**Oasis Academy South Bank**

**Year 11 Mock Revision**

**Chemistry Separate Paper 1**

**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Class: \_\_\_\_\_\_\_\_\_**

**Teacher: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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| **Step 1: Knowledge**  Learn each of the quiz questions and answers off by heart. This could be done by:   * turning them into **flash cards** and testing yourself * using **‘look, cover, write, check’** * asking a friend or family member to **quiz** you | | | | |
| **Topic** | **LCWC** | **Quiz 1** | **Quiz 2** | **Quiz 3** |
| The Three States (C.1) |  |  |  |  |
| Elements, compounds (C.2) |  |  |  |  |
| Mixtures (C.3) |  |  |  |  |
| Chromatography (C.4) |  |  |  |  |
| Structure of an atom (C.5) |  |  |  |  |
| The periodic table (C.6) |  |  |  |  |
| Types of bonding (C.7) |  |  |  |  |
| Properties of materials (C.8) |  |  |  |  |
| Describing chemical reactions, reactions of metals and gas tests (C.9) |  |  |  |  |
| Acids and Alkalis (C.10) |  |  |  |  |
| Chemical tests and calculations (triple only) (C.11) |  |  |  |  |
| Electrolysis (C.12) |  |  |  |  |
| Electrolysis & Half equations (HT mainly) (C.13) |  |  |  |  |
| Endothermic and exothermic reactions (C.14) |  |  |  |  |
| Cells and batteries (triple only) (C.16) |  |  |  |  |
| Rates of reaction (C.17) |  |  |  |  |
| Chemical calculations, volumes and concentrations (C.19) |  |  |  |  |
| Metals and alloys (C.23) |  |  |  |  |
| Alkanes and alkenes (C.28) |  |  |  |  |

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| **Step 2: Exam practice**   * Practice applying your knowledge using the **past exam questions** in each section. * Self-assess these using the **mark schemes** at the back and rewrite your answers. * Assess your **progress** using a ‘red, amber, green’ system (RAG) | | | |
| **Section** | **Completed** | **SA using green pen** |  |
| 1: Maths |  |  |  |
| 2. Required Practicals |  |  |  |
| 3. 6 markers |  |  |  |

**Exam practice**

**Section 1: Knowledge**

**Q1.**

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.

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**(1)**

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

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**(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.

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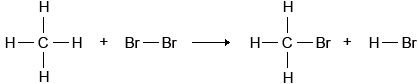
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**(3)**

(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.

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Bond energy **X** = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kJ/mol

**(4)**

**Q2.**

Titanium is a transition metal.

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

**Stage 1**   TiO2 + 2 C + 2 Cl2 ⟶ TiCl4 + 2 CO

**Stage 2**   TiCl4 + 4 Na ⟶ Ti + 4 NaCl

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

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**(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.

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**(1)**

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

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**(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.

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**(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?

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**(1)**

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

Na ⟶ \_\_\_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

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

The equation for the reaction is:

TiCl4 + 4 Na ⟶ 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.

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**(4)**

(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.

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Mass of titanium = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg

**(2)**

**(Total 15 marks)**

**Q3.**

This question is about atoms.

(a)     What does the number 19 represent in  ?

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**(1)**

(b)     How many atoms are present in one mole of fluorine atoms?

Tick (✔) **one** box.

|  |  |
| --- | --- |
| 2.03 × 1026 |  |
| 2.06 × 1023 |  |
| 6.02 × 1023 |  |
| 6.02 × 1026 |  |

**(1)**

(c)     The plum pudding model of the atom was replaced by the nuclear model.

The nuclear model was developed after the alpha particle scattering experiment.

Compare the plum pudding model with the nuclear model of the atom.

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**(4)**

(d)     An element has three isotopes.

The table shows the mass numbers and percentage of each isotope.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Isotope 1** | **Isotope 2** | **Isotope 3** |
| Mass number | 24 | 25 | 26 |
| Percentage (%) | 78.6 | 10.1 | 11.3 |

Calculate the relative atomic mass (*A*r) of the element.

Give your answer to 3 significant figures.

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Relative atomic mass = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

**(Total 8 marks)**

**Q4.**

A scientist produces zinc iodide (ZnI2).

This is the method used.

1. Weigh 0.500 g of iodine.

2. Dissolve the iodine in ethanol.

3. Add an excess of zinc.

4. Stir the mixture until there is no further change.

5. Filter off the excess zinc.

6. Evaporate off the ethanol.

(a)     Ethanol is flammable.

Suggest how the scientist could carry out **Step 6** safely.

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**(1)**

(b)     Explain why the scientist adds excess zinc rather than excess iodine.

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**(3)**

(c)     Calculate the minimum mass of zinc that needs to be added to 0.500 g of iodine so that the iodine fully reacts.

The equation for the reaction is:

Zn + I2 ⟶ ZnI2

Relative atomic masses (*M*r): Zn = 65  I = 127

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Minimum mass of zinc = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(3)**

A different scientist makes zinc iodide by the same method.

The scientist obtains 12.5 g of zinc iodide.

The percentage yield in this reaction is 92.0%.

(d)     What is the maximum theoretical mass of zinc iodide produced in this reaction?

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Maximum theoretical mass = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(3)**

(e)     Suggest **one** reason why the percentage yield in this reaction is **not** 100%.

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**(1)**

(f)      The scientist makes a solution of zinc iodide with a concentration of 0.100 mol / dm3

Calculate the mass of zinc iodide (ZnI2) required to make 250 cm3 of this solution.

Relative atomic masses (*A*r): Zn = 65 I = 127

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Mass = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(3)**

**(Total 14 marks)**

**Q5.**

Cells contain chemicals which react to produce electricity.

(a)     Why can a rechargeable cell be recharged?

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**(1)**

(b)     Give **two** factors that affect the voltage produced by a cell.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(c)     Balance the half-equation for the reaction occurring at an electrode in one type of hydrogen fuel cell.

H2   +  OH−  ⟶  H2O   +  e−

**(1)**

(d)     Why is the fuel cell in Question (c) described as an alkaline fuel cell?

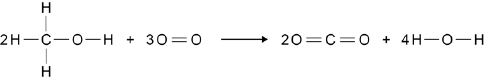
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**(1)**

(e)     Another type of fuel cell uses methanol instead of hydrogen.

The diagram represents the reaction in this fuel cell.



The table shows the bond energies for the reaction.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **C–H** | **C–O** | **O–H** | **O=O** | **C=O** |
| Bond energy in kJ / mol | 412 | 360 | 464 | 498 | 805 |

Calculate the overall energy change for the reaction.

Use the diagram and the table above.

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Overall energy change = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kJ / mol

**(3)**

**(Total 8 marks)**

**Q6.**

Aspirin tablets have important medical uses.



          A student carried out an experiment to make aspirin. The method is given below.

|  |
| --- |
| 1.  Weigh 2.00 g of salicylic acid. 2.  Add 4 cm3 of ethanoic anhydride (an excess). 3.  Add 5 drops of concentrated sulfuric acid. 4.  Warm the mixture for 15 minutes. 5.  Add ice cold water to remove the excess ethanoic anhydride. 6.  Cool the mixture until a precipitate of aspirin is formed. 7.  Collect the precipitate and wash it with cold water. 8.  The precipitate of aspirin is dried and weighed. |

(a)     The equation for this reaction is shown below.

          C7H6O3      +        C4H6O3      →      C9H8O4    +     CH3COOH

   salicylic acid                                     aspirin

          Calculate the maximum mass of aspirin that could be made from 2.00 g of salicylic acid.

          The relative formula mass (*M*r) of salicylic acid, C7H6O3, is 138

          The relative formula mass (*M*r) of aspirin, C9H8O4, is 180

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Maximum mass of aspirin = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(2)**

(b)     The student made 1.10 g of aspirin from 2.00 g of salicylic acid.

          Calculate the percentage yield of aspirin for this experiment.

          (If you did not answer part (a), assume that the maximum mass of aspirin that can be made from 2.00 g of salicylic acid is 2.50 g. This is **not** the correct answer to part (a).)

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Percentage yield of aspirin = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ %

**(2)**

(c)     Suggest **one** possible reason why this method does **not** give the maximum amount of aspirin.

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**(1)**

(d)     Concentrated sulfuric acid is a catalyst in this reaction.

          Suggest how the use of a catalyst might reduce costs in the industrial production of aspirin.

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**(1)**

**(Total 6 marks)**

**Q7.**

Limestone (CaCO3) is a raw material. On strong heating it is converted to calcium oxide which is a very useful substance.



(a)     Calculate the formula mass (Mr) of calcium carbonate.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Mr of calcium carbonate = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(b)     About 60 million tonnes of calcium oxide is made in Britain each year.  
Calculate the mass of calcium carbonate needed to make this amount of calcium oxide.

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Mass of calcium carbonate needed = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ million tonnes

**(4)**

(c)     Water is added to some of the calcium oxide produced in a process known as ‘slaking’. The product of this reaction is used to make plaster.

CaO(s)  +  H2O(1)→  Ca(OH)2(s)

(i)      Give the chemical name of Ca(OH)2.

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**(1)**

(ii)     What is the physical state of the Ca(OH)2 formed in the reaction?

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**(1)**

**(Total 8 marks)**

**Q8.**

The following passage was taken from a chemistry textbook.

Germanium is a white, shiny, brittle element. It is used in the electronics industry because it is able to conduct a small amount of electricity.

It is made from germanium oxide obtained from flue dusts of zinc and lead smelters.

The impure germanium oxide from the flue dusts is changed into germanium by the process outlined below.

**STEP 1**               The germanium oxide is reacted with hydrochloric acid to make

germanium tetrachloride. This is a volatile liquid in which the germanium and chlorine atoms are joined by covalent bonds.

**STEP 2**               The germanium tetrachloride is distilled off from the mixture.

**STEP 3**               The germanium tetrachloride is added to an excess of water to

produce germanium oxide and hydrochloric acid.

**STEPS 1 to 3**      are repeated several times.

**STEP 4**               The pure germanium oxide is reduced by hydrogen to form germanium.

(a)     Balance the equation below which represents the reaction in step 1.

GeO2    +    \_\_\_\_\_\_  HCl    →      GeCl4    +    \_\_\_\_\_\_  H2O

**(1)**

(b)     Write a word equation for the reaction in step 3.

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**(1)**

(c)     Suggest why steps 1 to 3 are repeated several times.

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**(1)**

(d)     The equation which represents the reaction in step 4 is shown below.

GeO2    +    2H2    →      Ge    +    2H2O

(i)      Explain what is meant by the term ‘reduced’.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(ii)     Calculate the mass of germanium which could be made from 525 g of germanium oxide. (Relative atomic masses: Ge = 73; O = 16).

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Mass \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

(e)     Germanium is difficult to classify as either a metal or a non-metal.

(i)      Give as much evidence as you can from the information in this question to support the view that germanium is a metal. Explain your answer as fully as you can.

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**(3)**

(ii)     Give as much evidence as you can from the information in this question to support the view that germanium is a non-metal. Explain your answer as fully as you can.

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**(3)**

**Q9.**

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.

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**(2)**

(b)  A 1.0 × 10−3 mol/dm3 solution of hydrochloric acid has a pH of 3.0

What is the pH of a 1.0 × 10−5 mol/dm3 solution of hydrochloric acid?

pH = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

A student titrated 25.0 cm3 portions of dilute sulfuric acid with a 0.105 mol/dm3 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 cm3 | 23.50 | 21.10 | 22.10 | 22.15 | 22.15 |

The equation for the reaction is:

2 NaOH + H2SO4 ⟶ Na2SO4 + 2 H2O

Calculate the concentration of the sulfuric acid in mol/dm3

Use only the student’s concordant results.

Concordant results are those within 0.10 cm3 of each other.

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Concentration of sulfuric acid = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mol/dm3

**(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.

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**(2)**

(e)  Calculate the mass of sodium hydroxide in 30.0 cm3 of a 0.105 mol/dm3 solution.

Relative formula mass (*M*r): NaOH = 40

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Mass of sodium hydroxide = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(2)**

**Q10.**

This question is about methanol.

(a)  Methanol is broken down in the body during digestion.

What type of substance acts as a catalyst in this process?

Tick **one** box.

|  |  |
| --- | --- |
| Amino acid |  |
| Enzyme |  |
| Ester |  |
| Nucleotide |  |

**(1)**

In industry, methanol is produced by reacting carbon monoxide with hydrogen.

The equation for the reaction is:

CO(g) + 2H2(g) ⇌ CH3OH(g)

(b)  How many moles of carbon monoxide react completely with 4.0 × 103 moles of hydrogen?

Tick **one** box.

|  |  |
| --- | --- |
| 1.0 × 103 moles |  |
| 2.0 × 103 moles |  |
| 4.0 × 103 moles |  |
| 8.0 × 103 moles |  |

**(1)**

(c)  The reaction is carried out at a temperature of 250 °C and a pressure of 100 atmospheres.

The forward reaction is exothermic.

Explain what happens to the yield of methanol if a temperature higher than 250 °C is used.

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**(2)**

(d)  A pressure of 100 atmospheres is used instead of atmospheric pressure.

The higher pressure gives a greater yield of methanol and an increased rate of reaction.

Explain why.

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**(4)**

A catalyst is used in the reaction to produce methanol from carbon monoxide and hydrogen.

(e)  Explain how a catalyst increases the rate of a reaction.

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**(2)**

(f)  Suggest why a catalyst is used in this industrial process.

Do **not** give answers in terms of increasing the rate of reaction.

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**(1)**

(g)  Suggest the effect of using the catalyst on the equilibrium yield of methanol.

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**(1)**

**(Total 12 marks)**

**Q11.**

A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

(a)     Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

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**(4)**

(b)     A student wanted to make 11.0 g of copper chloride.

The equation for the reaction is:

                             CuCO3 + 2HCl  →  CuCl2 + H2O + CO2

Relative atomic masses, *A*r: H = 1; C = 12; O = 16; Cl = 35.5; Cu = 63.5

Calculate the mass of copper carbonate the student should react with dilute hydrochloric acid to make 11.0 g of copper chloride.

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Mass of copper carbonate = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(4)**

(c)     The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced.

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Actual mass of copper chloride produced = \_\_\_\_\_\_\_\_\_\_\_\_ g

**(2)**

(d)     Look at the equations for the two reactions:

   Reaction 1        CuCO3(s) + 2HCl(aq)  →  CuCl2(aq) + H2O(l) + CO2(g)

   Reaction 2             CuO(s) + 2HCl(aq)  →  CuCl2(aq) + H2O(l)

Reactive formula masses: CuO = 79.5; HCl = 36.5; CuCl2 = 134.5; H2O = 18

The percentage atom economy for a reaction is calculated using:



Calculate the percentage atom economy for Reaction 2.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Percentage atom economy = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ %

**(3)**

(e)     The atom economy for Reaction 1 is 68.45 %.

Compare the atom economies of the two reactions for making copper chloride.

Give a reason for the difference.

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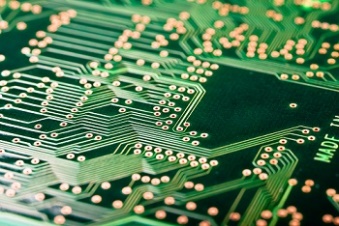
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**(1)**

**(Total 14 marks)**

**Q12.**

Etching is a way of making printed circuit boards for computers.



© Dario Lo Presti/Shutterstock

Printed circuit boards are made when copper sheets are etched using iron(III) chloride solution. Where the copper has been etched, only plastic remains.

(a)     Copper is a good conductor of electricity.

Explain why.

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**(2)**

(b)     Iron(III) chloride can be produced by the reaction shown in the equation:

2 Fe + 3 Cl2 → 2 FeCl3

(i)      Calculate the maximum mass of iron(III) chloride (FeCl3) that can be produced from 11.20 g of iron.

Relative atomic masses (*A*r): Cl = 35.5; Fe = 56.

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Maximum mass of iron(III) chloride = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(3)**

(ii)     The actual mass of iron(III) chloride (FeCl3) produced was 24.3 g.

Calculate the percentage yield.

(If you did not answer part (b)(i) assume that the maximum theoretical mass of iron(III) chloride (FeCl3) is 28.0 g. This is **not** the correct answer to part (b)(i).)

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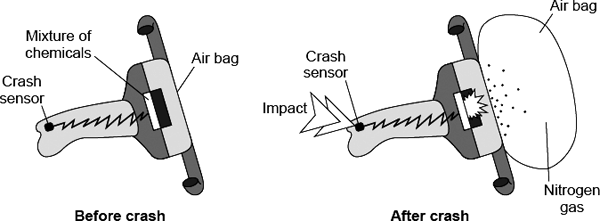
Percentage yield = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_%

**(1)**

**(Total 6 marks)**

**Q13.**

Air bags are used to protect the passengers in a car during an accident. When the crash sensor detects an impact it causes a mixture of chemicals to be heated to a high temperature. Reactions take place which produce nitrogen gas. The nitrogen fills the air bag.



(a)     The mixture of chemicals contains sodium azide (NaN3) which decomposes on heating to form sodium and nitrogen.

2NaN3       →       2Na       +       3N2

A typical air bag contains 130 g of sodium azide.

(i)      Calculate the mass of nitrogen that would be produced when 130 g of sodium azide decomposes.

Relative atomic masses (*A*r): N = 14; Na = 23

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Mass of nitrogen = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(3)**

(ii)     1 g of nitrogen has a volume of 0.86 litres at room temperature and pressure.

What volume of nitrogen would be produced from 130 g of sodium azide?

(If you did not answer part (a)(i), assume that the mass of nitrogen produced from 130 g of sodium azide is 80 g. This is **not** the correct answer to part (a)(i).)

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Volume = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ litres

**(1)**

(b)     The sodium produced when the sodium azide decomposes is dangerous.  
The mixture of chemicals contains potassium nitrate and silicon dioxide which help to make the sodium safe.

(i)      Sodium reacts with potassium nitrate to make sodium oxide, potassium oxide and nitrogen. Complete the balancing of the equation for this reaction.

10Na     +     \_\_\_\_\_KNO3     →     Na2O     +     K2O     +     N2

**(1)**

(ii)     The silicon dioxide reacts with the sodium oxide and potassium oxide to form silicates.

Suggest why sodium oxide and potassium oxide are dangerous in contact with the skin.

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**(1)**

**(Total 6 marks)**

**Section 2: Required Practicals**

**Q14.**

Sodium carbonate reacts with dilute hydrochloric acid:

                   Na2CO3 + 2HCl  →  2NaCl + H2O + CO2

A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

This is the method used.

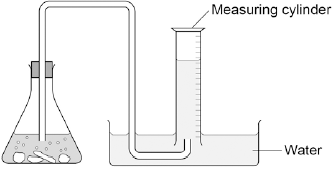
1.        Place a known mass of sodium carbonate in a conical flask.

2.        Measure 10 cm3 of dilute hydrochloric acid using a measuring cylinder.

3.        Pour the acid into the conical flask.

4.        Place a bung in the flask and collect the gas until the reaction is complete.

(a)     The student set up the apparatus as shown in the figure below.



Identify the error in the way the student set up the apparatus.

Describe what would happen if the student used the apparatus shown.

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**(2)**

(b)     The student corrected the error.

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

|  |  |
| --- | --- |
| **Mass of sodium carbonate in g** | **Volume of carbon dioxide gas  in cm3** |
| 0.07 | 16.0 |
| 0.12 | 27.5 |
| 0.23 | 52.0 |
| 0.29 | 12.5 |
| 0.34 | 77.0 |
| 0.54 | 95.0 |
| 0.59 | 95.0 |
| 0.65 | 95.0 |

The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this anomalous result.

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**(1)**

(c)     Why does the volume of carbon dioxide collected stop increasing at 95.0 cm3?

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**(1)**

(d)     What further work could the student do to be more certain about the minimum mass of sodium carbonate needed to produce 95.0 cm3 of carbon dioxide?

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**(1)**

(e)     The carbon dioxide was collected at room temperature and pressure.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm3.

How many moles of carbon dioxide is 95.0 cm3?

Give your answer in three significant figures.

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\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mol

**(2)**

(f)     Suggest **one** improvement that could be made to the apparatus used that would give more accurate results.

Give a reason for your answer.

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**(2)**

(g)     One student said that the results of the experiment were wrong because the first few bubbles of gas collected were air.

A second student said this would make no difference to the results.

Explain why the second student was correct.

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**(2)**

**Q15.**

Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:

                 2NaOH + H2SO4  →  Na2SO4 + 2H2O

(a)     Sulfuric acid is a strong acid.

What is meant by a strong acid?

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**(2)**

(b)     Write the ionic equation for this neutralisation reaction. Include state symbols.

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**(2)**

(c)     A student used a pipette to add 25.0 cm3 of sodium hydroxide of unknown concentration to a conical flask.

The student carried out a titration to find out the volume of 0.100 mol / dm3 sulfuric acid needed to neutralise the sodium hydroxide.

Describe how the student would complete the titration.

You should name a suitable indicator and give the colour change that would be seen.

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**(4)**

(d)     The student carried out five titrations. Her results are shown in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Titration 1 | Titration 2 | Titration 3 | Titration 4 | Titration 5 |
| Volume of 0.100 mol / dm3 sulfuric acid in cm3 | 27.40 | 28.15 | 27.05 | 27.15 | 27.15 |

Concordant results are within 0.10 cm3 of each other.

Use the student’s concordant results to work out the mean volume of 0.100 mol / dm3 sulfuric acid added.

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Mean volume = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm3

**(2)**

(e)     The equation for the reaction is:

                               2NaOH + H2SO4  →  Na2SO4 + 2H2O

Calculate the concentration of the sodium hydroxide.

Give your answer to three significant figures.

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Concentration = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mol / dm3

**(4)**

(f)     The student did another experiment using 20 cm3 of sodium hydroxide solution with a concentration of 0.18 mol / dm3.

Relative formula mass (*M*r) of NaOH = 40

Calculate the mass of sodium hydroxide in 20 cm3 of this solution.

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Mass = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(2)**

**(Total 16 marks)**

**Q16.**

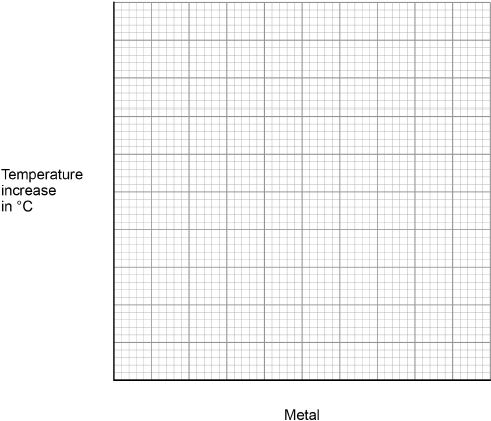
A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

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.

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**(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.

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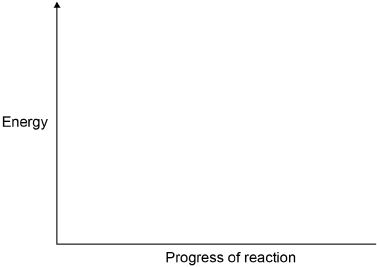
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**(4)**

(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)**

**Q17.**

Some students investigated the energy changes occurring in the reaction between potassium hydrogencarbonate and hydrochloric acid.

The equation for the reaction is:

KHCO3(s) + HCl(aq) ⟶ KCl(aq) + CO2(g) + H2O(l)

This is the method used.

1. Measure 50 cm3 hydrochloric acid into a glass beaker.

2. Measure the temperature of the hydrochloric acid.

3. Measure a given mass of potassium hydrogencarbonate.

4. Add the potassium hydrogencarbonate to the hydrochloric acid.

5. Stir until all the potassium hydrogencarbonate has reacted.

6. Record the lowest temperature reached.

7. Repeat three more times, using the same mass of potassium hydrogencarbonate.

Each student used a different mass of potassium hydrogencarbonate.

(a)     The method described will not give very accurate results.

Suggest **one** change to the apparatus that would improve the accuracy of the results.

Give a reason for your answer.

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**(2)**

(b)     The students controlled the volume of the hydrochloric acid.

Give **one** other control variable the students should use.

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**(1)**

(c)     The table shows one student’s results.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** |
| **Initial temperature in °C** | 21.2 | 21.1 | 21.0 | 21.1 |
| **Final temperature in °C** | 15.6 | 15.4 | 15.6 | 16.6 |
| **Temperature decrease in °C** | 5.6 | 5.7 | 5.4 | 4.5 |

Calculate the mean temperature decrease for the results shown in the table above.

Ignore any anomalous results.

Give your answer to 1 decimal place.

Give the uncertainty in your answer.

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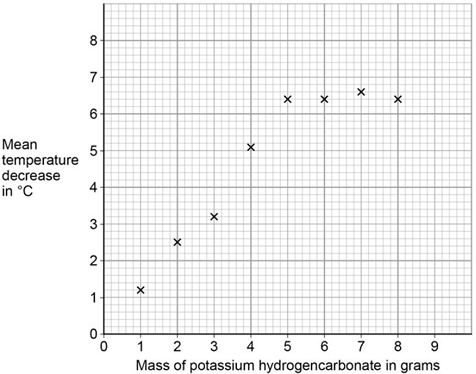
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Mean = \_\_\_\_\_\_\_\_\_\_ °C ± \_\_\_\_\_\_\_\_\_\_ °C

**(3)**

The graph below shows the students’ results.



(d)     Draw **two** intersecting straight lines of best fit on the graph above.

**(2)**

(e)     Explain why the graph has this shape.

Use data from the graph.

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**(3)**

(f)      Suggest a possible reason for the anomalous points.

Do **not** include errors in measuring.

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**(1)**

**(Total 12 marks)**

**Q18.**

A student makes a hypothesis:

‘When different salt solutions are electrolysed with inert electrodes, the product at the negative electrode is always a metal’.

(a)     Describe how you would test this hypothesis in the laboratory.

You should:

•   draw a labelled diagram of the apparatus

•   give the independent variable

•   describe what you would see at the negative electrode if the hypothesis is true.

Diagram

Independent variable \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Observation \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(5)**

(b)     The student’s hypothesis is only partially correct.

Explain why the product at the negative electrode is not always a metal.

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**(2)**

(c)     Predict the product at the positive electrode in the electrolysis of:

•   sodium chloride solution

•   copper sulfate solution.

Sodium chloride solution \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Copper sulfate solution \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

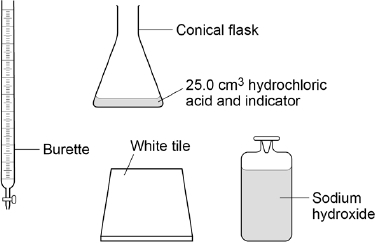
**(2)**

**(Total 9 marks)**

**Q19.**

Sodium hydroxide reacts with hydrochloric acid.

The diagram shows apparatus that can be used to find the volume of sodium hydroxide reacting with 25.0 cm 3 hydrochloric acid.



(a)     Describe a method to find the exact volume of sodium hydroxide that reacts with 25.0 cm 3 of hydrochloric acid.

**(6)**

The reaction produces a solution of sodium chloride.

A student wants to obtain sodium chloride crystals from the sodium chloride solution.

This is the method used.

1. Add solid charcoal to the sodium chloride solution to remove the indicator colour.

2. Remove the solid charcoal.

3. Evaporate the solution to dryness over a Bunsen burner.

(b)     Charcoal is not soluble in water.

Suggest a method the student could use to remove the solid charcoal in **Step 2**.

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**(1)**

(c)     The student obtains a powdery white solid.

Suggest how the student could improve **Step 3** of the method to obtain larger crystals instead of powder.

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**(1)**

**(Total 8 marks)**

**Q20.**

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

The salt called potassium chloride is made when potassium hydroxide solution reacts with hydrochloric acid.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| potassium hydroxide solution | + | hydrochloric acid |  | potassium chloride solution | + | water |

Describe a method for making **crystals** of potassium chloride from potassium hydroxide solution and hydrochloric acid.

In this method you should:

•        describe how you will add the correct amount of the hydrochloric acid to neutralise the potassium hydroxide solution

•        describe how you will get crystals of potassium chloride.

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**(6)**

(b)     Ammonium nitrate is another salt.  
Ammonium nitrate is made when ammonia solution is neutralised with an acid.

Name the acid to complete the word equation.

ammonia   +   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ acid      ammonium nitrate

**(1)**

(c)     Read the information.

|  |
| --- |
| **Ammonium nitrate – good or bad?** |
| Some farmers put a lot of ammonium nitrate on their farmland. |
| Many people are worried about this use of ammonium nitrate. |
| Rain water can wash the ammonium nitrate off the farmland and into rivers and lakes. The ammonium nitrate may get into drinking water supplies and could be harmful to health. |

(i)      Why do some farmers put ammonium nitrate on their farmland?

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**(1)**

(ii)     Which **one** of the questions in the table cannot be answered by science alone?

Tick () **one** question.

|  |  |
| --- | --- |
| **Question** | **Tick ()** |
| How much ammonium nitrate is in drinking water? |  |
| Should farmers stop using ammonium nitrate on their farmland? |  |
| Is ammonium nitrate soluble in rain water? |  |

Give **two** reasons why this question **cannot** be answered by science alone.

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**(3)**

**(Total 11 marks)**

**Section 3: 6 Mark Questions**

**Q21.**

Sulfur is a non-metal.

Sulfur burns in the air to produce sulfur dioxide, SO2

(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.

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**(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.

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**(3)**

(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.

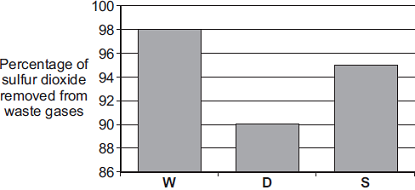
Three of the methods used to remove sulfur dioxide from gases produced when fossil fuels are burned are:

•        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**.

  
                        Method of removing sulfur dioxide

**Table 1**

|  |  |  |
| --- | --- | --- |
| **Method** | **Material used** | **How material is obtained** |
| **W** | Calcium carbonate, CaCO3 | Quarrying |
| **D** | Calcium oxide, CaO | Thermal decomposition of calcium carbonate: CaCO3    CaO  +  CO2 |
| **S** | Seawater | From the sea |

**Table 2**

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

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

Compare the three methods and give a justified conclusion.

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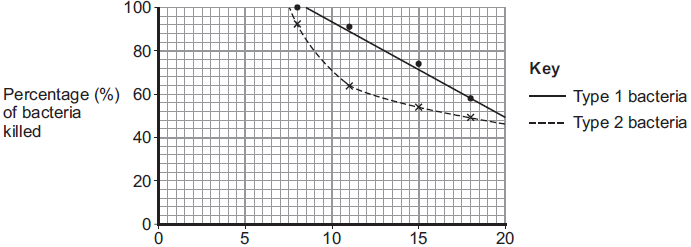
**(6)**

**(Total 12 marks)**

**Q22.**

Magnesium oxide nanoparticles can kill bacteria.

The figure below shows the percentage of bacteria killed by different sized nanoparticles.

  
Size of nanoparticles in nanometres

(a)     (i)      Give **two** conclusions that can be made from the figure above.

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**(2)**

(ii)     Points are plotted for only some sizes of nanoparticles.

Would collecting and plotting data for more sizes of nanoparticles improve the conclusions?

Give a reason for your answer.

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**(1)**

(b)     Magnesium oxide contains magnesium ions (Mg2+) and oxide ions (O2–).

Describe, as fully as you can, what happens when magnesium atoms react with oxygen atoms to produce magnesium oxide.

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**(4)**

**(Total 7 marks)**

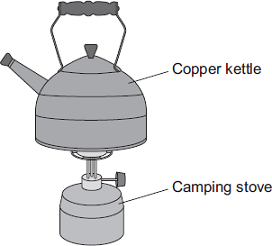
**Q23.**

The picture shows a copper kettle being heated on a camping stove.

Copper is a good material for making a kettle because:

•        it has a high melting point

•        it is a very good conductor of heat.



(a)     Explain why copper, like many other metals, has a high melting point.

Your answer should describe the structure and bonding of a metal.

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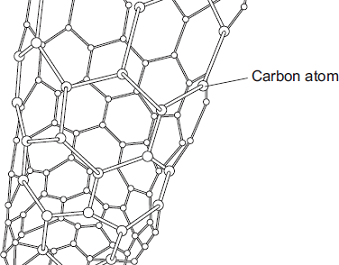
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**(4)**

(b)     Aeroplanes contain many miles of electrical wiring made from copper. This adds to the mass of the aeroplane.

It has been suggested that the electrical wiring made from copper could be replaced by carbon nanotubes which are less dense than copper.

The diagram shows the structure of a carbon nanotube.



(i)      What does the term ‘nano’ tell you about the carbon nanotubes?

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**(1)**

(ii)     Like graphite, each carbon atom in the carbon nanotube is joined to three other carbon atoms.

Explain why the carbon nanotube can conduct electricity.

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**(2)**

**(Total 7 marks)**

**Q24.**

This question is about some compounds of iodine.

(a)     Lead iodide can be made by mixing a solution containing lead ions with a solution containing iodide ions.

Lead iodide is formed as a precipitate.

Pb2+(aq)     +     2l–(aq)    →     Pbl2(s)

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

|  |  |
| --- | --- |
| **Soluble compounds** | **Insoluble compounds** |
| all sodium and potassium salts |  |
| all nitrates |  |
| most chlorides, bromides and iodides | silver and lead chlorides, bromides and iodides |

Use the table to help you name:

a soluble compound which contains lead ions \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

a soluble compound which contains iodide ions \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(ii)     Suggest a method of separating the lead iodide from the solution.

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**(1)**

(b)     Magnesium iodide can be made by reacting magnesium with iodine.

Mg     +     I2     →     MgI2

Magnesium iodide is an ionic compound. It contains magnesium ions (Mg2+) and iodide ions (I-).

Describe, in terms of electrons, what happens when magnesium reacts with iodine.

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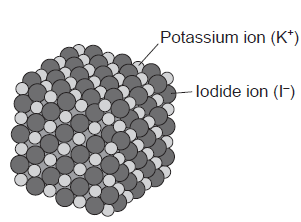
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**(4)**

(c)     The diagram shows the structure of potassium iodide.



Explain why a high temperature is needed to melt potassium iodide.

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**(2)**

**(Total 9 marks)**

**Q25.**

The extract below was taken from a leaflet on the uses of platinum. One of the uses described was in making electrodes for spark plugs in car engines. The spark plug produces the spark which ignites the fuel in the engine.

|  |
| --- |
| **Spark Plugs**  The electrodes in a spark plug have to conduct electricity very well. Since they project into the combustion chamber of the engine, they must also be able to withstand extremely high temperatures in a very corrosive atmosphere.  Nickel-based plugs have been produced for many years. They only last a fairly short time. As the electrodes wear, combustion becomes less efficient and the petrol is not burnt completely.  Platinum and other precious metals can now be used in spark plugs. These last much longer and are more efficient. This can help to reduce air pollution. |

The table below gives some information about platinum and nickel.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | MELTING POINT (° C) | BOILING POINT (° C) | POSITION IN REACTIVITY SERIES | COST (£/kg) |
| nickel | 1455 | 2920 | Higher than gold | 2.5 |
| platinum | 1769 | 4107 | below gold | 6110 |

(a)     Compare nickel and platinum for use in making the electrodes in spark plugs.

          A good answer should give advantages and disadvantages of each metal linking these to the properties of the metals. Marks will be given for the way in which you organise your answer.

***You will need a sheet of lined paper.***

**(8)**

(b)     (i)      Describe the structure and bonding in metals.

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**(3)**

(ii)     Explain why metals such as nickel and platinum are good conductors of electricity.

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**(2)**

**(Total 13 marks)**

**Q26.**

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:

                 Cu2S(s) + O2(g)  2 Cu(s) + SO2(g)

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

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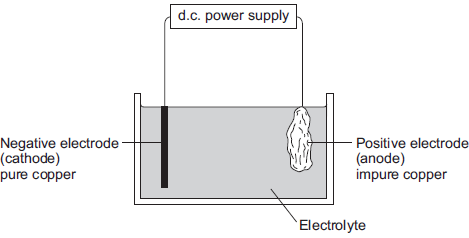
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**(2)**

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



Copper atoms are oxidised at the positive electrode to Cu2+ ions, as shown in the half equation.

                                    Cu(s)  Cu2+(aq) + 2e−

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

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**(1)**

(ii)     The Cu2+ ions are attracted to the negative electrode, where they are reduced to produce copper atoms.

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

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**(1)**

(iii)    Suggest a suitable electrolyte for the electrolysis.

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**(1)**

(c)     Copper metal is used in electrical appliances.

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

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**(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.

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**(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.

Relative atomic masses (*A*r): S = 32; Fe = 56; Cu = 63.5

You must show all of your working.

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Empirical formula = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(4)**

**(Total 16 marks)**

**Q27.**

The article gives some information about graphene.

|  |
| --- |
| Nanotunes!    Carbon can be made into nano-thin, strong sheets called graphene.  A graphene sheet is a single layer of graphite.  Graphene conducts electricity and is used in loudspeakers.  The picture shows the structure of graphene.                                                                  © 7immy/iStock |

(a)     Use the picture and your knowledge of bonding in graphite to:

(i)      explain why graphene is strong;

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**(3)**

(ii)     explain why graphene can conduct electricity.

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**(2)**

(b)     Graphite is made up of layers of graphene.

Explain why graphite is a lubricant.

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**(2)**

**(Total 7 marks)**

**Q28.**

This question is about sodium chloride and iodine.

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

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**(4)**

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

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

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**(2)**

(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.

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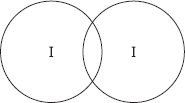
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**(1)**

(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.

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**(3)**

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

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**(2)**

**(Total 14 marks)**

**Q29.**

This question is about the reaction of ethene and bromine.

The equation for the reaction is:

                                                 C2H4 + Br2  →  C2H4Br2

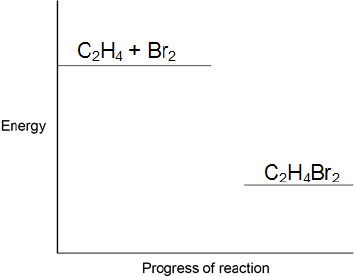
(a)     Complete the reaction profile in **Figure 1**.

Draw labelled arrows to show:

•        The energy given out (Δ*H*)

•        The activation energy.

**Figure 1**

****

**(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.

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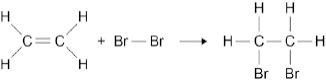
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**(2)**

(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.

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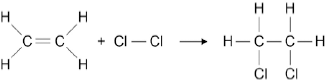
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Bond energy \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kJ / mole

**(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.

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**(6)**

**Section 1: Maths Mark Scheme**

**Q1.**

(a)  potassium chloride **and** iodine

*either order*

*allow KCl for potassium chloride and I2 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]**

**Q2.**

(a)  chlorine is toxic

*allow carbon monoxide is toxic*

*allow poisonous for toxic*

*ignore harmful / deadly / dangerous*

*allow a poisonous gas is used / produced*

*allow titanium chloride is corrosive*

**1**

(b)  any **one** from:

•   very exothermic reaction

*allow explosive*

*allow violent reaction*

*ignore vigorous reaction*

*ignore sodium is very reactive*

•   produces a corrosive solution

*allow caustic for corrosive*

*ignore alkaline*

•   produces hydrogen, which is explosive / flammable

*allow flames produced*

*ignore sodium burns*

**1**

(c)  argon is unreactive / inert

*allow argon will not react (with reactants / products / elements)*

**1**

oxygen (from air) would react with sodium / titanium

**or**

water vapour (from air) would react with sodium / titanium

*allow elements / reactants / products for sodium / titanium*

**1**

(d)  metal chlorides are usually ionic

*allow titanium chloride is ionic*

**1**

(so)(metal chlorides) are solid at room temperature

**or**

(so)(metal chlorides) have high melting points

*allow titanium chloride for metal chlorides*

**1**

(because) they have strong (electrostatic) forces between the ions

*ignore strong ionic bonds*

**or**

(but) must be a small molecule or covalent

*allow molecular*

**1**

*allow alternative approach:*

*titanium chloride must be covalent* ***or*** *has small molecules (1)*

*with weak forces between molecules*

*do* ***not*** *accept bonds unless intermolecular bonds(1)*

*(but) metal chlorides are usually ionic (1)*

(e)  sodium (atoms) lose electrons

*do* ***not*** *accept references to oxygen*

**1**

(f)  Na ⟶ Na+ + e−

*do* ***not*** *accept e for e−*

**1**

(g)  (*M*r of TiCl4 =) 190



**1**

****

**1**

*\*allow* ***1*** *mark for 0.870 mol Na* ***and*** *0.211 mol TiCl4*

*allow use of incorrectly calculated Mr from step 1*

**either**

(sodium is in excess because) 870 mol Na is more than the 844 mol needed

**or**

(because) 211 mol TiCl4 is less than the 217.5 mol needed

*the mark is for correct application of the factor of 4*

*other correct reasoning showing, with values of moles or mass, an excess of sodium or insufficient TiCl4 is acceptable*

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

**1**

*alternative approaches:*

***approach 1:***

*(Mr of TiCl4 =) 190(1)*

*(40 kg TiClr needs)*

**

*(=) 19.4 (kg) (1)*

*so 20 kg is an excess (1)*

***approach 2:***

*(Mr of TiCl4 =) 190(1)*

*(20 kg Na needs)*

**

*(=) 41.3 (kg) (1)*

*so 40 kg is not enough (1)*

(h)  

**or**

(actual mass =) 0.923 × 13.5

**1**

= 12.5 (kg)

*allow 12 / 12.46 / 12.461 / 12.4605 (kg)*

**1**

*an answer 12.5 (kg) scores* ***2*** *marks*

**[15]**

**Q3.**

(a)     mass number

*allow the number of protons + neutrons*

**1**

(b)     6.02 × 1023

**1**

(c)     **Level 2 (3-4 marks):**

Scientifically relevant features are identified; the ways in which they are similar / different is made clear.

**Level 1 (1-2 marks):**

Relevant features are identified and differences noted.

**Level 0**

No relevant content.

**Indicative content**

**similarities**

•   both have positive charges

•   both have (negative) electrons

•   neither has neutrons

**differences**

|  |  |
| --- | --- |
| **plum pudding model** | **nuclear model** |
| ball of positive charge (spread throughout) | positive charge concentrated at the centre |
| electrons spread throughout (embedded in the ball of positive charge) | electrons outside the nucleus |
| no empty space in the atom | most of the atom is empty space |
| mass spread throughout | mass concentrated at the centre |

**4**

(d)     

**or**

(24 × 0.786) + (25 × 0.101) +

(26 × 0.113)

**1**

= 24.3

**1**

*an answer of 24.3 scores* ***2*** *marks*

**[8]**

**Q4.**

(a)     heat with a water bath

**or**

heat with an electric heater

**or**

allow to evaporate / crystallise at room temperature

**1**

(b)     to make sure that all the iodine reacts

*allow so can see the reaction is complete*

**1**

(as) excess iodine would remain in solution

**1**

(so) iodine could not be filtered off

*allow (whereas) excess zinc could be filtered off*

**or**

(so) the zinc iodide would not be pure

*allow (so) would have to separate iodine from zinc iodide*

**1**

(c)     

*allow moles I2 = 0.00197*

*allow 65 g Zn: 254 g I2*

**1**

mass Zn = 0.00197 × 65 (g)

**1**

mass = 0.128 (g)

**1**

*allow an expression  (g) for the first* ***2*** *marks*

(d)     

**1**

****

**1**

= 13.6 (g)

*allow 13.5869... (g)*

**1**

(e)     some product lost on separation

*allow incomplete reaction*

**1**

(f)      *M*r ZnI2 = 319

**1**

moles needed



**or**

mass per dm 3 = 31.9 (g)

**1**

(mass) = 7.98 (g)

*allow 7.975 / 8.0 (g)*

**1**

*an answer of 7.975, 7.98 or 8.0 (g) scores* ***3*** *marks*

**[14]**

**Q5.**

(a)     the chemical reaction is reversible

**1**

(b)     any **two** from:

•   type of electrode

•   electrolyte

•   concentration of electrolyte

•   temperature

**2**

(c)     H2 + **2**OH− → **2**H2O + **2** e−

*allow multiples*

**1**

(d)     contains OH− ions

**1**

(e)     (bonds broken)

((6 × 412) + (2 × 360) + (2 × 464) + (3 × 498)) = 5614

**1**

(bonds made)

((4 × 805) + (8 × 464)) = 6932

**1**

(overall energy change)

(6932 − 5614) = −1318 (kJ / mol)

*allow ecf from marking point 1 and / or marking point 2*

**1**

*an answer of 1318 (kJ / mol) scores* ***3*** *marks*

**[8]**

**Q6.**

(a)     2.61 / range 2.5 to 2.7

*correct answer with* ***or*** *without* ***or*** *with wrong working gains* ***2*** *marks*

*(accept answers between 2.5 and 2.7)*

*if answer incorrect moles of salicylic acid = 2/138 = 0.0145 moles  
ie 2/138* ***or*** *0.0145 gains* ***1*** *mark****or****(180/138) × 2 gains* ***1*** *mark****or****1 g → 180/138 = (1.304 g) gains* ***1*** *mark  
(****not*** *1.304g alone)*

**2**

(b)     42.1 range 40.7 to 42.3

*accept correct answer with* ***or*** *without* ***or*** *with wrong working for* ***2*** *marks*

*ecf ie (1.1 / their answer from (a)) × 100 correctly calculated gains* ***2*** *marks*

*if answer incorrect percentage yield = 1.1 / 2.61 × 100 gains* ***1*** *mark*

          if they do not have an answer to part (a)  
**or**they choose not to use their answer then:

•        yield = (1.1 / 2.5) × 100 (1)

•        = 44

*accept 44 for* ***2*** *marks with no working*

**2**

(c)     any **one** from:

•        errors in weighing

•        some (of the aspirin) lost

*do* ***not*** *allow ‘lost as a gas’*

•        not all of the reactant may have been converted to product

*eg reaction didn’t go to completion*

*allow loss of some reactants*

•        the reaction is reversible

*accept other products / chemicals*

•        side reactions

*ignore waste products*

•        reactants impure

•        not heated for long enough

•        not hot enough for reaction to take place

**1**

(d)     any **one** from:

•        use lower temperature

•        use less fuel / energy

*ignore references to use of catalyst*

•        produce product faster **or** speed up reaction

•        more product produced in a given time (owtte)

•        increased productivity

•        lowers activation energy

**1**

**[6]**

**Q7.**

(a)     40 + 12 + (3 × 16) = 100

*each for 1 mark*

**2**

(b)     Mr of CaO = 56

*for 1 mark*

mass required = 60 × 100/56

*for 2 marks*

= 107.1

*for 1 mark*

**4**

(c)     (i)      calcium hydroxide

**1**

(ii)     solid

**1**

**[8]**

**Q8.**

(a)     4 HCl / 2H2O, allow multiples **or** fractions if whole equation balances

*for 1 mark*

**1**

(b)     germanium tetrachloride + water = germanium oxide + hydrochloric acid  
If symbol equation given it must be correctly balanced  
Allow germanium

*for 1 mark*

**1**

(c)     to purify the germanium oxide/remove impurities/give in   
pure product/to make puregermanium

*for 1 mark*

**1**

          ensure complete reaction/reaction does not give a good yield

**not** to increase efficiency/to purify germanium

*for 1 mark*

**1**

(d)     (i)      remove oxygen/addition of hydrogen/gain up electrons allow remove  
oxygen molecules

(ii)     GeO2 =  73 + (2 × 16) = 105  
mass of germanium = 525 × (73/105)   
                              = 365 g  
(or alternative methods)  
apply consequential marking

*for 1 mark each*

**3**

(e)     (i)      germanium is shiny/lustrous  
conducts a small amount of electricity \*  
germanium oxide reacts with hydrochloric acid  
(and) metal oxides react with acid  
metal oxides are basic  
metal oxides are reduced by hydrogen  
Information must be taken from the passage.  
Apply the list principle if more than three answers are given.  
Assume the word ‘it’ refers to the metal.

*any 3 for 1 mark each*

**3**

(ii)     germanium is brittle  
germanium tetrachloride is a (volatile) liquid   
made of molecules   
germanium tetrachloride has covalent bonding or when two non-metals   
      react they have covalent bonding  
GaC14/the salt of germanium undergiven hydrolysis/reacts with water  
germanium is not a good conductor of electricity\*  
\* conductivity mark can only be given once

*any 3 for 1 mark each*

**3**

**[13]**

**Q9.**

(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 (cm3)

*allow average titre = 22.13(3…) (cm3)*

*allow a correctly calculated average from an incorrect choice of titrations*

**1**

(calculation):

(moles NaOH =



*allow use of incorrect average titre from step 2*

**1**

(moles H2SO4 =

½ × 0.002324 =) 0.001162

*allow use of incorrect number of moles from step 3*

**1**

(concentration =



= 0.0465 (mol/dm3)

*allow use of incorrect number of moles from step 4*

**1**

*alternative approach for step 3, step 4 and step 5*

**

*(concentration H2SO4 =)*

**

*= 0.0465 (mol/dm3) (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)  

**or** 0.00315 (mol)

**or**

(mass per dm3 =) 0.105 × 40

**or** 4.2 (g)

**1**

****

= 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]**

**Q10.**

(a)  enzyme

**1**

(b)  2.0 × 103 moles

**1**

(c)  smaller yield

*allow less methanol is produced*

**1**

(because) favours endothermic reaction

*allow (because) favours reverse reaction*

*allow equilibrium / reaction shifts to the left*

*allow equilibrium / reaction shifts to reduce the temperature*

*ignore reference to forward reaction is exothermic*

*ignore references to rate*

**1**

(d)  (yield)

equilibrium position moves to the product side

*allow equilibrium / reaction moves to the right*

*allow equilibrium / reaction shifts to reduce the pressure*

**1**

(because) fewer molecules / moles / particles on product side

*allow (because) fewer molecules / moles / particles on the right*

*allow (because) smaller volume on product side*

**1**

(rate)

more collisions per unit time

*allow increases collision frequency / rate*

*ignore more collisions alone*

*ignore faster collisions*

*do* ***not*** *accept any indication of more energetic / forceful collisions*

**1**

(because) more molecules / particles per unit volume

*allow (gas) molecules / particles closer together*

*ignore more molecules / particles alone*

**1**

*allow converse arguments*

(e)  provides different reaction pathway

*allow provides a different mechanism / route*

**1**

(which has a) lower activation energy

**1**

*ignore references to collisions*

(f)  less energy is needed

*allow reduces the temperature required*

*allow reduces costs*

*ignore references to pressure*

*ignore references to rate or time*

**1**

(g)  no effect / change

**1**

**[12]**

**Q11.**

(a)     add excess copper carbonate (to dilute hydrochloric acid)

*accept alternatives to excess, such as ‘until no more reacts’*

**1**

filter (to remove excess copper carbonate)

*reject heat until dry*

**1**

heat filtrate to evaporate some water **or** heat to point of crystallisation

*accept leave to evaporate or leave in evaporating basin*

**1**

leave to cool (so crystals form)

*until crystals form*

**1**

*must be in correct order to gain* ***4*** *marks*

(b)     *M*r CuCl2 = 134.5

*correct answer scores* ***4*** *marks*

**1**

moles copper chloride = (mass / *M*r = 11 / 134.5) = 0.0817843866

**1**

*M*r CuCO3= 123.5

**1**

Mass CuCO3 (=moles × M2= 0.08178 × 123.5) = 10.1(00)

**1**

*accept 10.1 with no working shown for* ***4*** *marks*

(c)    

**or**

11.0 × 0.791

**1**

8.70 (g)

**1**

*accept 8.70(g) with no working shown for* ***2*** *marks*

(d)     Total mass of reactants = 152.5

**1**

134.5

152.5

*allow ecf from step 1*

**1**

88.20 (%)

**1**

*allow 88.20 with no working shown for* ***3*** *marks*

(e)     atom economy using carbonate lower because an additional product is made **or** carbon dioxide is made as well

*allow ecf*

**1**

**[14]**

**Q12.**

(a)    copper has delocalised electrons

*accept copper has free electrons  
ignore sea of electrons* ***or*** *mobile electrons*

**1**

(electrons) which can move through the metal / structure

*allow (electrons) which can carry a charge through the metal / structure*

**1**

(b)     (i)      (M r FeCl 3 =) 162.5

*correct answer with or without working gains* ***3*** *marks*

*can be credited from correct substitution in step* ***2***

**1**

**or**

2 (moles of) FeCl 3  = 325

**or**

112 → 325



*allow ecf from step 1*

*accept *

**1**

= 32.5

*accept 32.48*

**1**

(ii)     74.8

*accept 74.77 – 75*

*accept ecf from (b)(i)*

*if there is no answer to part(i)*

***or***

*if candidate chooses not to use their answer then accept 86.79 – 87*

**1**

**[6]**

**Q13.**

(a)      (i)     84 / 84.5 / 83.98

*correct answer with or without working gains* ***3*** *marks*

*(moles of NaN3 =) 130/65 (1)*

*moles of nitrogen = 3 (1)*

*mass of nitrogen = 3 x 28 = 84 (1)*

***or***

*2 x (23 + (3 x 14)) (1)*

*3 x (2 x14) (1)*

***or***

*2NaN3 = 130 (1)*

*3N2 = 84 (1)*

*if answer is incorrect then look for evidence of correct working.*

*allow ecf from previous stage*

***1*** *mark lost for each mistake in the working if they do not have the correct answer.*

**3**

(ii)     72 / 72.24 / 72.2

*allow ecf from part (i) × 0.86*

**or**

*ignore working*

69 **or** 68.8

**1**

(b)     (i)      2 **and** 5

**1**

(ii)     any **one** from:

•        corrosive / burns

•        alkaline / basic

*do* ***not*** *accept acidic*

•        attacks / destroys / damages living tissue / cells

*allow irritant*

*ignore reference to reactivity*

*ignore reference to silicates*

*ignore harmful / toxic*

**1**

**[6]**

**Section 2: Required Practicals Mark Schemes**

**Q14.**

(a)     (delivery) tube sticks into the acid

**1**

the acid would go into the water **or** the acid would leave the flask or go up the delivery  
tube

*ignore no gas collected*

**1**

(b)     any **one** from:

•        bung not put in firmly / properly

•        gas lost before bung put in

•        leak from tube

**1**

(c)     all of the acid has reacted

**1**

(d)     take more readings in range 0.34 g to 0.54 g

**1**

*take more readings is insufficient*

*ignore repeat*

(e)        95

24000

**1**

0.00396

**or**

3.96 × 10−3

**1**

*accept 0.00396 or 3.96 × 10−3 with no working shown for* ***2*** *marks*

(f)     use a pipette / burette to measure the acid

**1**

because it is more accurate volume than a measuring cylinder

**or**

greater precision than a measuring cylinder

**or**

use a gas syringe to collect the gas

so it will not dissolve in water

**or**

use a flask with a divider

*accept description of tube suspended inside flask*

so no gas escapes when bung removed

**1**

(g)     they should be collected because carbon dioxide is left in flask at end

**1**

and it has the same volume as the air collected / displaced

**1**

**[11]**

**Q15.**

(a)     (sulfuric acid is) completely / fully ionised

**1**

In aqueous solution **or** when dissolved in water

**1**

(b)     H+(aq) + OH−(aq) → H2O(l)

*allow multiples*

***1*** *mark for equation*

***1*** *mark for state symbols*

**2**

(c)     adds indicator, eg phenolpthalein / methyl orange / litmus added to the sodium hydroxide  
(in the conical flask)

*do* ***not*** *accept universal indicator*

**1**

(adds the acid from a) burette

**1**

with swirling **or** dropwise towards the end point **or** until the indicator just changes colour

**1**

until the indicator changes from pink to colourless (for phenolphthalein) or yellow to red  
(for methyl orange) or blue to red (for litmus)

**1**

(d)     titrations 3, 4 and 5

**or**

****

**1**

27.12 cm3

*accept 27.12 with no working shown for* ***2*** *marks*

**1**

*allow 27.1166 with no working shown for* ***2*** *marks*

(e)     Moles H2SO4 = conc × vol = 0.00271

*allow ecf from 8.4*

**1**

Ratio H2SO4:NaOH is 1:2

**or**

Moles NaOH = Moles H2SO4 × 2 = 0.00542

**1**

Concentration NaOH = mol / vol = 0.00542 / 0.025 = 0.2168

**1**

0.217 (mol / dm3)

*accept 0.217 with no working for* ***4*** *marks*

**1**

*accept 0.2168 with no working for* ***3*** *marks*

(f)           ×   0.18 = no of moles

**or**

0.15 × 40 g

**1**

0.144 (g)

**1**

*accept 0.144g with no working for* ***2*** *marks*

**[16]**

**Q16.**

(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

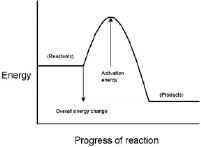
**1**

labelled (overall) energy change

**1**

*ignore arrow heads*

*an answer of:*

**

*scores* ***3*** *marks*

**[10]**

**Q17.**

(a)     use a polystyrene cup instead of a (glass) beaker

*allow insulate the beaker*

*allow use a lid*

**1**

minimises energy transfer from the surroundings

**or**

for better insulation

**1**

(b)     concentration of hydrochloric acid

**1**

(c)     

**1**

= 5.6 (°C)

**1**

± 0.2

**1**

(d)     straight line from origin to (5.0, 6.4)

*must not deviate to anomalous point*

**1**

horizontal line from (5.0, 6.4) to (8.0, 6.4)

*must not deviate to anomalous point*

**1**

(e)     as mass (of potassium hydrogencarbonate) increases, temperature decrease / change increases

**1**

*until 5 g (to 8 g) (of potassium hydrogencarbonate has been added)*

*allow ecf from lines of best fit*

**1**

(because) the reaction has finished

**or**

(because) all the acid has reacted

**or**

(because) no more solid can react

**or**

(because) the solid is in excess

**1**

(f)      not stirred correctly

**1**

**[12]**

**Q18.**

(a)     **(diagram)**

complete circuit with power supply

**1**

test solution in beaker or other appropriate apparatus

**1**

electrodes

*allow carbon, platinum or inert electrodes*

**1**

**(independent variable)**

salt solutions (with different metal ions)

**1**

**(observation)**

solid / metal deposit on the negative electrode

**1**

(b)     (sometimes) hydrogen is produced

**1**

(because) the metal is more reactive than hydrogen

**1**

(c)     chlorine

**1**

oxygen

**1**

**[9]**

**Q19.**

(a)     fill burette with sodium hydroxide

**1**

add sodium hydroxide from the burette to the hydrochloric acid and indicator

**1**

stop when colour changes

**1**

measure volume used from burette

**1**

plus any **two** from:

•   stand flask on white tile

•   swirl

•   add dropwise near the endpoint

•   repeat

**2**

(b)     filtration

**1**

(c)     evaporate some of the solution and leave to cool

***or***

*heat with an electric heater*

**1**

**[8]**

**Q20.**

(a)       Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response.  
Examiners should also apply a "best-fit" approach to the marking.

**0 marks**

No relevant content.

**Level 1 (1-2 marks)**There is a simple description of a laboratory procedure for obtaining potassium chloride.

**Level 2 (3-4 marks)**There is a clear description of a laboratory procedure for obtaining potassium chloride from potassium hydroxide solution and hydrochloric acid that does not necessarily allow the procedure to be completed successfully by another person. The answer must include the use of an indicator or a method of obtaining crystals.

**Level 3 (5-6 marks)**There is a detailed description of a laboratory procedure for obtaining potassium chloride from potassium hydroxide solution and hydrochloric acid that can be followed by another person. The answer must include the use of an indicator and a method of obtaining crystals.

**examples of the chemistry/social points made in the response:**

•        One reagent in beaker (or similar)

•        Add (any named) indicator

•        Add other reagent

•        Swirl or mix

•        Add dropwise near end point

•        Stop addition at change of indicator colour

•        Note volume of reagent added

•        Repeat without indicator, adding same volume of reagent **or** remove indicator using charcoal

•        Pour solution into basin / dish

•        Heat (using Bunsen burner)

•        Leave to crystallise / leave for water to evaporate / boil off water

**Accept** any answers based on titration

**6**

(b)     nitric (acid)

*allow HNO3*

*ignore incorrect formula*

**1**

(c)     (i)     because it is a fertiliser / helps plants grow

*allow plant food*

*do* ***not*** *accept pesticide / herbicide / neutralising soil*

**1**

(ii)    tick by: ‘Should farmers stop using ammonium nitrate on their land?’

**1**

any **two** from:

•       cannot be done by experiment

*accept difficult to get / not enough evidence*

•       based on opinion / view

*allow must be done by survey*

•       ethical **or** economic issue

*if top box ticked allow* ***1*** *mark for drinking water varies from place to place*

**2**

**[11]**

**Section 3: 6 Mark Questions Mark Scheme**

**Q21.**

(a)     Sulfur dioxide causes acid rain.

**1**

(b)     red / orange / yellow

*do* ***not*** *accept any other colours*

**1**

because sulfur dioxide (when in solution) is an acid

**1**

(c)     (there are) weak forces (of attraction)

*do* ***not*** *accept any reference to covalent bonds breaking*

**1**

between the molecules

*do* ***not*** *accept any other particles*

**1**

(these) take little energy to overcome

*award third mark only if first mark given*

**1**

(d)     Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a ‘best-fit’ approach to the marking.

**0 marks**No relevant content

**Level 1 (1 – 2 marks)**A relevant comment is made about the data.

**Level 2 (3 – 4 marks)**Relevant comparisons have been made, and an attempt made at a conclusion.

**Level 3 (5 – 6 marks)**Relevant, detailed comparisons made and a justified conclusion given.

**examples of the points made in the response**

**effectiveness**

•        W removes the most sulfur dioxide

•        D removes the least sulfur dioxide

**material used**

•        Both W and D use calcium carbonate

•        Calcium carbonate is obtained by quarrying which will create scars on landscape / destroy habitats

•        D requires thermal decomposition, this requires energy

•        D produces carbon dioxide which may cause global warming / climate change

•        S uses sea water, this is readily available / cheap

**waste materials**

•        W product can be sold / is useful

•        W makes carbon dioxide which may cause global warming / climate change

•        D waste fill landfill sites

•        S returned to sea / may pollute sea / easy to dispose of

**6**

**[12]**

**Q22.**

(a)     (i)      any **two** from:

*ignore any conclusion drawn referring to data below 7.5 nm or above 20 nm*

•        *100% of (type 1 and type 2) bacteria are killed with a particle size of 7.5 to 8.5 nm*

*accept nanoparticles in the range of 7.5 to 8.5 nm are most effective at killing (type 1 and type 2) bacteria*

•        *as the size increases (beyond 8.5 nm), nanoparticles are less effective at killing (type 1 and type 2) bacteria*

•        *type 1 shows a linear relationship* ***or*** *type 2 is non-linear*

•        type 1 bacteria more susceptible than type 2 (at all sizes of nanoparticles shown on the graph)

*allow type 2 bacteria are harder to kill*

**2**

(ii)     (yes) because you *could confirm the pattern that has been observed*

*allow would reduce the effect of anomalous points / random errors*

*allow would give better line of best fit*

*ignore references to reliability / precision / accuracy / reproducibility / repeatability / validity*

**or**

(no) because trend / *conclusion* is already clear

**1**

(b)     magnesium loses electron(s)

**1**

oxygen gains electron(s)

**1**

two electrons (per atom)

**1**

gives full outer shells (of electrons) **or** *eight electrons in highest energy level*

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

**1**

**or**

(electrostatic) attraction between ions **or** forms ionic bonds

*accept noble gas structure*

**[7]**

**Q23.**

(a)                        *reference to incorrect bonding* ***or*** *incorrect structure* ***or*** *incorrect particles = max* ***3***

giant structure / lattice

*ignore many bonds*

**1**

made up of positive ions surrounded by delocalized / free electrons

*allow positive ions surrounded by a sea of electons*

**1**

with strong bonds / attractions

*allow hard to break for strong*

**1**

so a lot of energy is needed to break these bonds / attractions / forces

*ignore high temperature*

*ignore heat*

**1**

(b)     (i)      that they are very small

**or**

1-100 nanometres **or** a few(hundred) atoms

*accept tiny / really small / a lot smaller / any indication of very small eg. microscopic, smaller than the eye can see*

*ignore incorrect numerical values if very small is given*

**1**

(ii)     delocalised / free electrons

*allow sea of electrons*

**1**

one non-bonded electron from each atom

*accept electron(s) moving through the structure / nanotube*

*allow electron(s) carry / form / pass current / charge*

**1**

**[7]**

**Q24.**

(a)      (i)     lead nitrate

*accept Pb(NO3)2*

*do* ***not*** *accept nitride*

**1**

sodium iodide / potassium iodide

*accept NaI / KI*

*accept other correct soluble iodides*

*do* ***not*** *accept sodium iodine / potassium iodine*

**1**

(ii)     filter / filtration / filtering

*accept decant / decanting etc.*

*accept centrifugation*

*ignore evaporation* ***or*** *heating if after filtration*

**1**

(b)     *metallic / sharing / covalent* ***or*** *molecule = max* ***3***

magnesium loses **2** electrons

*all three underlined ideas must be present*

*two underlined ideas =* ***1*** *mark*

*eg magnesium loses electrons*

***or***

*magnesium gains 2 electrons*

***or***

*magnesium loses 2 ions*

*nb magnesium* ***ion*** *loses 2 electrons =* ***1*** *mark*

*2 errors =* ***0*** *marks*

*eg magnesium gains electrons*

*all four underlined ideas must be present*

**2**

iodine gains **1 / an** electron

*three underlined ideas =* ***1*** *mark*

*eg iodine gains electron(s)*

***or***

*iodine loses 1 / an electron*

***or***

*iodine gains 1 / an ion*

***or***

*iodide (ion) gains 1 / an electron*

*2 errors =* ***0*** *marks*

**2**

(c)     any **two** from:

*mention of molecules / intermolecular / covalent / atoms = max* ***1***

•        forces (of attraction) / bonds are strong **or** lot of energy needed to break bonds

•        oppositely charged ions attract **or** electrostatic attraction between ions

•        giant structure **or** lattice

*allow many bonds*

*ignore ionic bonding unqualified*

**2**

**[9]**

**Q25.**

(a)     8 marks       Particularly well structured answer with most points mentioned.

          7-6 marks    Well structured answer. The two metals will have been  
compared rather than simply listing advantages/disadvantages. Most  
of the advantages and disadvantages of each metal have been mentioned.

          5-3 marks    Some structure to the answer.  An attempt to compare the metals  
by giving some advantages and disadvantages.

          2-1 marks    Little structure or attempt to compare.  Marks gained by listing a few advantages or disadvantages.

**Advantages of Nickel:**Relatively low cost which makes the sparking plugs cheaper to produce.  
Quite high melting point which is needed because the temperature in the  
engine is very high.  
Good conductor of electricity needed to carry electricity into combustion  
chamber to produce spark.

**Disadvantages of Nickel:**Subject to corrosion in engine which means they only last a short time  
*because nickel is higher in reactivity than platinum.*Idea that this leads to reduced efficiency, unburnt petrol and air pollution.

**Advantages of Platinum:**Less susceptible to corrosion (not corroded) because platinum is very low in reactivity.  
Idea that this improves efficiency and reduces pollution.-  
Higher melting point than nickel to withstand the high temperatures in the combustion chamber.  
Last a lot longer than nickel electrodes due to low reactivity.   
(Sensible extension here could be longer service intervals etc.)-  
Good conductor of electricity as for nickel.  
Extension here could be linked to the idea that the conductivity   
does not deteriorate as quickly as nickel.)

**Disadvantages of Platinum:**Cost *which will make the sparking plug more expensive.*A good candidate might justify cost by longer life, better fuel consumption and less pollution.

**8**

(b)     (i)      giant structure/lattice/regular arrangements of atoms

*any for 1 mark*

         of atoms/of ions (provided free electrons mentioned)

*either for 1 mark*

         delocalised or free electrons

*for 1 mark*

**3**

(ii)     electrons free/can move

*for 1 mark each*

**2**

**[13]**

**Q26.**

(a)     because sulfur dioxide causes acid rain

**1**

which kills fish / aquatic life **or** dissolves / damages statues / stonework **or** kills / stunts growth of trees

*if no other mark awarded then award 1 mark for sulfur dioxide is toxic or causes breathing difficulties.*

**1**

(b)     (i)      electrons are lost

**1**

(ii)     Cu2+ + 2e−→ Cu

*allow Cu2+→ Cu − 2e−*

*ignore state symbols*

**1**

(iii)    copper sulfate

*allow any ionic copper compound*

**1**

(c)     (lattice of) positive ions

**1**

delocalised electrons

*accept sea of electrons*

**1**

(electrostatic) attraction between the positive ions and the electrons

**1**

electrons can move through the metal / structure **or** can flow

*allow electrons can carry charge through the metal / structure*

*if wrong bonding named or described or attraction between oppositely charged ions then do not award M1 or M3 − MAX 2*

**1**

(d)     (copper compounds are absorbed / taken up by) plants

*allow crops*

**1**

which are burned

**1**

the ash contains the copper compounds

*do not award M3 if the ash contains copper (metal)*

**1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (e) | / Ar | 55.6 / 63.5 | 16.4 / 56 | 28.0 / 32 |
|  | moles | 0.876 | 0.293 | 0.875 |
|  | ratio | 3 | 1 | 3 |
|  | formula | Cu3FeS3 | | |

*award* ***4*** *marks for Cu3FeS3 with some correct working*

*award* ***3*** *marks for Cu3FeS3 with* ***no*** *working*

*if the answer is not Cu3FeS3 award up to* ***3*** *marks for correct steps from the table apply ecf*

*if the student has inverted the fractions award* ***3*** *marks for an answer of CuFe3S*

**4**

**[16]**

**Q27.**

(a)     (i)      giant lattice

*allow each carbon atom is joined to three others*

**1**

atoms in graphene are covalently bonded

*max.* ***2*** *marks if any reference to wrong type of bonding*

**1**

and covalent bonds are strong **or** need a lot of energy to be broken

*allow difficult to break*

**1**

(ii)     because graphene has delocalised electrons

*allow each carbon atom has one free electron*

**1**

which can move throughout the structure

*do* ***not*** *accept just electrons can move.*

**1**

(b)     because there are weak forces between molecules

*allow no bonds between the layers*

**1**

so layers / molecules can slip / slide.

**1**

**[7]**

**Q28.**

(a)     lattice / giant structure

*max* ***3*** *if incorrect structure or bonding or particles*

**1**

ionic **or** (contains) ions

**1**

Na+ **and** Cl-

*accept in words or dot and cross diagram: must include type and magnitude of charge for each ion*

**1**

electrostatic attraction

*allow attraction between opposite charges*

**1**

(b)     hydrogen

*allow H2*

**1**

sodium hydroxide

*allow NaOH*

**1**

(c)     any **one** from, eg:

•        people should have the right to choose

•        insufficient evidence of effect on individuals

•        individuals may need different amounts.

*allow too much could be harmful*

*ignore religious reasons*

*ignore cost*

*ignore reference to allergies*

**1**

(d)     (i)      one bonding pair of electrons

*accept dot, cross or e or − or any combination, eg  
*

**1**

6 unbonded electrons on each atom

**1**

(ii)     simple molecules

*max* ***2*** *if incorrect structure or bonding or particles*

*accept small molecules*

*accept simple / small molecular structure*

**1**

with intermolecular forces

*accept forces between molecules*

*must be no contradictory particles*

**1**

which are weak **or** which require little energy to overcome − must be linked to second marking point

*reference to weak covalent bonds negates second and third marking points*

**1**

(iii)    iodine has no delocalised / free / mobile electrons or ions

**1**

so cannot carry charge

*if no mark awarded iodine molecules have no charge gains* ***1*** *mark*

**1**

**[14]**

**Q29.**

(a)     line goes up before it goes down

**1**

energy given out correctly labelled

**1**

activation energy labelled correctly

**1**

(b)     electrostatic force of attraction between shared pair of negatively charged electrons

**1**

and both positively charged nuclei

**1**

(c)     bonds formed = 348 +4(412) + 2(276) = 2548 kJ / mol

**1**

bonds broken − bonds formed = 612 + 4(412) + (Br-Br) − 2548 = 95 kJ / mol

**1**

*Alternative approach without using C-H bonds*

*For step 1 allow = 348 + 2(276) = 900 kJ / mol*

*Then for step 2 allow 612 + (Br-Br) − 900 = 95 kJ / mol*

193 (kJ / mol)

**1**

*accept (+)193 (kJ / mol) with no working shown for* ***3*** *marks*

*−193(kJ / mol) scores* ***2*** *marks*

*allow ecf from step 1 and step 2*

(d)     **Level 3 (5–6 marks):**

A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links. A conclusion is reached.

**Level 2 (3–4 marks):**

An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. A conclusion may be reached but the logic used may not be clear or linked to bond energies.

**Level 1 (1–2 marks):**

Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.

**0 marks:**

No relevant content.

**Indicative content**

Size and strength

•        chlorine atoms have fewer electron energy levels/shells

•        chlorine atoms form stronger bonds

•        Cl–Cl bond stronger than Br–Br

•        C–Cl bond stronger than C–Br

Energies required

•        more energy required to break bonds with chlorine

•        more energy given out when making bonds with chlorine

•        overall energy change depends on sizes of energy changes

Conclusions

•        if C−Cl bond changes less, then less exothermic

•        if C−Cl bond changes more, then more exothermic

•        can’t tell how overall energy change will differ as do not know which changes more.

**6**

**[14]**