products is less than the energy of the reactants

1

ignore because it is exothermic
ignore references to copper

(c) suitable method described

1

the observations / measurements required to place in order
dependent on a suitable method

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

a control variable to give a valid result

1

approaches that could be used
approach 1:
add the unknown metal to copper sulfate solution (1)
measure temperature change (1)
place the metals in order of temperature change (1)
any **one** from (1):
- same volume of solution
- same concentration of solution
- same mass / moles of metal
- same state of division of metal

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)
measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)
place the metals in order of temperature change **or**
compare whether there is a reaction to place in correct order (1)
any **one** from (1):
- same volume of salt solutions
- same concentration of salt solutions
- same (initial) temperature of salt solutions
- same mass / moles of metal **or** metal oxide
- same state of division of metal **or** metal oxide

approach 3:
add all of the metals to an acid (1)
measure temperature change or means of comparing rate of reaction (1)
place the metals in order of temperature change or rate of reaction (1)
any **one** from (1):
- same volume of acid
- same concentration of acid
- same (initial) temperature of acid
- same mass / moles of metal
- same state of division of metal

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)
measure the voltage of the cell (1)
place the metals in order of voltage (1)
any **one** from (1):
- same electrolyte
- same concentration of electrolyte

- same (initial) temperature of acid
- same temperature of electrolyte

(d) correct shape for exothermic reaction

the reactant and product lines needed not be labelled
*do **not** accept incorrectly labelled reactant and product lines*

1

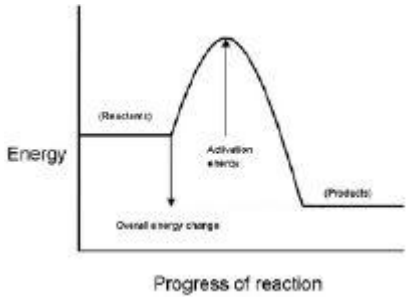
labelled activation energy

1

labelled (overall) energy change

1

ignore arrow heads
an answer of:



*scores **3** marks*

[10]

Q3.

(a) water vapour

allow steam
allow gaseous water

1

(b) 75 (cm^3)

1

(c) product level below reactants

ignore labelling of products

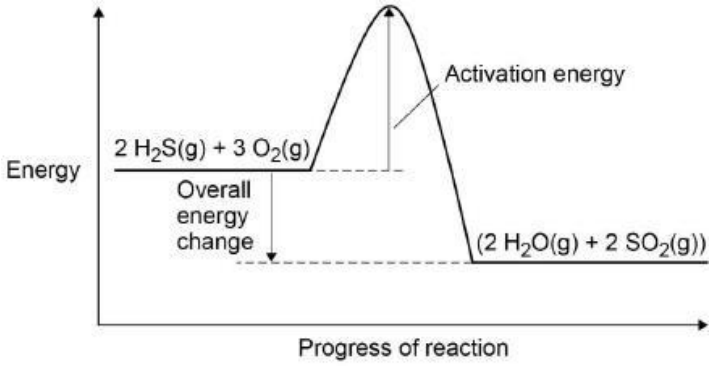
1

activation energy drawn and labelled

1

overall energy change drawn and labelled

if endothermic profile drawn allow corresponding overall energy change



scores **3** marks

1

(d) (bonds broken = 4(364) + 3(498) =) 2950

1

(bonds formed = 2950 + 1034 =) 3984

allow correct use of incorrectly calculated values of bonds broken

1

4**X** + 4(464) = 3984

allow correct use of incorrectly calculated values of bonds formed

1

4**X** = **(**3984 – 1856 =) 2128

1

X = 532 (kJ/mol)

1

alternative approach:
(bonds broken = 4(364) + 3(498) =) 2950 (1)
(bonds formed = 4(464) + 4**X** =) 1856 + 4**X** (1)
(1856 + 4**X**) – 2950 = 1034 (1)

allow correct use of incorrectly calculated values of bonds broken and/or bonds formed

4**X** = (1034 + 2950 – 1856 =) 2128 (1)
X = 532 (kJ/mol) (1)

[10]

Q4.

(a) any **two** from:

- temperature (of solution)

  ignore room temperature
- concentration of electrolyte / solution
- compound / ions in electrolyte / solution

  allow volume of electrolyte / solution
  allow size of electrode
  allow distance between electrodes
  *do **not** accept electrode **X** unqualified*
  *do **not** accept (measured) voltage*

2

(b) order:
(most reactive) magnesium
cobalt
nickel
tin
copper
(least reactive) silver

*allow **1** mark for magnesium, cobalt, nickel, tin in order at top*
*allow **1** mark for copper and silver in order at the bottom*

2

justification:
the higher the (positive) voltage, the more reactive (the metal)

allow the most reactive (metal) has the highest voltage

1

silver has a negative voltage because silver is less reactive than copper

1

(c) magnesium and tin

1

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

allow (in a fuel cell) hydrogen reacts with oxygen (to produce water) **1**

water is produced / released as gas / vapour / steam

*if no other mark awarded, allow **1** mark for fuel cells produce water* **1**

[9]