AQA GCSE CHEMISTRY (HIGHER) · 8462

# CHEMISTRY



EXAM QUESTION PACK

## 4.2.1 CHEMICAL BONDS: IONIC, COVALENT AND METALLIC (PACK 1)

| SCORE | PERCENTAGE |
| --- | --- |
| /402 | % |

STEMUP

# These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

## What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

## Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

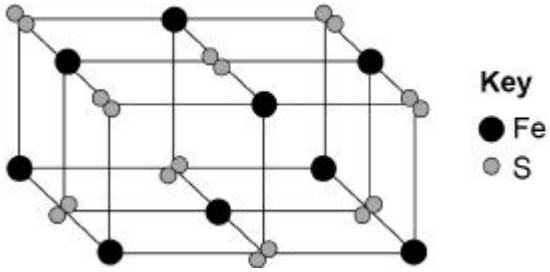
If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

## Q1.

This question is about metals and metal compounds.

(a) Iron pyrites is an ionic compound.

The diagram below shows a structure for iron pyrites.




Determine the formula of iron pyrites.

Use the diagram above.

_____

**(1)**

(b) An atom of iron is represented as $^{56}_{26}Fe$

Give the number of protons, neutrons and electrons in this atom of iron.

Number of protons _____

Number of neutrons _____

Number of electrons _____

**(3)**

(c) Iron is a transition metal.

Sodium is a Group 1 metal.

Give **two** differences between the properties of iron and sodium.

1. _____

_____

2. _____

_____

**(2)**

Nickel is extracted from nickel oxide by reduction with carbon.

(d) Explain why carbon can be used to extract nickel from nickel oxide.

_____



STEMUP.CO.UK

_____

_____

_____

**(2)**

(e) An equation for the reaction is:

$$NiO + C \longrightarrow Ni + CO$$

Calculate the percentage atom economy for the reaction to produce nickel.

Relative atomic masses ($A_r$): C = 12 Ni = 59

Relative formula mass ($M_r$): NiO = 75

Give your answer to 3 significant figures.

_____

_____

_____

_____

_____

_____

Percentage atom economy = _____ %

**(3)**

**(Total 11 marks)**

## Q2.

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.

_____

_____

_____



STEMUP.CO.UK

_____

_____

_____

**(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.

_____

_____

_____

_____

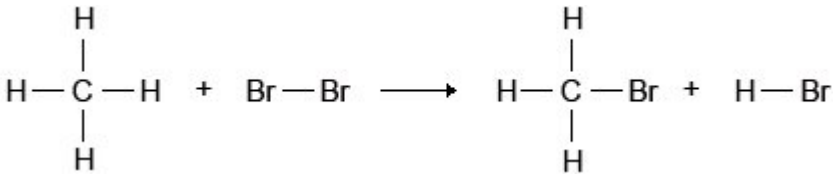
_____

_____

**(3)**

(d) Bromine reacts with methane in sunlight.

The diagram below shows the displayed formulae for the reaction of bromine with methane.



The table below shows the bond energies and the overall energy change in the reaction.

| | **C—H** | **Br—Br** | **C—Br** | **H—Br** | **Overall energy change** |
|---|---|---|---|---|---|
| **Energy in kJ/mol** | 412 | 193 | **X** | 366 | −51 |

Calculate the bond energy **X** for the C—Br bond.

Use the diagram and the table above.

_____

_____

_____



STEMUP.CO.UK

_____

_____

_____

_____

Bond energy **X** = _____ kJ/mol

**(4)**

**(Total 11 marks)**

## Q3.

Titanium is a transition metal.

Titanium is extracted from titanium dioxide in a two-stage industrial process.

**Stage 1** $TiO_2 + 2\ C + 2\ Cl_2 \longrightarrow TiCl_4 + 2\ CO$

**Stage 2** $TiCl_4 + 4\ Na \longrightarrow Ti + 4\ NaCl$

(a) Suggest **one** hazard associated with **Stage 1**.

_____

_____

**(1)**

(b) Water must be kept away from the reaction in **Stage 2**.

Give **one** reason why it would be hazardous if water came into contact with sodium.

_____

_____

**(1)**

(c) Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air.

_____

_____

_____

_____

**(2)**

(d) Titanium chloride is a liquid at room temperature.

Explain why you would **not** expect titanium chloride to be a liquid at room temperature.

_____



STEMUP.CO.UK

_____

_____

_____

_____

_____

_____

**(3)**

In **Stage 2**, sodium displaces titanium from titanium chloride.

(e) Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction?

_____

_____

**(1)**

(f) Complete the half equation for the oxidation reaction.

$$Na \longrightarrow _____ + _____$$

**(1)**

(g) In Stage 2, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:

$$TiCl_4 + 4\ Na \longrightarrow Ti + 4\ NaCl$$

Relative atomic masses ($A_r$): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**



STEMUP.CO.UK

(h) For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced.

_____

_____

_____

Mass of titanium = _____ kg

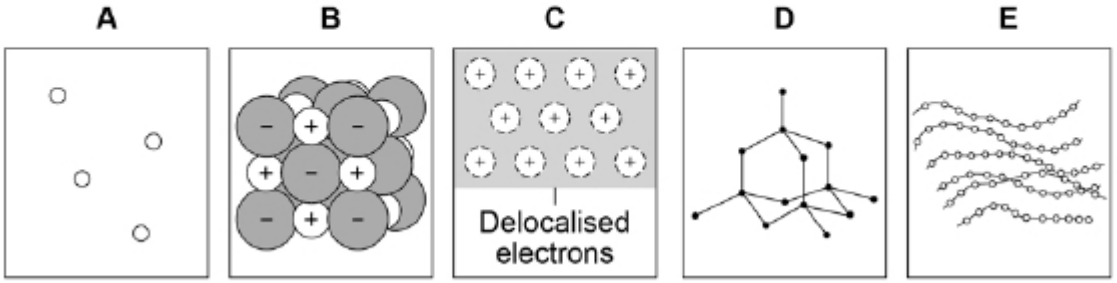
**(2)**

**(Total 15 marks)**

## Q4.

**Figure 1** shows the structure of five substances.

**Figure 1**




(a) Which diagram shows a gas?

Tick (✔) **one** box.

**A** ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

**(1)**

(b) Which diagram shows the structure of diamond?

Tick (✔) **one** box.

**A** ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

**(1)**

(c) Which diagram shows a metallic structure?

Tick (✔) **one** box.

**A** ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐



STEMUP.CO.UK

**(1)**

(d) Which diagram shows a polymer?

Tick (✔) **one** box.

**A** ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

**(1)**

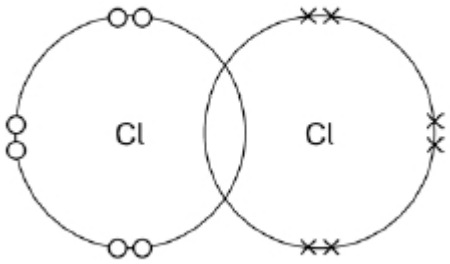
(e) A chlorine atom has 7 electrons in the outer shell.

Two chlorine atoms covalently bond to form a chlorine molecule, $Cl_2$

**Figure 2** is a dot and cross diagram showing the outer shells and some electrons in a chlorine molecule.

Complete the dot and cross diagram.
Show only the electrons in the outer shell.

**Figure 2**




**(1)**

(f) What is the reason for chlorine's low boiling point?

Tick (✔) **one** box.

Strong covalent bonds ☐

Strong forces between molecules ☐

Weak covalent bonds ☐

Weak forces between molecules ☐

**(1)**

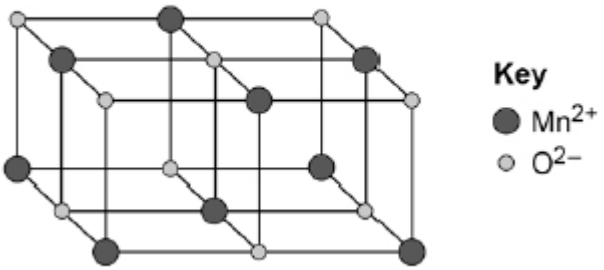
**Figure 3** represents the structure of manganese oxide.

Manganese oxide is an ionic compound.



STEMUP.CO.UK

**Figure 3**




(g) Determine the empirical formula of manganese oxide.

Use **Figure 3**.

_____

_____

Empirical formula = _____

**(1)**

(h) Why does manganese oxide conduct electricity as a liquid?

Tick (✔) **one** box.

| | |
|---|---|
| Atoms move around in the liquid | ☐ |
| Electrons move around in the liquid | ☐ |
| Ions move around in the liquid | ☐ |
| Molecules move around in the liquid | ☐ |

**(1)**

**(Total 8 marks)**

## Q5.

This question is about metal compounds.

(a) Lithium reacts with chlorine to produce lithium chloride.

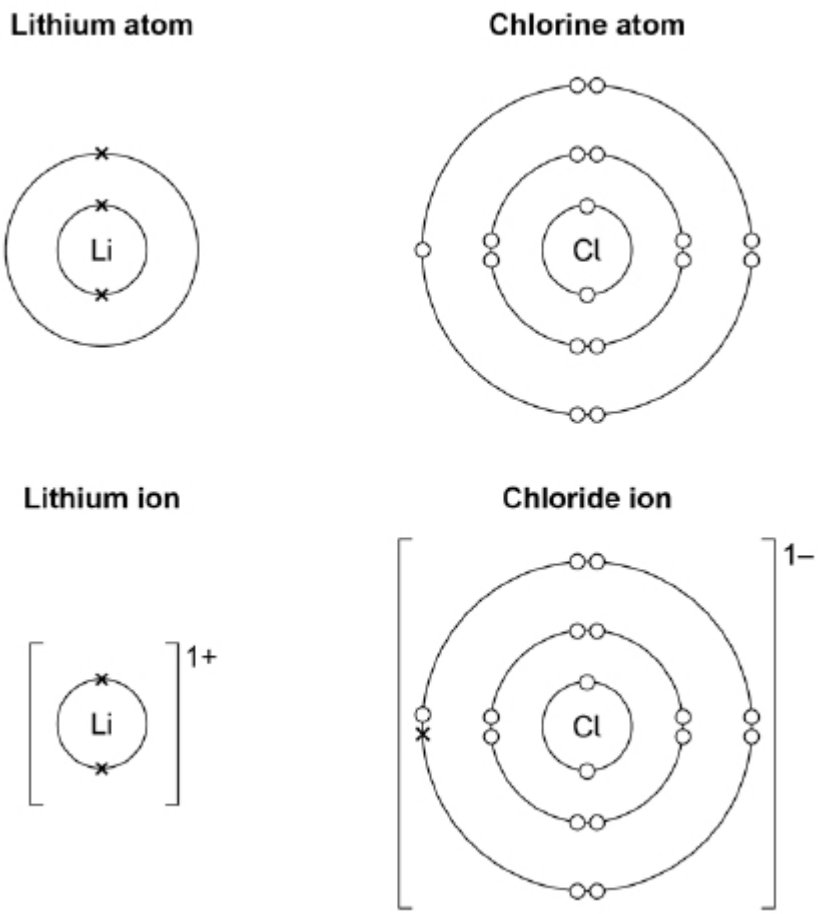
When lithium atoms and chlorine atoms react to produce lithium chloride, lithium ions and chloride ions are formed.

The diagram shows the electronic structures of the atoms and ions.

The symbols **o** and **x** are used to represent electrons.



STEMUP.CO.UK




Describe what happens when a lithium atom reacts with a chlorine atom.

Answer in terms of electrons.

**(4)**

Zinc sulfate can be made by two methods.

The equations for the two methods are:

**Method 1**: $ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$

**Method 2**: $ZnCO_3 + H_2SO_4 \longrightarrow ZnSO_4 + H_2O + CO_2$



STEMUP.CO.UK

(b) Calculate the percentage atom economy for making zinc sulfate in **Method 1**.

Use the equation:

percentage atom economy =

$$\frac{\text{relative formula mass of } ZnSO_4}{\text{relative formula mass of } ZnO + \text{relative formula mass of } H_2SO_4} \times 100$$

Give your answer to 3 significant figures.

Relative formula masses ($M_r$): ZnO = 81 $H_2SO_4$ = 98 $ZnSO_4$ = 161

_____

_____

_____

_____

_____

Percentage atom economy = _____ %

**(3)**

(c) **Method 1** gives a higher percentage atom economy for making zinc sulfate than **Method 2**.

Give a reason why it is important to use a reaction with a high atom economy.

_____

_____

**(1)**

(d) A student uses 50 $cm^3$ of a zinc sulfate solution of 80 $g/dm^3$

What mass of zinc sulfate is dissolved in 50 $cm^3$ of this zinc sulfate solution?

_____

_____

_____

_____

Mass = _____ g

**(2)**

**(Total 10 marks)**

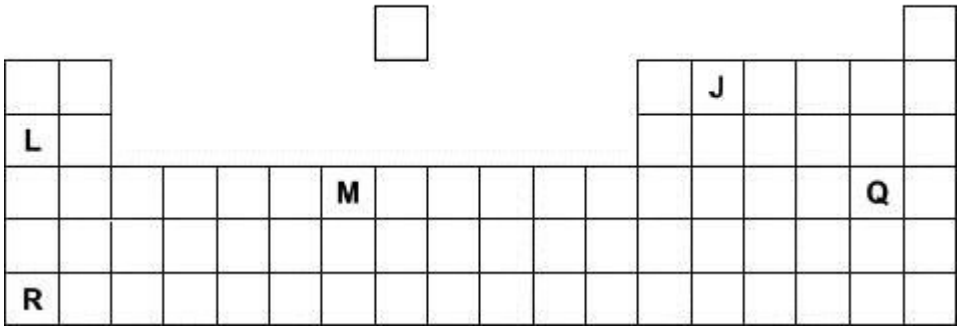
## Q6.

**Figure 1** shows an outline of the modern periodic table.



STEMUP.CO.UK

Figure 1




**J**, **L**, **M**, **Q** and **R** represent elements in the periodic table.

(a) Which element has four electrons in its outer shell?

Tick (✔) **one** box.

**J** ☐ **L** ☐ **M** ☐ **Q** ☐ **R** ☐

**(1)**

(b) Which **two** elements in **Figure 1** are in the same period?

_____ and _____

**(1)**

(c) Which element reacts with potassium to form an ionic compound?

Tick (✔) **one** box.

**J** ☐ **L** ☐ **M** ☐ **Q** ☐ **R** ☐

**(1)**

(d) Which element forms ions with different charges?

Tick (✔) **one** box.

**J** ☐ **L** ☐ **M** ☐ **Q** ☐ **R** ☐

**(1)**

(e) Which element has three electron shells?

Tick (✔) **one** box.

**J** ☐ **L** ☐ **M** ☐ **Q** ☐ **R** ☐

**(1)**

(f) In the 1860s scientists were trying to organise elements.

**Figure 2** shows the table published by John Newlands in 1865.
The elements are arranged in order of their atomic weights.



STEMUP.CO.UK

**Figure 2**

| | | | | | | |
|---|---|---|---|---|---|---|
| H | Li | Be | B | C | N | O |
| F | Na | Mg | Al | Si | P | S |
| Cl | K | Ca | Cr | Ti | Mn | Fe |
| Co,Ni | Cu | Zn | Y | In | As | Se |
| Br | Rb | Sr | Ce,La | Zr | Di,Mo | Ro,Ru |
| Pd | Ag | Cd | U | Sn | Sb | Te |

**Figure 3** shows the periodic table published by Dmitri Mendeleev in 1869.

**Figure 3**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| H | | | | | | | |
| Li | Be | B | C | N | O | F | |
| Na | Mg | Al | Si | P | S | Cl | |
| K Cu | Ca Zn | ? ? | Ti ? | V As | Cr Se | Mn Br | Fe Co Ni |
| Rb Ag | Sr Cd | Y In | Zr Sn | Nb Sb | Mo Te | ? I | Ru Rh Pd |

Mendeleev's table became accepted by other scientists whereas Newlands' table was not.

Evaluate Newlands' and Mendeleev's tables.

You should include:

- a comparison of the tables
- reasons why Mendeleev's table was more acceptable.

Use **Figure 2** and **Figure 3** and your own knowledge.

**(6)**

**(Total 11 marks)**

## Q7.

A student investigated the law of conservation of mass.

The law of conservation of mass states that the mass of the products is equal to the mass of the reactants.

This is the method used.



STEMUP.CO.UK

1. Pour lead nitrate solution into a beaker labelled **A**.
2. Pour potassium chromate solution into a beaker labelled **B**.
3. Measure the mass of both beakers and contents.
4. Pour the solution from beaker **B** into beaker **A**.
5. Measure the mass of both beakers and contents again.

When lead nitrate solution and potassium chromate solution are mixed, a reaction takes place.

This is the equation for the reaction:

$$Pb(NO_3)_2(aq) + K_2CrO_4(aq) \longrightarrow PbCrO_4(s) + 2KNO_3(aq)$$

(a) What would the student see when the reaction takes place?

_____

_____

**(1)**

(b) The table shows the student's results.

| | **Mass in g** |
|---|---|
| Beaker **A** and contents before mixing | 128.71 |
| Beaker **B** and contents before mixing | 128.97 |
| Beaker **A** and contents after mixing | 154.10 |
| Beaker **B** after mixing | 103.58 |

Show that the law of conservation of mass is true.

Use the data from the table above.

_____

_____

_____

_____

**(2)**

(c) What is the resolution of the balance used to obtain the results in the table?

Tick (✔) **one** box.

0.01 g ☐ 0.1 g ☐ 1 g ☐ 100 g ☐

**(1)**

(d) Calculate the relative formula mass ($M_r$) of lead nitrate $Pb(NO_3)_2$

Relative atomic masses ($A_r$): N = 14 O = 16 Pb = 207



STEMUP.CO.UK

_____

_____

_____

_____

Relative formula mass = _____

**(2)**

(e) The formula of potassium chromate is $K_2CrO_4$

The charge on the potassium ion is +1

What is the formula of the chromate ion?

Tick (✔) **one** box.

$CrO_4^+$ ☐

$CrO_4^{2+}$ ☐

$CrO_4^-$ ☐

$CrO_4^{2-}$ ☐

**(1)**

(f) Another student also tests the law of conservation of mass using the same method.

The student uses a different reaction.

This is the equation for the reaction.

$$Na_2CO_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

Explain why this student's results would **not** appear to support the law of conservation of mass.

_____

_____

_____

_____

_____

_____

**(3)**

**(Total 10 marks)**



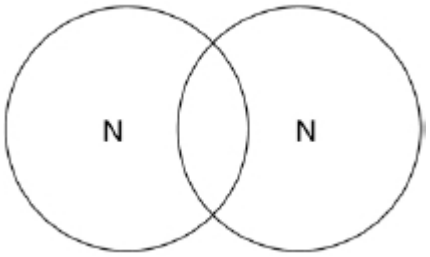
STEMUP.CO.UK

## Q8.

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.

_____

_____

_____

_____

_____

_____

_____

_____

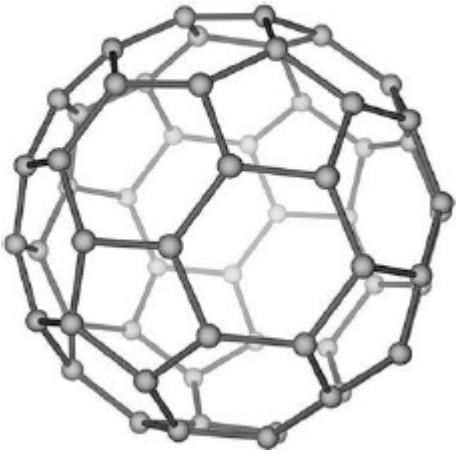


STEMUP.CO.UK

**(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**.

_____

_____

_____

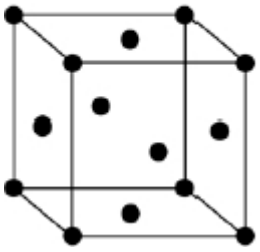
_____

**(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.

_____

_____



STEMUP.CO.UK

_____

_____

_____

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)**

## Q9.

The Haber Process is used to produce ammonia from nitrogen and hydrogen.

The equation for the reaction is:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(a) An ammonia molecule has the formula $NH_3$

How many atoms are there in one molecule of ammonia?

Tick (✔) **one** box.

2 ☐ 3 ☐ 4 ☐ 6 ☐

**(1)**

(b) What does the symbol ⇌ mean?

_____

**(1)**

(c) Draw **one** line from each gas to the source of that gas.

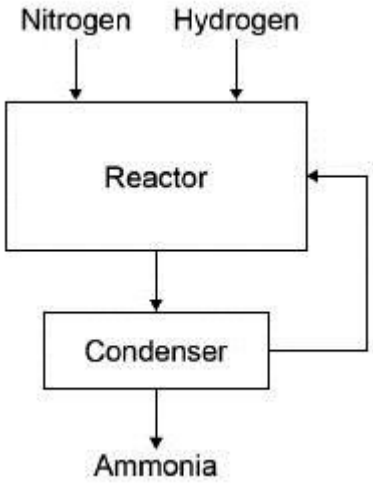


STEMUP.CO.UK

| Gas | Source |
|---|---|
| | Air |
| Hydrogen | Alcohol |
| | Ammonia |
| Nitrogen | Iron |
| | Natural gas |

**(2)**

The diagram shows the Haber process.




A mixture of ammonia, hydrogen and nitrogen gases leave the reactor.

**Table 1** shows the boiling points of the gases.

**Table 1**

| Gas | Boiling point in °C |
|---|---|
| Ammonia | – 33 |
| Nitrogen | – 196 |
| Hydrogen | – 253 |

(d) The mixture is cooled to a temperature at which **only** the ammonia condenses to a liquid.

Which temperature could be used?



STEMUP.CO.UK

Tick (✔) **one** box.

− 20 °C ☐

− 40 °C ☐

− 200 °C ☐

− 260 °C ☐

**(1)**

(e) What happens to the unreacted nitrogen?

Tick (✔) **one** box.

Collected and sold ☐

Recycled to the reactor ☐

Released into the air ☐

Used as a catalyst ☐

**(1)**

Ammonia from the Haber process can be used to produce fertilisers.

**Table 2** gives information about two compounds used in fertilisers.

**Table 2**

| Fertiliser | Compound | Cost in £ / kg |
|---|---|---|
| A | Potassium chloride | 0.24 |
| B | Diammonium phosphate | 0.35 |

(f) What type of bonding is present in potassium chloride?

Tick (✔) **one** box.

Covalent ☐

Ionic ☐



STEMUP.CO.UK

Metallic ☐

**(1)**

(g) Diammonium phosphate has the chemical formula $(NH_4)_2HPO_4$

Which **two** elements in $(NH_4)_2HPO_4$ improve agricultural productivity?

Tick (✔) **two** boxes.

Chlorine ☐

Hydrogen ☐

Nitrogen ☐

Oxygen ☐

Phosphorus ☐

A farmer uses fertilisers **A** and **B** on a field with an area of 0.05 $km^2$

**(2)**

(h) 50 kg of fertiliser A will cover an area of 0.01 $km^2$

Calculate the cost of fertilising a field with an area of 0.05 $km^2$ with fertiliser **A**.

Use **Table 2**.

_____

_____

Cost = £ _____

**(2)**

(i) Fertiliser **B** is more expensive than fertiliser **A**.

Suggest why the farmer uses **both** fertilisers.

_____

_____

**(1)**

**(Total 12 marks)**

## Q10.

Cobalt forms coloured compounds.



STEMUP.CO.UK

A pink cobalt compound reacts with hydrochloric acid.

The reaction can be represented as:

pink cobalt compound + hydrochloric acid ⇌ blue cobalt compound + water

The forward reaction is endothermic.

When both cobalt compounds are present in a solution at equilibrium, the equilibrium mixture is purple.

(a) What is meant by equilibrium?

_____

_____

_____

_____

**(2)**

(b) The equilibrium mixture is cooled.

Explain what happens to the concentration of the pink cobalt compound.

_____

_____

_____

_____

_____

_____

**(3)**

(c) More hydrochloric acid is added.

Explain what happens to the colour of the equilibrium mixture

_____

_____

_____

_____

_____

_____

**(3)**

(d) Why does cobalt form different coloured compounds?



STEMUP.CO.UK

**(1)**

(e) An oxide of cobalt has the formula $Co_2O_3$

Which cobalt ion is present in this oxide?

Tick (✔) **one** box.

$Co^+$ ☐

$Co^{2+}$ ☐

$Co^{3+}$ ☐

$Co^{4+}$ ☐

**(1)**

(f) Cobalt compounds can act as catalysts.

Which two statements about cobalt compounds are correct?

Tick (✔) **two** boxes.

They allow reactions to reach equilibrium more quickly. ☐

They are reactants in reactions catalysed by cobalt compounds. ☐

They are used up when acting as catalysts. ☐

They increase the equilibrium yield of reactions. ☐

They provide a different reaction pathway. ☐

**(2)**

(g) The reaction of hydrogen with carbon monoxide is catalysed by cobalt metal.

Balance the equation for the reaction.

$$H_2 \quad + \quad CO \quad \longrightarrow \quad C_6H_{14} \quad + \quad H_2O$$

**(1)**

(h) $C_6H_{14}$ is an alkane.

What is the formula of an alkane containing 18 hydrogen atoms?

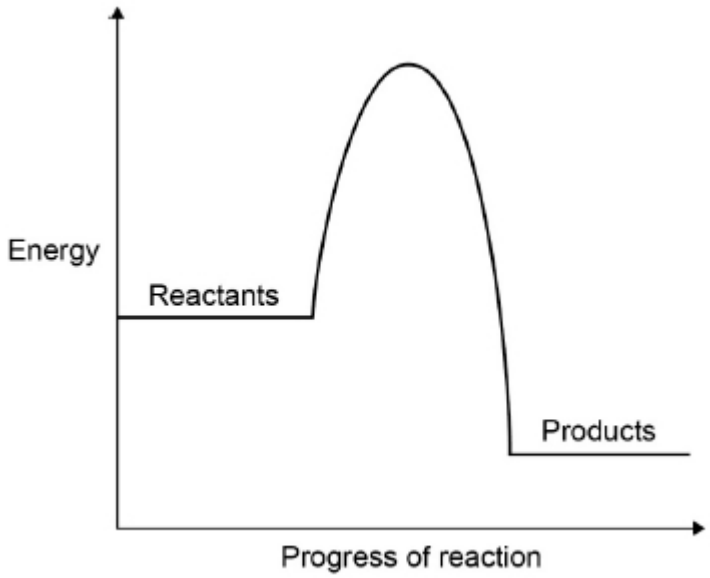


STEMUP.CO.UK

_____

**(1)**

(i) The graph shows a reaction profile diagram for a reaction **without** a catalyst.




On the graph:

- draw the reaction profile diagram for a catalysed reaction
- draw and label an arrow to show the activation energy for the reaction **without** a catalyst.

**(2)**

**(Total 16 marks)**

## Q11.

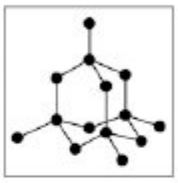
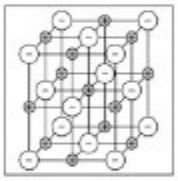
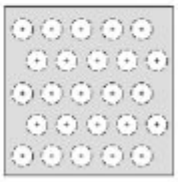
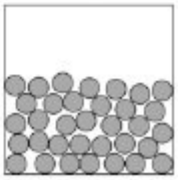
This question is about different substances and their structures.

(a) Draw **one** line from each statement to the diagram which shows the structure.

| **Statement** | **Structure** |
|---|---|



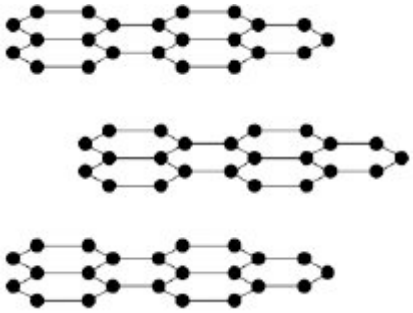
STEMUP.CO.UK

| | |
|---|---|
| The substance is a gas |  |
| The substance is a liquid |  |
| The substance is ionic |  |
| The substance is a solid metal |  |
| |  |

**(4)**

(b) **Figure 1** shows the structure of an element.

**Figure 1**



What is the name of this element?

Tick **one** box.

- Carbon ☐
- Chloride ☐
- Nitrogen ☐
- Xenon ☐



STEMUP.CO.UK

**(1)**

(c) Why does this element conduct electricity?

Tick **one** box.

It has delocalised electrons ☐

It contains hexagonal rings ☐

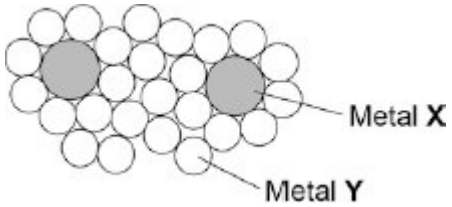
It has weak forces between the layers ☐

It has ionic bonds ☐

**(1)**

(d) **Figure 2** shows the structure of an alloy.

**Figure 2**




Explain why this alloy is harder than the pure metal **Y**.

_____

_____

_____

_____

**(2)**

(e) What percentage of the atoms in the alloys are atoms of **X**?

_____

_____

_____

_____

**(2)**

(f) What type of substance is an alloy?

Tick **one** box.

Compound ☐



STEMUP.CO.UK

Element ☐

Mixture ☐

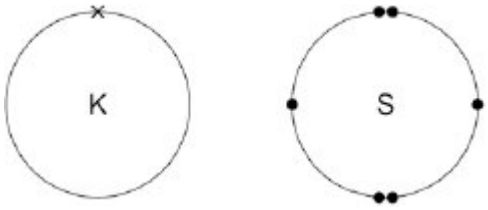
**(1)**

**(Total 11 marks)**

## Q12.

**Figure 1** shows the outer electrons in an atom of the Group 1 element potassium and in an atom of the Group 6 element sulfur.

**Figure 1**




(a) Potassium forms an ionic compound with sulfur.

Describe what happens when **two** atoms of potassium react with **one** atom of sulfur.

Give your answer in terms of electron transfer.

Give the formulae of the ions formed.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

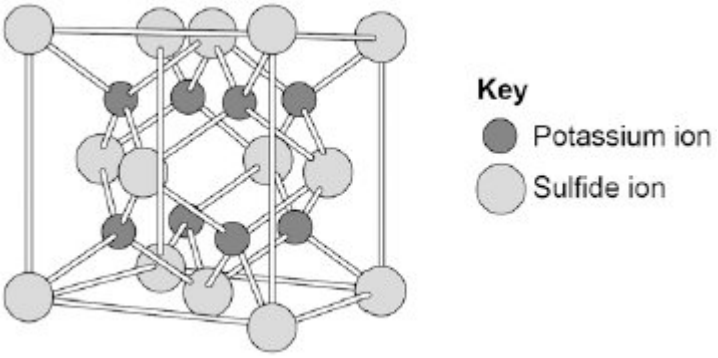
**(5)**

(b) The structure of potassium sulfide can be represented using the ball and stick model in **Figure 2**.

**Figure 2**



STEMUP.CO.UK




The ball and stick model is **not** a true representation of the structure of potassium sulfide.

Give **one** reason why.

_____

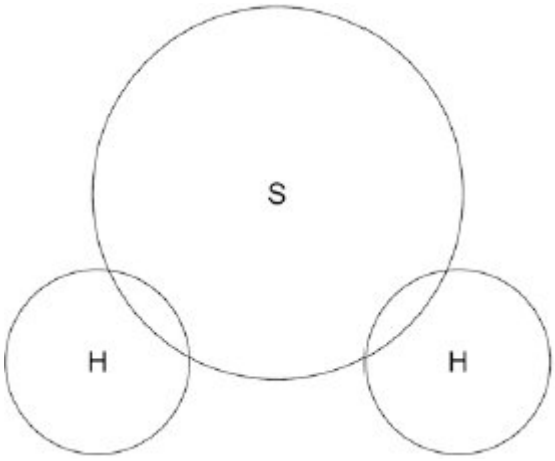
_____

**(1)**

(c) Sulfur can also form covalent bonds.

Complete the dot and cross diagram to show the covalent bonding in a molecule of hydrogen sulfide.

Show the outer shell electrons only.




**(2)**

(d) Calculate the relative formula mass ($M_r$) of aluminium sulfate $Al_2(SO_4)_3$

Relative atomic masses ($A_r$): oxygen = 16; aluminium = 27; sulfur = 32

_____

_____

_____

Relative formula mass = _____

**(2)**



STEMUP.CO.UK

(e) Covalent compounds such as hydrogen sulfide have low melting points and do **not** conduct electricity when molten.

Draw **one** line from each property to the explanation of the property.

| **Property** | **Explanation of property** |
|---|---|
| Low melting point | Electrons are free to move |
| | There are no charged particles free to move |
| | Ions are free to move |
| | Weak intermolecular forces of attraction |
| Does not conduct electricity when molten | |
| | Bonds are weak |
| | Bonds are strong |

**(2)**

(f) Ionic compounds such as potassium sulfide have high boiling points and conduct electricity when dissolved in water.

Draw **one** line from each property to the explanation of the property.

| **Property** | **Explanation of property** |
|---|---|
| | Electrons are free to move |
| | There are no |



STEMUP.CO.UK

| | |
|---|---|
| High boiling point | charged particles free to move |
| | Ions are free to move |
| | Weak intermolecular forces of attraction |
| Conduct electricity when molten | |
| | Bonds are weak |
| | Bonds are strong |

**(2)**

**(Total 14 marks)**

## Q13.

This question is about the reaction of ethene and bromine.

The equation for the reaction is:

$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

(a) Complete the reaction profile in **Figure 1**.

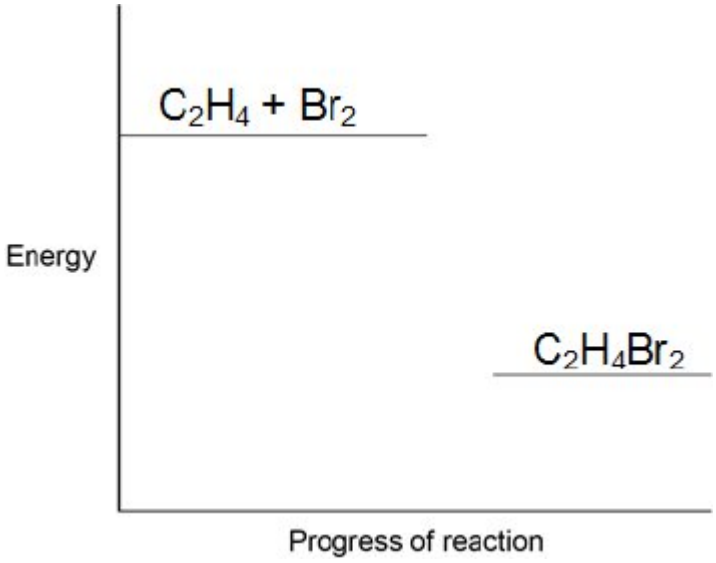
Draw labelled arrows to show:

- The energy given out ($\Delta H$)
- The activation energy.

**Figure 1**



STEMUP.CO.UK




**(3)**

(b) When ethene reacts with bromine, energy is required to break covalent bonds in the molecules.

Explain how a covalent bond holds two atoms together.

_____

_____

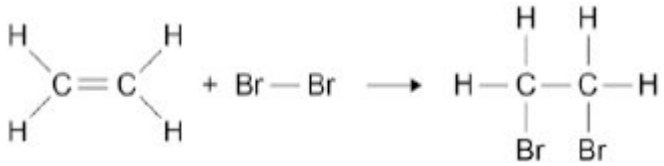
_____

_____

**(2)**

(c) **Figure 2** shows the displayed formulae for the reaction of ethene with bromine.

**Figure 2**



The bond enthalpies and the overall energy change are shown in the table below.

| | **C=C** | **C–H** | **C–C** | **C–Br** | **Overall energy change** |
|---|---|---|---|---|---|
| **Energy in kJ / mole** | 612 | 412 | 348 | 276 | −95 |

Use the information in the table above and **Figure 2** to calculate the bond energy for the Br–Br bond.

_____

_____



STEMUP.CO.UK

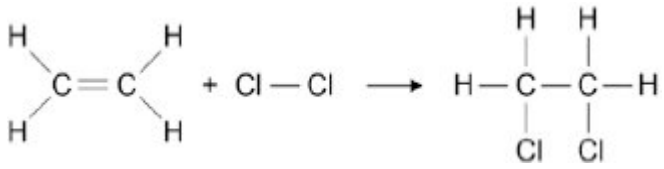
_____

Bond energy _____ kJ / mole

**(3)**

(d) **Figure 3** shows the reaction between ethene and chlorine and is similar to the reaction between ethene and bromine.

**Figure 3**




"The more energy levels (shells) of electrons an atom has, the weaker the covalent bonds that it forms."

Use the above statement to predict and explain how the overall energy change for the reaction of ethene with chlorine will differ from the overall energy change for the reaction of ethene with bromine.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

**(6)**

**(Total 14 marks)**

## Q14.

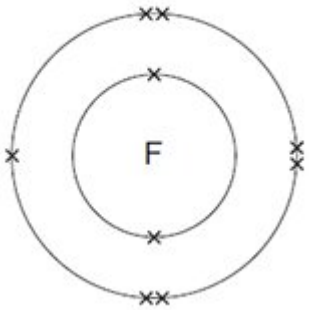
This question is about fluorine.

(a) **Figure 1** shows the arrangement of electrons in a fluorine atom.



STEMUP.CO.UK

**Figure 1**




(i) In which group of the periodic table is fluorine?

Group _____

**(1)**

(ii) Complete the table below to show the particles in an atom and their relative masses.

| Name of particle | Relative mass |
|---|---|
| Proton | |
| Neutron | 1 |
| | Very small |

**(2)**

(iii) Use the correct answer from the box to complete the sentence.

| alkalis | alloys | isotopes |
|---|---|---|

Atoms of fluorine with different numbers of neutrons are

called _____ .

**(1)**

(b) Sodium reacts with fluorine to produce sodium fluoride.

(i) Complete the word equation for this reaction.

sodium + _____ → _____

**(1)**

(ii) Complete the sentence.

Substances in which atoms of two or more different elements are chemically

combined are called _____ .

**(1)**

(iii) The relative formula mass ($M_r$) of sodium fluoride is 42.



STEMUP.CO.UK

Use the correct answer from the box to complete the sentence.

| ion | mole | molecule |
|---|---|---|

The relative formula mass ($M_r$), in grams, of sodium fluoride is one

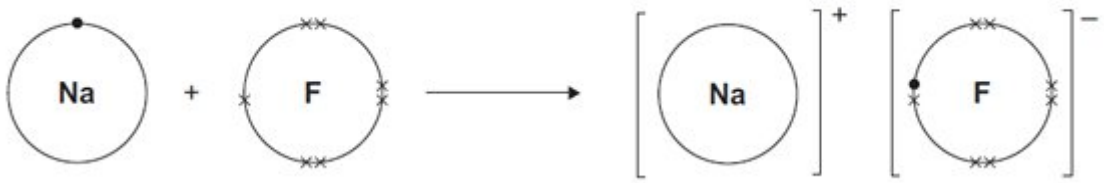
_____ of the substance.

**(1)**

(iv) **Figure 2** shows what happens to the electrons in the outer shells when a sodium atom reacts with a fluorine atom.

The dots (•) and crosses (×) represent electrons.

**Figure 2**




Use **Figure 2** to help you answer this question.

Describe, as fully as you can, what happens when sodium reacts with fluorine to produce sodium fluoride.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

(v) Sodium fluoride is an ionic substance.

What are **two** properties of ionic substances?

Tick (✔) **two** boxes.

Dissolve in water ☐

Gas at room temperature ☐



STEMUP.CO.UK

High melting point ☐

Low boiling point ☐

**(2)**

**(Total 13 marks)**

## Q15.

This question is about substances containing carbon atoms.

(a) Diamond is made of carbon atoms.

(i) Diamond is used for tips of drills.

**Figure 1** shows a drill.

**Figure 1**



© Kershawj/iStock

Give **one** reason why diamond is used for tips of drills.

_____

_____

**(1)**

(ii) Diamond nanoparticles can be made.

Use the correct answer from the box to complete the sentence.

| **hundred** | **million** | **thousand** |
|---|---|---|

Nanoparticles contain a few _____ atoms.

**(1)**

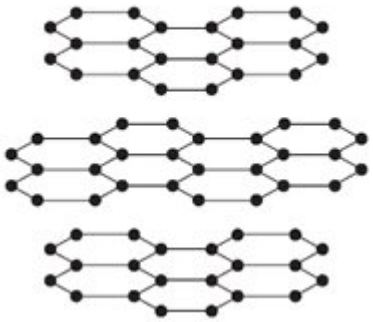
(b) Graphite is made of carbon atoms.

**Figure 2** shows the structure of graphite.



STEMUP.CO.UK

**Figure 2**



(i) What type of bonding does graphite have?

Tick (✔) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

**(1)**

(ii) How many carbon atoms does each carbon atom bond to in graphite?

Tick (✔) **one** box.

1 ☐

2 ☐

3 ☐

4 ☐

**(1)**

(iii) What is a property of graphite?

Tick (✔) **one** box.

Dissolves in water ☐

Has a low melting point ☐

Soft and slippery ☐

**(1)**

(c) Poly(ethene) is made of carbon and hydrogen atoms.

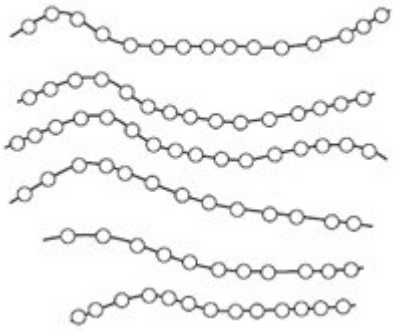
Poly(ethene) is a thermosoftening polymer.



STEMUP.CO.UK

**Figure 3** shows the structure of a thermosoftening polymer.

**Figure 3**



(i) Complete the sentence.

Between the polymer chains in a thermosoftening polymer there

are no _____ .

**(1)**

(ii) Use the correct answer from the box to complete the sentence.

| **condense** | **dissolve** | **melt** |
|---|---|---|

Heating would cause a thermosoftening polymer to

_____ .

**(1)**

(iii) Many ethene molecules react together to make poly(ethene).

Different types of poly(ethene) can be made by changing the conditions for the reaction.
Suggest **two** conditions that could be changed.

1. _____

2. _____

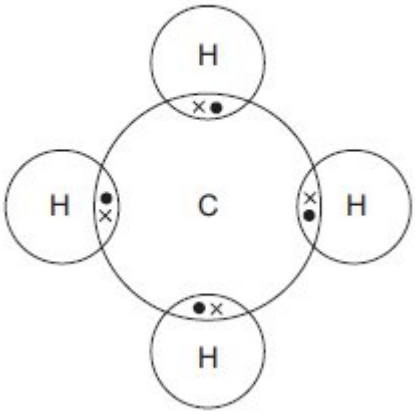
**(2)**

(d) **Figure 4** shows how the atoms are bonded in methane.



STEMUP.CO.UK

**Figure 4**




(i) What is the formula for methane?

Tick (✔) **one** box.

$C_4H$ ☐

$CH_4$ ☐

$C_4H_4$ ☐

**(1)**

(ii) Methane has a low boiling point.

What does methane consist of?

Tick (✔) **one** box.

Charged ions ☐

A giant lattice ☐

Small molecules ☐

**(1)**

**(Total 11 marks)**

## Q16.

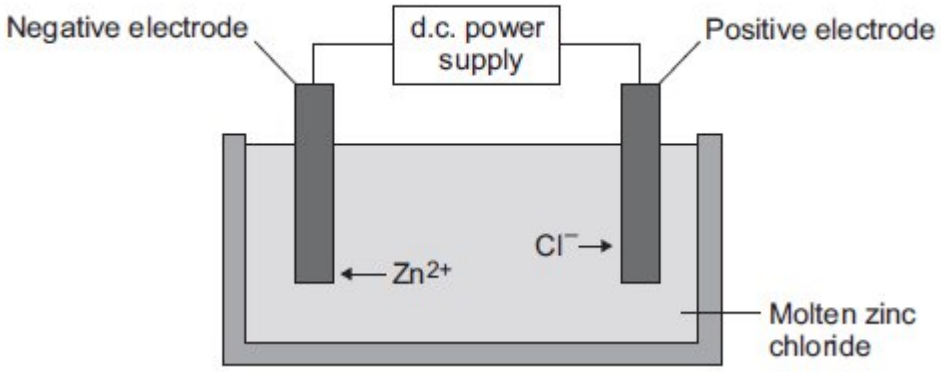
This question is about zinc.

**Figure 1** shows the electrolysis of molten zinc chloride.



STEMUP.CO.UK

**Figure 1**




(a) Zinc chloride is an ionic substance.
Complete the sentence.

When zinc chloride is molten, it will conduct _____ .

**(1)**

(b) Zinc ions move towards the negative electrode where they gain electrons to produce zinc.

(i) Name the product formed at the positive electrode.

_____

**(1)**

(ii) Explain why zinc ions move towards the negative electrode.

_____

_____

_____

_____

**(2)**

(iii) What type of reaction occurs when the zinc ions gain electrons?

Tick (✔) **one** box.

Neutralisation ☐

Oxidation ☐

Reduction ☐

**(1)**

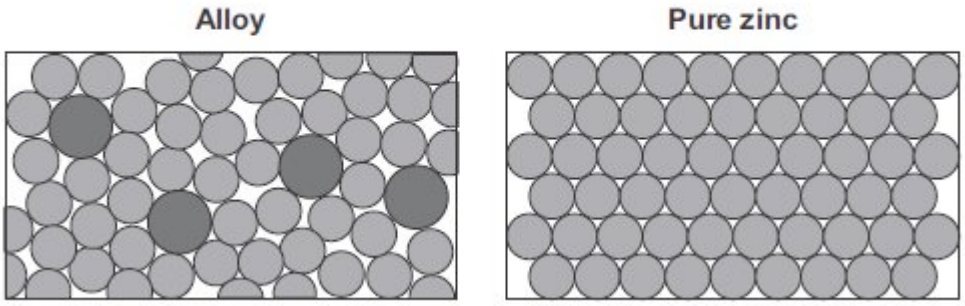
(c) Zinc is mixed with copper to make an alloy.

(i) **Figure 2** shows the particles in the alloy and in pure zinc.



STEMUP.CO.UK

**Figure 2**




Use **Figure 2** to explain why the alloy is harder than pure zinc.

_____

_____

_____

_____

**(2)**

(ii) Alloys can be bent. Some alloys return to their original shape when heated.

What name is used for these alloys?

_____

**(1)**

**(Total 8 marks)**

## Q17.

This question is about atoms, molecules and nanoparticles.

(a) Different atoms have different numbers of sub-atomic particles.

(i) An oxygen atom can be represented as $^{16}_{8}O$

Explain why the mass number of this atom is 16.

You should refer to the numbers of sub-atomic particles in the nucleus of the atom.

_____

_____

_____

_____

_____

_____

**(2)**



STEMUP.CO.UK

(ii) Explain why $^{12}_{6}C$ and $^{14}_{6}C$ are isotopes of carbon.

You should refer to the numbers of sub-atomic particles in the nucleus of each isotope.

_____

_____

_____

_____

_____

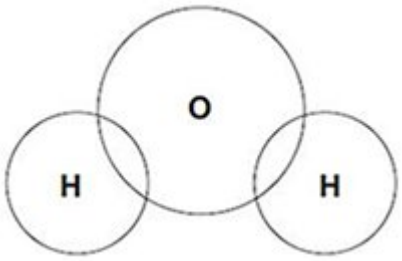
_____

**(3)**

(b) Hydrogen atoms and oxygen atoms chemically combine to produce water molecules.

(i) Complete the figure below to show the arrangement of the outer shell electrons of the hydrogen and oxygen atoms in a molecule of water.

Use dots (•) or crosses (×) to represent the electrons.




**(2)**

(ii) Name the type of bonding in a molecule of water.

_____

**(1)**

(iii) Why does pure water **not** conduct electricity?

_____

_____

**(1)**

(c) Nanoparticles of cobalt oxide can be used as catalysts in the production of hydrogen from water.

(i) How does the size of a nanoparticle compare with the size of an atom?

_____

_____

**(1)**



STEMUP.CO.UK

(ii) Suggest **one** reason why 1 g of cobalt oxide nanoparticles is a better catalyst than 1g of cobalt oxide powder.

_____

_____

**(1)**

**(Total 11 marks)**

## Q18.

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.

_____

_____

_____

_____

_____

_____

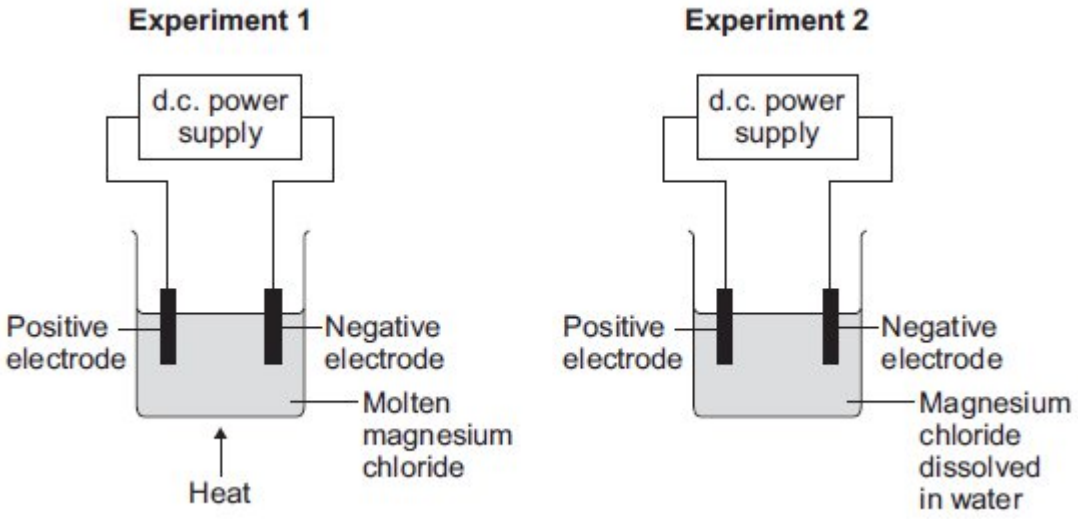
_____

_____

**(4)**

(b) Magnesium chloride can be electrolysed.

The diagram below shows two experiments for electrolysing magnesium chloride.






STEMUP.CO.UK

(i) Explain why magnesium chloride must be molten or dissolved in water to be electrolysed.

_____

_____

_____

_____

**(2)**

(ii) Explain how magnesium is produced at the negative electrode in **Experiment 1**.

_____

_____

_____

_____

_____

_____

**(3)**

(iii) In **Experiment 2** a gas is produced at the negative electrode.
Name the gas produced at the negative electrode.

_____

**(1)**

(iv) Suggest why magnesium is **not** produced at the negative electrode in **Experiment 2**.

_____

_____

**(1)**

(v) Complete and balance the half equation for the reaction at the positive electrode.

$$_____\ Cl^- \longrightarrow Cl_2 + _____$$

**(1)**

(c) Magnesium is a metal.

Explain why metals can be bent and shaped.

_____

_____

_____



STEMUP.CO.UK

_____

**(2)**

**(Total 14 marks)**

## Q19.

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)**

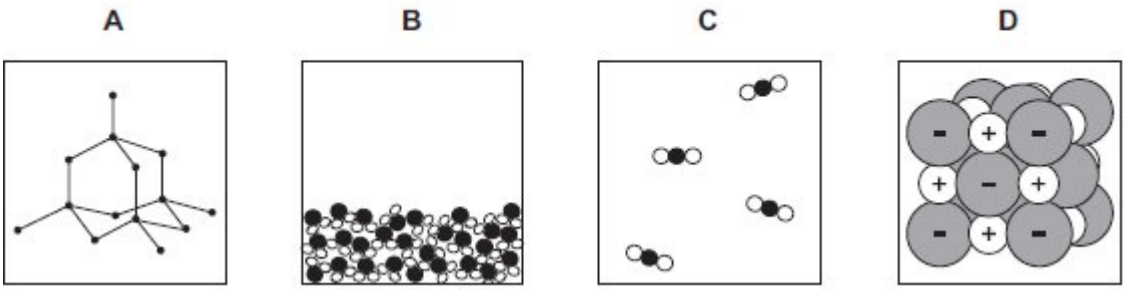
## Q20.

The structures of four substances, **A**, **B**, **C** and **D**, are represented in **Figure 1**.



STEMUP.CO.UK

**Figure 1**




(a) Use the correct letter, **A**, **B**, **C** or **D**, to answer each question.

(i) Which substance is a gas?

**(1)**

(ii) Which substance is a liquid?

**(1)**

(iii) Which substance is an element?

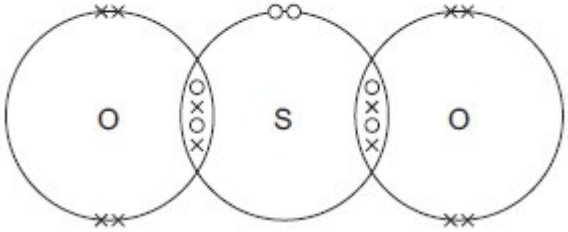
**(1)**

(iv) Which substance is made of ions?

**(1)**

(b) **Figure 2** shows the bonding in substance **C**.

**Figure 2**




(i) What is the formula of substance **C**?

Draw a ring around the correct answer.

**$SO_2$** **$SO^2$** **$S_2O$**

**(1)**

(ii) Use the correct answer from the box to complete the sentence.



STEMUP.CO.UK

| delocalised | shared | transferred |
|---|---|---|

When a sulfur atom and an oxygen atom bond to produce substance **C**, electrons are _____

**(1)**

(iii) What is the type of bonding in substance **C**?

Draw a ring around the correct answer.

**covalent** **ionic** **metallic**

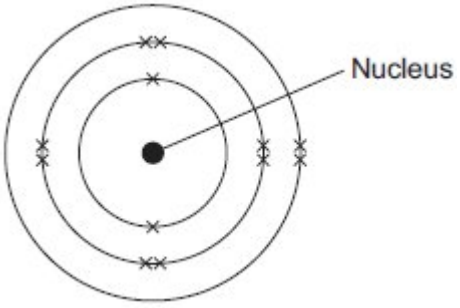
**(1)**

**(Total 7 marks)**

## Q21.

This question is about magnesium.

(a) (i) The electronic structure of a magnesium atom is shown below.




Use the correct answer from the box to complete each sentence.

| electrons | neutrons | protons | shells |
|---|---|---|---|

The nucleus contains protons and _____ .

The particles with the smallest relative mass that move around the nucleus are called _____ .

Atoms of magnesium are neutral because they contain the same number of electrons and _____ .

**(3)**

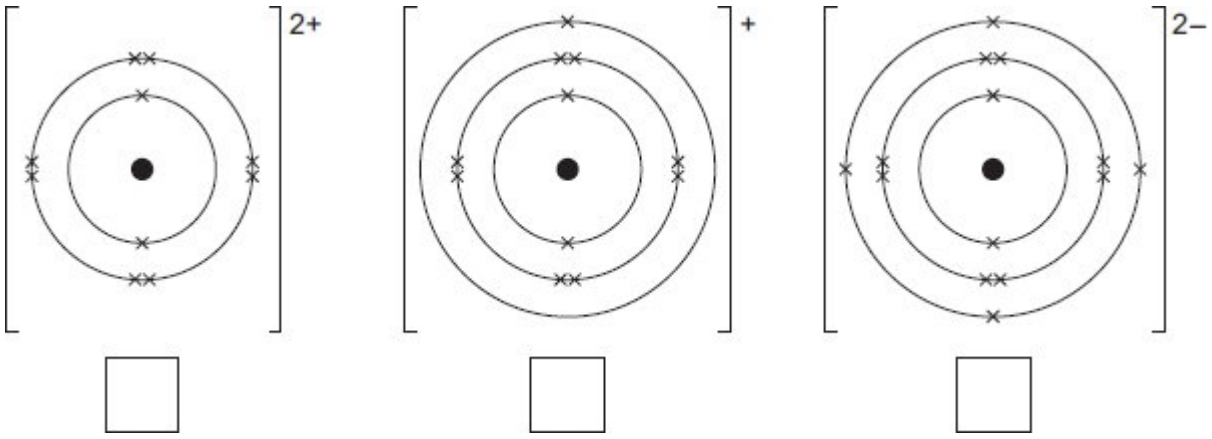
(ii) A magnesium atom reacts to produce a magnesium ion.

Which diagram shows a magnesium ion?

Tick (✓) **one** box.



STEMUP.CO.UK




**(1)**

(b) Magnesium and dilute hydrochloric acid react to produce magnesium chloride solution and hydrogen.

$$Mg(s) + 2\,HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

(i) State **two** observations that could be made during the reaction.

1. _____

_____

2. _____

_____

**(2)**

(ii) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Describe a method for making pure crystals of magnesium chloride from magnesium and dilute hydrochloric acid.

In your method you should name the apparatus you will use.

You do **not** need to mention safety.

_____

_____

_____

_____

_____

_____

_____

_____

_____



STEMUP.CO.UK

_____

**(6)**

**(Total 12 marks)**

## Q22.

This question is about copper.

(a) Copper can be extracted by smelting copper-rich ores in a furnace.

The equation for one of the reactions in the smelting process is:

$$Cu_2S(s) + O_2(g) \longrightarrow 2\,Cu(s) + SO_2(g)$$

Explain why there would be an environmental problem if sulfur dioxide gas escaped into the atmosphere.

_____

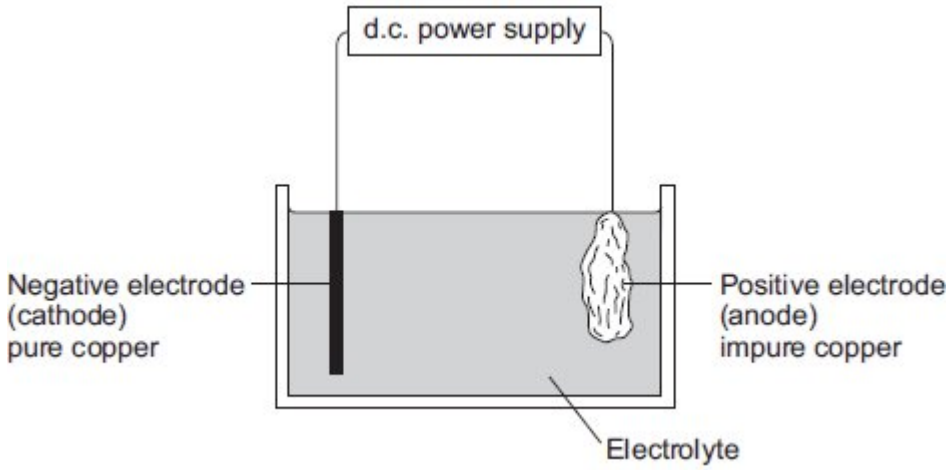
_____

_____

_____

**(2)**

(b) The impure copper produced by smelting is purified by electrolysis, as shown below.




Copper atoms are oxidised at the positive electrode to $Cu^{2+}$ ions, as shown in the half equation.

$$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$$

(i) How does the half equation show that copper atoms are oxidised?

_____

_____

**(1)**

(ii) The $Cu^{2+}$ ions are attracted to the negative electrode, where they are reduced to produce copper atoms.



STEMUP.CO.UK

Write a balanced half equation for the reaction at the negative electrode.

_____

**(1)**

(iii) Suggest a suitable electrolyte for the electrolysis.

_____

**(1)**

(c) Copper metal is used in electrical appliances.

Describe the bonding in a metal, and explain why metals conduct electricity.

_____

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

(d) Soil near copper mines is often contaminated with low percentages of copper compounds.

Phytomining is a new way to extract copper compounds from soil.

Describe how copper compounds are extracted by phytomining.

_____

_____

_____

_____

_____

_____

**(3)**

(e) A compound in a copper ore has the following percentage composition by mass:

55.6% copper, 16.4% iron, 28.0% sulfur.

Calculate the empirical formula of the compound.



STEMUP.CO.UK

Relative atomic masses ($A_r$): S = 32; Fe = 56; Cu = 63.5

You must show all of your working.

_____

_____

_____

_____

_____

_____

_____

_____

Empirical formula = _____

**(4)**

**(Total 16 marks)**

## Q23.

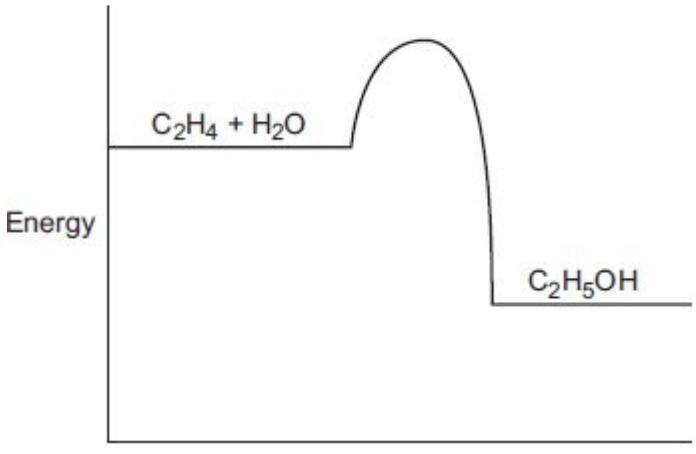
This question is about ethanol.

(a) Ethanol is produced by the reaction of ethene and steam:

$$C_2H_4 + H_2O \longrightarrow C_2H_5OH$$

(i) **Figure 1** shows the energy level diagram for the reaction.

**Figure 1**




How does the energy level diagram show that the reaction is exothermic?

_____

_____

**(1)**



STEMUP.CO.UK

(ii) A catalyst is used for the reaction.

Explain how a catalyst increases the rate of the reaction.

_____

_____

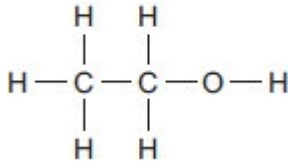
_____

_____

**(2)**

(b) **Figure 2** shows the displayed structure of ethanol.

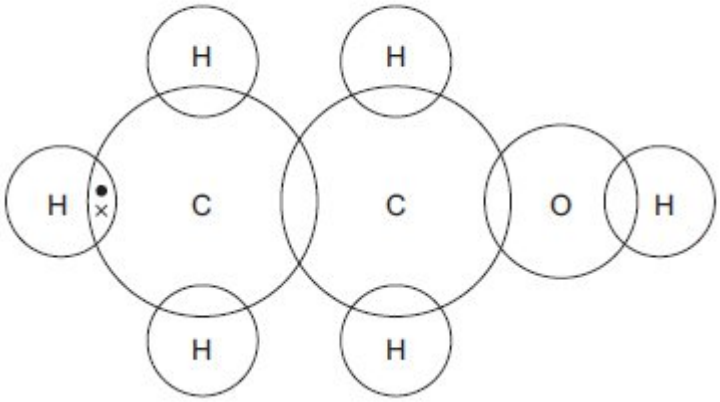
**Figure 2**




Complete the dot and cross diagram in **Figure 3** to show the bonding in ethanol.

Show the outer shell electrons only.

**Figure 3**




**(2)**

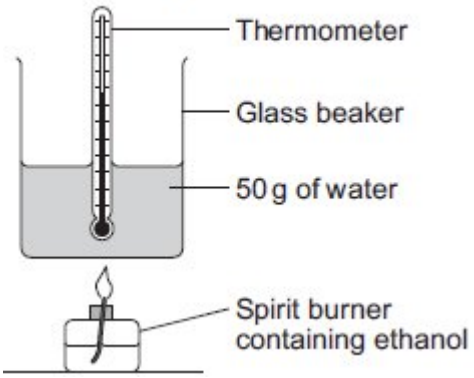
(c) A student burned some ethanol.

**Figure 4** shows the apparatus the student used.



STEMUP.CO.UK

**Figure 4**




(i) The student recorded the temperature of the water before and after heating.

His results are shown in **Table 1**.

**Table 1**

| | |
|---|---|
| Temperature before heating | 20.7 °C |
| Temperature after heating | 35.1 °C |

Calculate the energy used to heat the water.

Use the equation $Q = m \times c \times \Delta T$

The specific heat capacity of water = 4.2 J / g / °C

_____

_____

_____

_____

_____

Energy used = _____ J

**(3)**

(ii) **Table 2** shows the mass of the spirit burner before the ethanol was burned and after the ethanol was burned.

**Table 2**

| | |
|---|---|
| Mass of spirit burner before ethanol was burned | 72.80 g |
| Mass of spirit burner after ethanol was burned | 72.10 g |

Calculate the number of moles of ethanol ($C_2H_5OH$) that were burned.



STEMUP.CO.UK

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

_____

_____

_____

_____

_____

Number of moles burned = _____

**(3)**

(iii) Calculate the energy released in joules per mole.

You should assume that all the energy from the ethanol burning was used to heat the water.

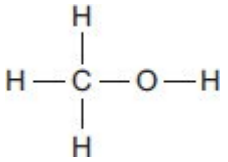
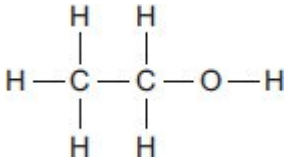
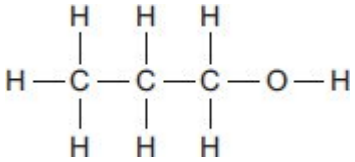
_____

Energy = _____ J / mole

**(1)**

(d) The names, structures and boiling points of ethanol and two other alcohols are shown in **Table 3**.

**Table 3**

| **Name** | **Methanol** | **Ethanol** | **Propanol** |
|---|---|---|---|
| **Structure** |  |  |  |
| **Boiling point in °C** | 65 | 78 | 97 |

Use your knowledge of structure and bonding to suggest why the boiling points increase as the number of carbon atoms increases.

_____

_____

_____

_____

_____

_____

_____



STEMUP.CO.UK

**(3)**
**(Total 15 marks)**

## Q24.

This question is about atoms.

Atoms contain electrons, neutrons and protons.

(a) (i) Which of these particles has a positive charge?

Tick (✓) **one** box.

Electron ☐

Neutron ☐

Proton ☐

**(1)**

(ii) Which of these particles does **not** have an electrical charge?

Tick (✓) **one** box.

Electron ☐

Neutron ☐

Proton ☐

**(1)**

(b) How are the elements in the periodic table arranged?

Tick (✓) **one** box.

In order of increasing atomic number ☐



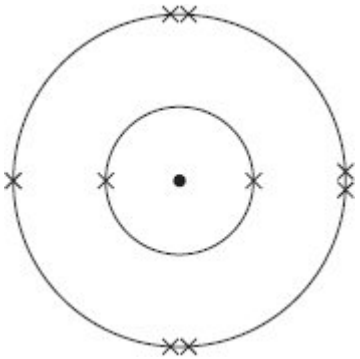
STEMUP.CO.UK

In order of increasing mass number ☐

In order of increasing reactivity ☐

**(1)**

(c) The diagram shows the arrangement of the electrons in an atom of fluorine.



(i) How many protons are in an atom of fluorine?

Tick (✓) **one** box.

2 ☐

7 ☐

9 ☐

**(1)**

(ii) The boiling point of fluorine is −188 °C.

What is the state of fluorine at room temperature?

Tick (✓) **one** box.

Solid ☐



STEMUP.CO.UK

Liquid ☐

Gas ☐

**(1)**

(d) Fluorine reacts with copper to form an ionic compound.

(i) Explain, in terms of electrons and electronic structure, what happens to a fluorine atom when it reacts with copper.

Use the figure above to help you to answer this question.

_____

_____

_____

_____

_____

**(2)**

(ii) Describe a chemical test which would show that a solution contains copper(II) ions.

_____

_____

_____

_____

_____

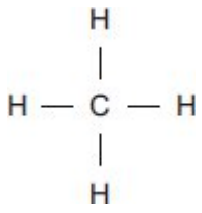
**(2)**

**(Total 9 marks)**

## Q25.

Methane ($CH_4$) is used as a fuel.

(a) The displayed structure of methane is:




Draw a ring around a part of the displayed structure that represents a covalent bond.



STEMUP.CO.UK

**(1)**

(b) Why is methane a compound?

Tick (✓) **one** box.

Methane contains atoms of two elements, combined chemically. ☐

Methane is not in the periodic table. ☐

Methane is a mixture of two different elements. ☐

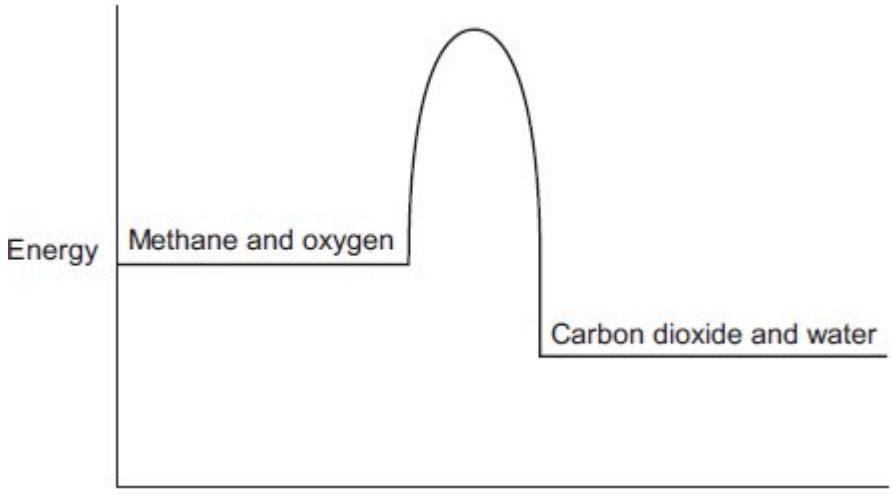
**(1)**

(c) Methane burns in oxygen.

(i) The diagram below shows the energy level diagram for the complete combustion of methane.

Draw and label arrows on the diagram to show:

- the activation energy
- the enthalpy change, $\Delta H$.




**(2)**

(ii) Complete and balance the symbol equation for the complete combustion of methane.

$$CH_4 + _____ \longrightarrow CO_2 + _____$$

**(2)**

(iii) Explain why the **incomplete** combustion of methane is dangerous.

_____

_____



STEMUP.CO.UK

_____

_____

**(2)**

(iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

_____

_____

_____

_____

_____

_____

**(3)**

(d) Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:



Some bond dissociation energies are given in the table.

| **Bond** | **Bond dissociation energy in kJ per mole** |
|---|---|
| C−H | 413 |
| C−Cl | 327 |
| Cl−Cl | 243 |
| H−Cl | 432 |

(i) Show that the enthalpy change, $\Delta H$, for this reaction is −103 kJ per mole.

_____

_____

_____

_____

_____



STEMUP.CO.UK

**(3)**

(ii) Methane also reacts with bromine in the presence of sunlight.



This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, $\Delta H$, is −45 kJ per mole.

What is a possible reason for this?

Tick (✓) **one** box.

$CH_3Br$ has a lower boiling point than $CH_3Cl$ ☐

The C−Br bond is weaker than the C−Cl bond. ☐

The H−Cl bond is weaker than the H−Br bond. ☐

Chlorine is more reactive than bromine. ☐

**(1)**

**(Total 15 marks)**

## Q26.

This question is about salts.

(a) Salt (sodium chloride) is added to many types of food.

Sodium chloride is produced by reacting sodium with chlorine.

sodium + chlorine ⟶ sodium chloride

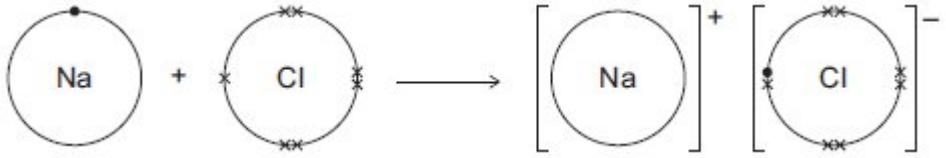
The diagram shows what happens to atoms of sodium and chlorine in this reaction.

The dots (•) and crosses (×) represent electrons.

Only the outer electrons are shown.



STEMUP.CO.UK




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

_____

_____

_____

_____

_____

_____

**(3)**

(b) Lack of iodine can affect the learning ability of children.

One idea is that salt (sodium chloride) should have iodine added.

(i) Iodine consists of simple molecules.

What is a property of substances that have simple molecules?

Tick (✓) **one** box.

| | |
|---|---|
| Have no overall electric charge | ☐ |
| Have high boiling points | ☐ |
| Have giant covalent structures | ☐ |

**(1)**

(ii) Which one of the following questions cannot be answered by science alone?

Tick (✓) **one** box.

| | |
|---|---|
| How much sodium chloride is in food? | ☐ |



STEMUP.CO.UK

What harm does a lack of iodine do? ☐

Should iodine be added to salt in food? ☐

Give **one** reason why this question cannot be answered by science alone.

_____

_____

**(2)**

(c) A student produced the salt ammonium nitrate by adding an acid to ammonia solution.

(i) Name the acid used.

_____

**(1)**

(ii) Use the correct answer from the box to complete the sentence.

| **an acid** | **an alkali** | **a salt** |
|---|---|---|

Ammonia solution (ammonium hydroxide) is _____ .

**(1)**

(iii) The student added a few drops of a solution which changed colour when the reaction was complete.

Complete the sentence.

The solution added is an _____ .

**(1)**

(d) Farmers buy solid ammonium nitrate in poly(ethene) sacks.

(i) How is solid ammonium nitrate made from a solution of ammonium nitrate?

Tick (✓) **one** box.

Crystallisation ☐

Decomposition ☐

Electrolysis ☐



STEMUP.CO.UK

**(1)**

(ii) Why do farmers use ammonium nitrate on their fields?

_____

_____

**(1)**

(iii) The properties of poly(ethene) depend on the reaction conditions when it is made.

State **one** reaction condition that can be changed when making poly(ethene).

_____

_____

**(1)**

**(Total 12 marks)**

## Q27.

This question is about electrolysis.

(a) Metal spoons can be coated with silver.
This is called electroplating.

Suggest **one** reason why spoons are electroplated.

_____

_____

**(1)**

(b) When sodium chloride solution is electrolysed the products are hydrogen and chlorine.

(i) What is made from chlorine?

Tick (✓) **one** box.

Bleach ☐

Fertiliser ☐

Soap ☐

**(1)**

(ii) Sodium chloride solution contains two types of positive ions, hydrogen ions ($H^+$) and sodium ions ($Na^+$).



STEMUP.CO.UK

Why is hydrogen produced at the negative electrode and **not** sodium?

Tick (✓) **one** box.

Hydrogen is a gas. ☐

Hydrogen is less reactive than sodium. ☐

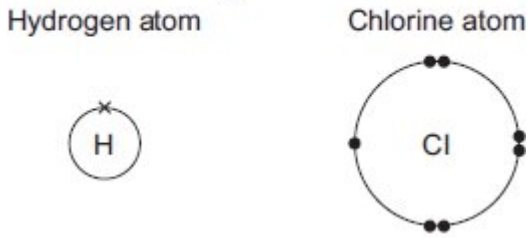
Hydrogen ions move faster than sodium ions. ☐

**(1)**

(iii) Hydrogen and chlorine can be used to produce hydrogen chloride.

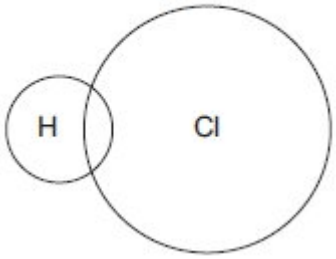
The diagrams in **Figure 1** show how the outer electrons are arranged in an atom of hydrogen and an atom of chlorine.

**Figure 1**




Complete **Figure 2** to show how the outer electrons are arranged in a molecule of hydrogen chloride (HCl).

**Figure 2**




**(1)**

(iv) What is the type of bond in a molecule of hydrogen chloride?

Tick (✓) **one** box.

Covalent ☐



STEMUP.CO.UK

Ionic ☐

Metallic ☐

**(1)**

(v) Why is hydrogen chloride a gas at room temperature (20 °C)?

Tick (✓) **two** boxes.

Hydrogen chloride has a low boiling point. ☐

Hydrogen chloride has a high melting point. ☐

Hydrogen chloride is made of simple molecules. ☐

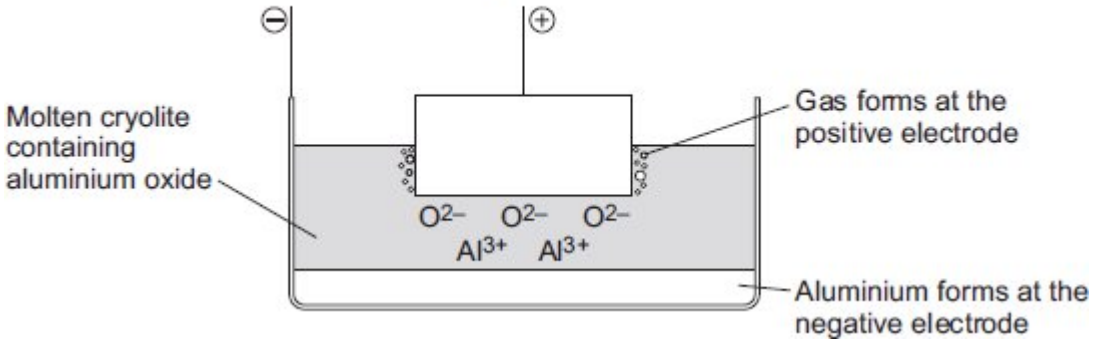
Hydrogen chloride does not conduct electricity. ☐

Hydrogen chloride has a giant structure. ☐

**(2)**

(c) Aluminium is produced by electrolysis of a molten mixture of aluminium oxide and cryolite.
This is shown in **Figure 3**.

**Figure 3**




(i) Name a gas produced at the positive electrode.

_____

**(1)**



STEMUP.CO.UK

(ii) Aluminium ions move to the negative electrode.

Explain why.

_____

_____

_____

_____

**(2)**

(iii) At the negative electrode, the aluminium ions gain electrons to produce aluminium.

What is this type of reaction called?

Tick (✓) **one** box.

Combustion ☐

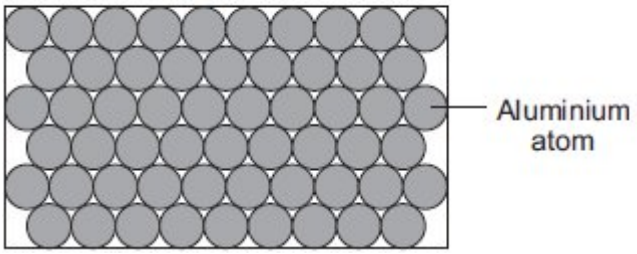
Oxidation ☐

Reduction ☐

**(1)**

(iv) Aluminium has layers of atoms, as shown in **Figure 4**.

**Figure 4**




Complete the sentence.

Metals can be bent and shaped because the layers of atoms can _____

_____

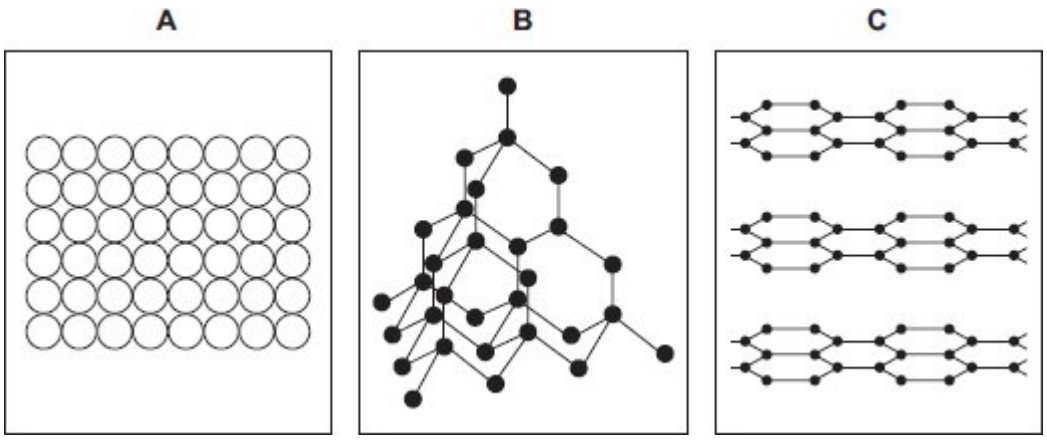
**(1)**

(d) Electrodes used in the production of aluminium are made from graphite.

(i) Which diagram, **A, B** or **C**, shows the structure of graphite?



STEMUP.CO.UK




The structure of graphite is shown in diagram ☐

**(1)**

(ii) The temperature for the electrolysis is 950 °C.

Use the correct answer from the box to complete the sentence.

| **cross links** | **a giant ionic lattice** | **strong covalent bonds** |
|---|---|---|

The graphite does not melt at 950 °C because

graphite has _____ .

**(1)**

**(Total 14 marks)**

## Q28.

This question is about metals and alloys.

(a) Explain how electricity is conducted in a metal.

To gain full marks you must include a description of the structure and bonding of a metal.

_____

_____

_____

_____

_____

_____

_____

_____



STEMUP.CO.UK

**(4)**

(b) Describe how the structure of an alloy is different from the structure of a pure metal.

_____

_____

_____

_____

**(2)**

(c) Alloys are used to make dental braces and coins.

(i) Nitinol is an alloy used in dental braces.

Why is Nitinol used in dental braces?

_____

_____

**(1)**

(ii) Suggest **one** reason why coins are not made of pure copper.

Do **not** give cost as a reason.

_____

_____

**(1)**

(iii) Some coins are made from an alloy of aluminium.

Complete the sentence.

Aluminium is manufactured by the electrolysis of a molten mixture of cryolite and _____ .

**(1)**

(iv) Banks keep coins in poly(ethene) bags. These bags are made from low density poly(ethene).

High density poly(ethene) can also be made from the same monomer.

How can the same reaction produce two different products?

_____

_____

**(1)**

(d) Give **two** reasons why instrumental methods of analysis are used to detect impurities in metals.

_____



STEMUP.CO.UK

_____

_____

**(1)**

**(Total 11 marks)**

## Q29.

This question is about compounds.

(a) The table gives information about the solubility of some compounds.

| Soluble compounds |
|---|
| All potassium and sodium salts |
| All nitrates |
| Chlorides, bromides and iodides, except those of silver and lead |

Use information from the table to answer these questions.

(i) Name a soluble compound that contains silver ions.

_____

**(1)**

(ii) Name a soluble compound that contains carbonate ions.

_____

**(1)**

(b) Metal oxides react with acids to make salts.

What type of compound is a metal oxide?

_____

**(1)**

(c) Lead nitrate solution is produced by reacting lead oxide with nitric acid.

(i) State how solid lead nitrate can be obtained from lead nitrate solution.

_____

_____

**(1)**

(ii) Balance the equation for the reaction.

$PbO + HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$

**(1)**

(iii) Give the total number of atoms in the formula $Pb(NO_3)_2$

_____



STEMUP.CO.UK

**(1)**

(d) An oxide of lead that does **not** have the formula PbO contains 6.21 g of lead and 0.72 g of oxygen.

Calculate the empirical formula of this lead oxide.

Relative atomic masses ($A_r$): O = 16; Pb = 207

You must show your working to gain full marks.

_____

_____

_____

_____

_____

_____

Empirical formula = _____

**(4)**

**(Total 10 marks)**

## Q30.

This question is about sodium chloride and iodine.

(a) Describe the structure and bonding in sodium chloride.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

(b) When sodium chloride solution is electrolysed, one product is chlorine.

Name the **two** other products from the electrolysis of sodium chloride solution.

_____

_____

**(2)**



STEMUP.CO.UK

(c) Many people do not have enough iodine in their diet.

Sodium chloride is added to many types of food. Some scientists recommend that sodium chloride should have a compound of iodine added.

Give **one** ethical reason why a compound of iodine should **not** be added to sodium chloride used in food.

_____

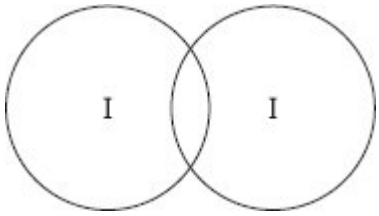
_____

**(1)**

(d) The bonding in iodine is similar to the bonding in chlorine.

(i) Complete the diagram below to show the bonding in iodine.

Show the outer electrons only.




**(2)**

(ii) Explain why iodine has a low melting point.

_____

_____

_____

_____

_____

_____

**(3)**

(iii) Explain, in terms of particles, why liquid iodine does not conduct electricity.

_____

_____

_____

_____

**(2)**

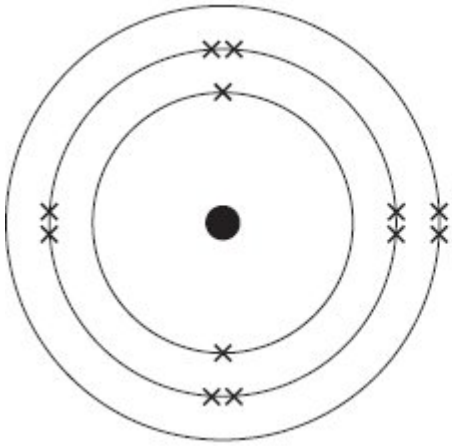
**(Total 14 marks)**

## Q31.

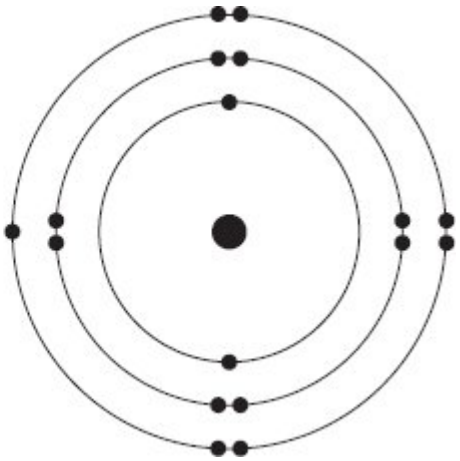
(a) The diagram shows an atom of magnesium and an atom of chlorine.



STEMUP.CO.UK



**Magnesium**



**Chlorine**

Describe, in terms of electrons, how magnesium atoms and chlorine atoms change into ions to produce magnesium chloride ($MgCl_2$).

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

(b) Calculate the relative formula mass ($M_r$) of magnesium chloride ($MgCl_2$).

Relative atomic masses ($A_r$): magnesium = 24; chlorine = 35.5

_____

_____

_____

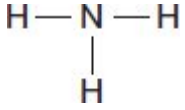
Relative formula mass ($M_r$) = _____

**(2)**

**(Total 6 marks)**

## Q32.

(a) A particle of ammonia is represented by the formula $NH_3$ or as:






STEMUP.CO.UK

(i) How many different elements are there in a particle of ammonia?

_____

**(1)**

(ii) Draw a ring around the correct answer to complete the sentence.

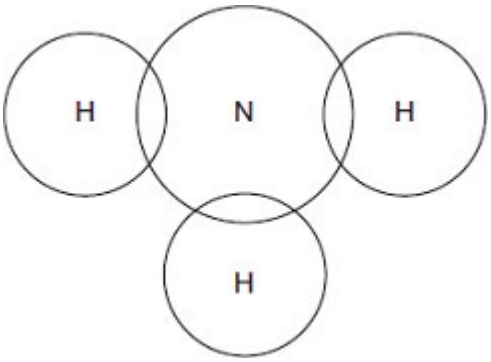
A particle of ammonia is called

an atom.
an ion.
a molecule.

**(1)**

(iii) Complete the dot and cross bonding diagram for ammonia.

Show **only** electrons in the outer energy level of each atom.




**(2)**

(b) Ammonia gas reacts with hydrogen chloride gas to produce a white solid.

The formula of the white solid is $NH_4Cl$

(i) Complete the equation by adding the correct state symbols.

$$NH_3(g) + HCl(____) \longrightarrow NH_4Cl(____)$$

**(1)**

(ii) The white solid has the formula $NH_4Cl$

Complete the name of the white solid.

Ammonium _____

**(1)**

(c) Concentrated ammonia solution gives off ammonia gas.

Concentrated hydrochloric acid gives off hydrogen chloride gas.

Apparatus was set up as shown in **Diagram 1**.

**Diagram 1**

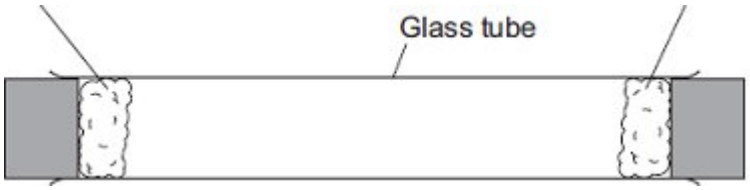
Cotton wool soaked in concentrated

Cotton wool soaked in concentrated



STEMUP.CO.UK

hydrochloric acid ammonia solution




(i) Concentrated hydrochloric acid is corrosive.

Give **one** safety precaution you should take when using concentrated hydrochloric acid.

_____

_____

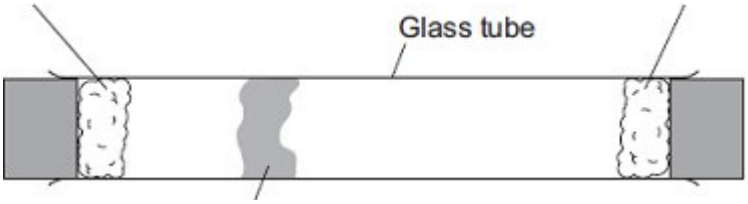
**(1)**

(ii) After 3 minutes a white solid was seen in the glass tube, as shown in **Diagram 2**.

**Diagram 2**

Cotton wool soaked in concentrated hydrochloric acid

Cotton wool soaked in concentrated ammonia solution




White solid formed here

Suggest why the white solid is seen nearer the concentrated hydrochloric acid than the concentrated ammonia.

_____

_____

**(1)**

(iii) The experiment was repeated at a higher temperature.

Explain why the white solid was produced in less than 3 minutes.

_____

_____

_____

_____

**(2)**



STEMUP.CO.UK

**(Total 10 marks)**

## Q33.

Sulfur is a non-metal.

Sulfur burns in the air to produce sulfur dioxide, $SO_2$

(a) Why is it important that sulfur dioxide is **not** released into the atmosphere?

Tick (✔) **one** box.

Sulfur dioxide causes acid rain. ☐

Sulfur dioxide causes global dimming. ☐

Sulfur dioxide causes global warming. ☐

**(1)**

(b) Sulfur dioxide dissolves in water.

What colour is universal indicator in a solution of sulfur dioxide?
Give a reason for your answer.

_____

_____

_____

_____

**(2)**

(c) Sulfur dioxide is a gas at room temperature.

The bonding in sulfur dioxide is covalent.

Explain, in terms of its structure and bonding, why sulfur dioxide has a low boiling point.

_____

_____

_____

_____

_____

_____

**(3)**



STEMUP.CO.UK

(d) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Sulfur dioxide is produced when fossil fuels are burned.

It is important that sulfur dioxide is not released into the atmosphere.

Three of the methods used to remove sulfur dioxide from gases produced when fossil fuels are burned are:

- wet gas desulfurisation (**W**)
- dry gas desulfurisation (**D**)
- seawater gas desulfurisation (**S**).

Information about the three methods is given in the bar chart and in **Table 1** and **Table 2**.

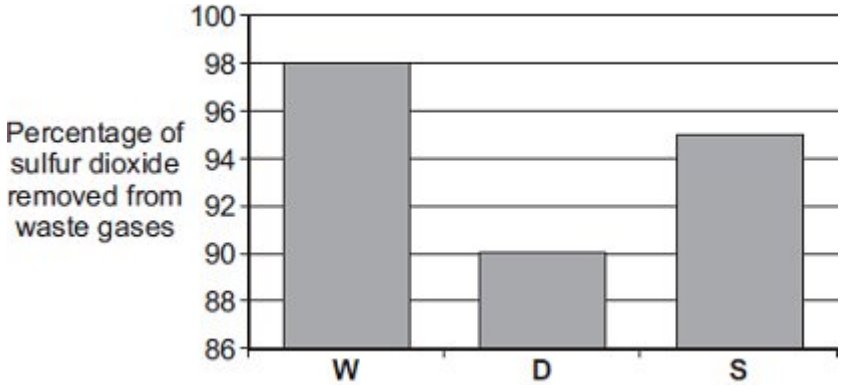



**Table 1**

| Method | Material used | How material is obtained |
|---|---|---|
| **W** | Calcium carbonate, $CaCO_3$ | Quarrying |
| **D** | Calcium oxide, CaO | Thermal decomposition of calcium carbonate: $CaCO_3 \longrightarrow CaO + CO_2$ |
| **S** | Seawater | From the sea |

**Table 2**

| Method | What is done with waste material |
|---|---|
| **W** | Solid waste is sold for use in buildings.<br>Carbon dioxide is released into the atmosphere. |
| **D** | Solid waste is sent to landfill. |
| **S** | Liquid waste is returned to the sea. |



STEMUP.CO.UK

Evaluate the three methods of removing sulfur dioxide from waste gases.

Compare the three methods and give a justified conclusion.

**(6)**
**(Total 12 marks)**

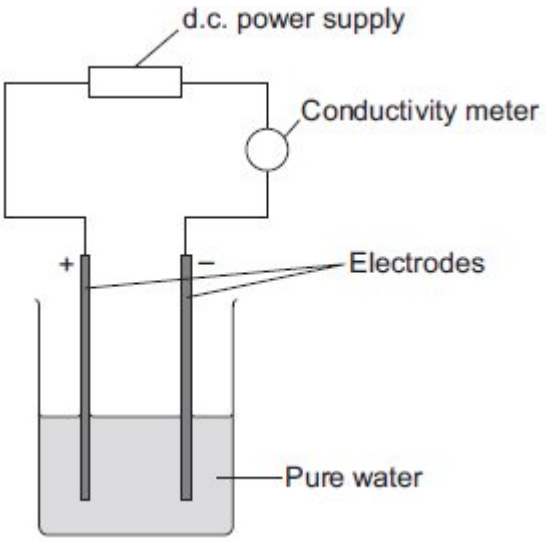
## Q34.

A student investigated the conductivity of different concentrations of sodium chloride solution.
The student set the apparatus up as shown in **Figure 1**.

**Figure 1**



STEMUP.CO.UK




The student measured the conductivity of the pure water with a conductivity meter.

The reading on the conductivity meter was zero.

(a) The student:

- added sodium chloride solution one drop at a time
- stirred the solution
- recorded the reading on the conductivity meter.

The student's results are shown in the table below.

| **Number of drops of sodium chloride solution added** | **Relative conductivity of solution** |
|---|---|
| 0 | 0 |
| 1 | 100 |
| 2 | 120 |
| 3 | 310 |
| 4 | 400 |
| 5 | 510 |
| 6 | 590 |
| 7 | 710 |
| 8 | 800 |

(i) The student plotted the results on the grid shown in **Figure 2**.

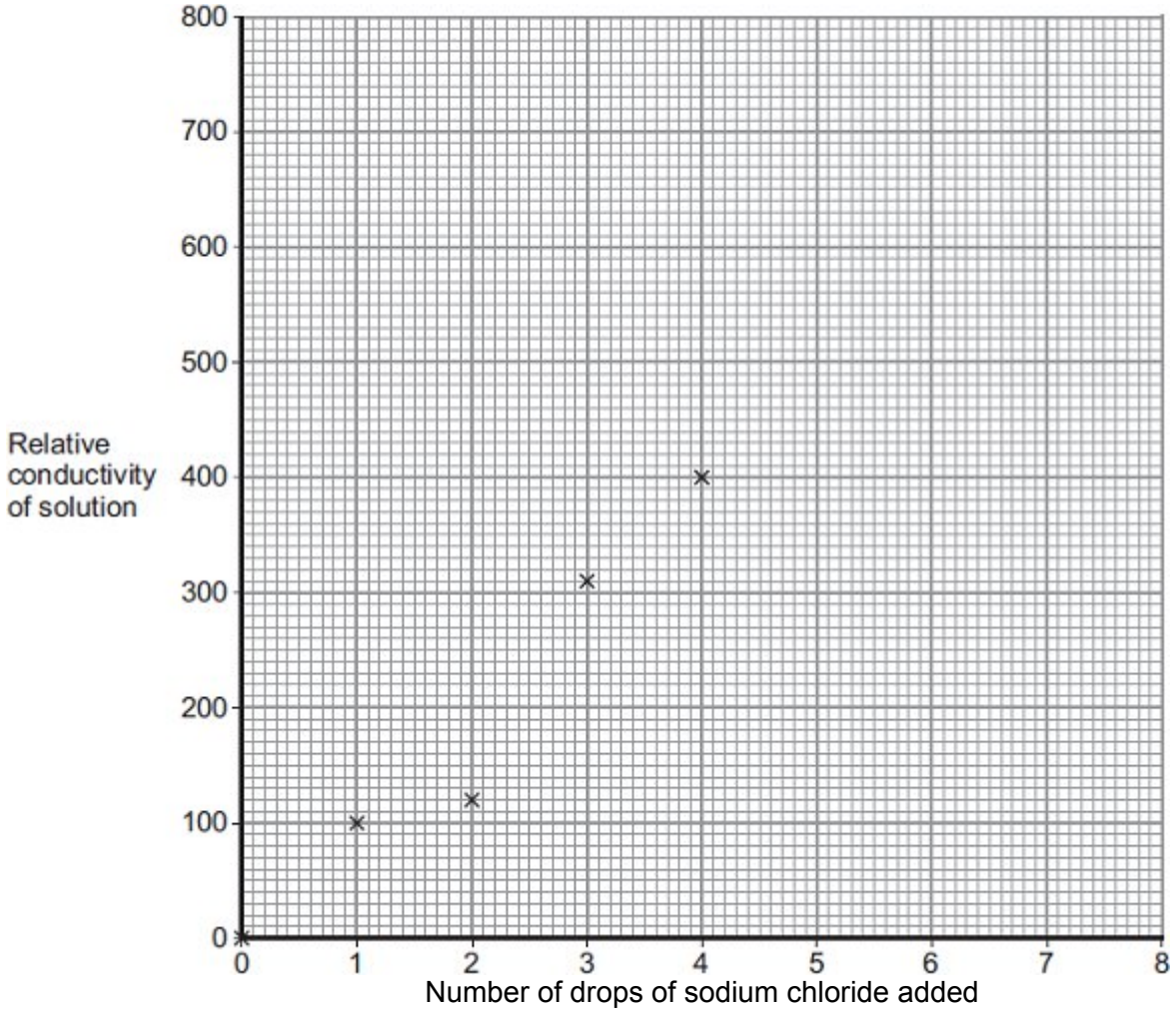
Plot the four remaining results.



STEMUP.CO.UK

Draw a line of best fit, ignoring the anomalous result.

**Figure 2**




**(3)**

(ii) One of the points is anomalous.

Suggest **one** error that the student may have made to cause the anomalous result.

_____

_____

**(1)**

(iii) The student wanted to compare the conductivity of sodium chloride solution with the conductivity of potassium chloride solution.

State **one** variable he should keep constant when measuring the conductivity of the two solutions.

_____

**(1)**

(b) (i) Explain, in terms of bonding, why pure water does **not** conduct electricity.



STEMUP.CO.UK

_____

_____

_____

_____

**(2)**

(ii) Explain why sodium chloride solution conducts electricity.

_____

_____

_____

_____

**(2)**

(iii) After he had added sodium chloride solution, the student noticed bubbles of gas at the negative electrode.

Complete the sentence.

The gas produced at the negative electrode is _____

**(1)**

**(Total 10 marks)**

## Q35.

This question is about diamonds.

Draw a ring around the correct answer to complete each sentence.

(a) Diamonds are found in meteorites.

(i) Meteorites get very hot when they pass through the Earth's atmosphere, but the diamonds do not melt.

Diamond has a | high / low / very low | melting point.

**(1)**

(ii) Most diamonds found in meteorites are nanodiamonds.

A nanodiamond contains a few | hundred / thousand / million. | atoms

**(1)**



STEMUP.CO.UK

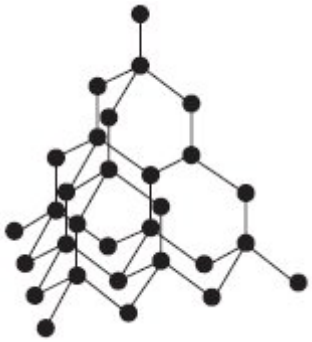
(b) Diamonds are used for the cutting end of drill bits.

Diamonds can be used for drill bits because they are

| |
|---|
| hard. |
| shiny. |
| soft. |

**(1)**

(c) The figure below shows the arrangement of atoms in diamond.



(i) Diamond is made from

| |
|---|
| carbon |
| nitrogen |
| oxygen |

atoms.

**(1)**

(ii) Each atom in diamond is bonded to

| |
|---|
| three |
| four |
| five |

other atoms.

**(1)**

(iii) Diamond has a giant

| |
|---|
| covalent |
| ionic |
| metallic |

structure.

**(1)**

(iv) In diamond

| |
|---|
| all |
| none |
| some |

of the atoms are bonded together.

**(1)**

**(Total 7 marks)**



STEMUP.CO.UK