

General Marking Guidance

- **Acceptable Answers:** Mark schemes are prepared by subject specialists. They indicate the points required to gain marks. Alternative wording or symbols that express the same chemical meaning should be accepted.
 - **Bolding:** Bold chemical terms are key elements that must be present in the student's answer to score the mark.
 - **Error Carried Forward (ECF):** ECF applies to mathematical calculations. If a student makes an early arithmetic error, they lose that specific mark but can score full marks for subsequent steps that apply correct chemical calculations to their incorrect value.
 - **Reject Boxes:** These specify incorrect chemical concepts or terminology that negate the mark if included.
- Page 1 **Ignore:** Refers to details that are irrelevant and neither score nor penalise. Turn over →

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GCSE CHEMISTRY MARK SCHEME

Topic 1 Total: 16 Marks

Topic 1: Atomic Structure & Periodic Table

(a) Mendeleev vs Newlands [6 Marks]

- M1:** John Newlands arranged elements in order of increasing atomic weight and proposed the **law of octaves**, but this failed after calcium because elements in the same group had different properties [1].
- M2:** Mendeleev also arranged elements by atomic weight, but he swapped the order of some elements (e.g. tellurium and iodine) to ensure elements with **similar chemical properties** were placed in the same group [1].
- M3:** Mendeleev left **gaps** for elements that had not yet been discovered [1].
- M4:** Mendeleev used his table to **predict the properties** of these undiscovered elements [1].
- M5:** When these elements were discovered (e.g. gallium) and their properties matched Mendeleev's predictions, his periodic table was **accepted** by the scientific community [1].
- M6:** The later discovery of isotopes explained why ordering elements strictly by atomic weight was incorrect, validating Mendeleev's decision to swap elements [1].

Reject:

Any statement claiming Mendeleev ordered elements by atomic number.

(b) Chlorine relative atomic mass calculation [4 Marks]

- M1:** Calculates total mass contribution of isotopes: $(35 * 75.77) + (37 * 24.23)$ [1].
- M2:** Sums isotope contributions: $2651.95 + 896.51 = 3548.46$ [1].
- M3:** Divides by 100 to get relative atomic mass: **35.4846** [1].
- M4:** Correctly rounds to 2 decimal places: **35.48** [1].

Note:

An answer of 35.5 scores a maximum of 3 marks (for incorrect rounding).

(c) Electronic configuration of oxygen and sulfur [4 Marks]

- M1:** Oxygen electronic configuration is **2,6** [1].
- M2:** Sulfur electronic configuration is **2,8,6** [1].
- M3:** Both oxygen and sulfur have **6 electrons in their outer shell** [1].
- M4:** The group number in the periodic table corresponds to the number of outer-shell electrons, so both are placed in Group 6 [1].

(d) Modern periodic table arrangement [2 Marks]

- M1:** Ordered by increasing **atomic number / proton number** [1].
- M2:** Early tables were ordered by atomic weight because protons, neutrons, and electrons had not yet been discovered [1].

GCSE CHEMISTRY MARK SCHEME

Topic 2 Total: 22 Marks

Topic 2: Bonding, Structure & Properties

(a) Carbon dioxide dot-and-cross diagram [4 Marks]

- M1:** Carbon atom shares 4 electrons (needs double bonds on both sides) [1].
- M2:** Each Oxygen atom shares 2 electrons [1].
- M3:** Correct number of shared electrons in overlap regions (4 electrons in each overlap area, e.g. 2 dots and 2 crosses) [1].
- M4:** Non-bonding outer electrons shown correctly (4 non-bonding electrons on each oxygen atom; no non-bonding outer-shell electrons on the carbon atom) [1].

(b) Graphite vs Graphene comparison [6 Marks]

- M1:** Graphene is a **single layer of carbon atoms** arranged in hexagons, whereas graphite consists of many layers of graphene stacked together [1].
- M2:** In both structures, each carbon atom forms **three strong covalent bonds** with adjacent carbon atoms [1].
- M3:** Graphene is very strong because it has a continuous 2D network of strong covalent bonds which require a large amount of energy to break [1].
- M4:** Graphite is soft and slippery because its layers are held together by **weak intermolecular forces**, allowing layers to slide over each other easily [1].
- M5:** Because each carbon atom only uses three of its four outer electrons in bonding, each carbon has **one delocalized electron** [1].
- M6:** These delocalized electrons are free to move throughout the structure and **carry electrical charge** [1].

(c) Carbon dioxide properties [6 Marks]

- M1:** Carbon dioxide has a **simple molecular structure** [1].
- M2:** Covalent bonds within the molecules are strong [1].
- M3:** However, the intermolecular forces between individual molecules are **very weak** [1].
- M4:** Consequently, only a small amount of thermal energy is needed to overcome these weak intermolecular forces, giving a low boiling point [1].
- M5:** Carbon dioxide does not conduct electricity because it has **no free-moving charged particles** [1].
- M6:** All outer electrons are fixed in covalent bonds, so there are no free-moving ions or delocalized electrons [1].

Reject:

Any claim that covalent bonds break when carbon dioxide boils.

(d) Silicon dioxide vs Carbon dioxide [6 Marks]

- M1:** Carbon dioxide is simple molecular, whereas silicon dioxide is a **giant covalent structure** [1].
- M2:** In carbon dioxide, there are weak intermolecular forces. In silicon dioxide, there are no molecules, only a continuous 3D network of covalent bonds [1].
- M3:** In silicon dioxide, each silicon atom is bonded to four oxygen atoms, and each oxygen atom is bonded to two silicon atoms [1].

M4: Melting silicon dioxide requires breaking many **strong covalent bonds** throughout the giant lattice [1].

M5: Breaking these covalent bonds requires a **very large amount of energy** [1].

M6: Thus, silicon dioxide has a very high melting point, whereas carbon dioxide has a very low melting point because only weak intermolecular forces need to be overcome [1].

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Question 3 Mark Scheme (Total: 25 Marks)**(a) Limiting reactant & ammonia mass [8 Marks]**

M1: Calculates moles of N₂: Moles = $56.0 / 28 = 2.0 \text{ mol}$ [1].

M2: Calculates moles of H₂: Moles = $15.0 / 2 = 7.5 \text{ mol}$ [1].

M3: Uses stoichiometric ratio: 1 mole of N₂ reacts with 3 moles of H₂, so 2.0 mol N₂ requires **6.0 mol H₂** [1].

M4: States H₂ is in excess: Since 7.5 mol H₂ is present (which is greater than the required 6.0 mol), H₂ is in excess [1].

M5: Identifies limiting reactant: Nitrogen (N₂) is the **limiting reactant** [1].

M6: Relates limiting reactant moles to product moles: 1 mol N₂ produces 2 mol NH₃, so 2.0 mol N₂ produces **4.0 mol NH₃** [1].

M7: Calculates Mr of NH₃: Mr = $14 + (3 * 1) = 17$ [1].

M8: Calculates mass of NH₃: Mass = $4.0 * 17 = 68.0 \text{ g}$ (Accept 68 g) [1].

Note:

Award full marks for a final answer of 68.0 g with correct working. If limiting reactant logic is incorrect, apply ECF.

(b) Titration calculation [9 Marks]

M1: Converts volume of H₂SO₄ to dm³: $18.5 \text{ cm}^3 = 0.0185 \text{ dm}^3$ [1].

M2: Calculates moles of H₂SO₄: Moles = $0.125 * 0.0185 = 0.0023125 \text{ mol}$ [1].

M3: Relates stoichiometry: 1 mole H₂SO₄ reacts with 2 moles KOH, so moles of KOH = $0.0023125 * 2 = 0.004625 \text{ mol}$ [1].

M4: Converts volume of KOH to dm³: $25.0 \text{ cm}^3 = 0.0250 \text{ dm}^3$ [1].

M5: Calculates concentration of KOH in mol/dm³: Moles / Volume = $0.004625 / 0.0250 = 0.185 \text{ mol/dm}^3$ [1].

M6: Calculates the Mr of KOH: Mr = $39 + 16 + 1 = 56$ [1].

M7: Calculates concentration of KOH in g/dm³: $0.185 * 56 = 10.36 \text{ g/dm}^3$ [1].

M8: Rounds concentration in mol/dm³ to 3 significant figures: **0.185 mol/dm³** [1].

M9: Rounds concentration in g/dm³ to 3 significant figures: **10.4 g/dm³** [1].

(c) Percentage yield [3 Marks]

M1: States/uses formula: Percentage Yield = (Actual Yield / Theoretical Yield) * 100 [1].

M2: Substitutes values: $(51.0 / 68.0) * 100$ [1].

M3: Correct answer rounded to 3 significant figures: **75.0%** [1].

(d) Gas volume calculation [2 Marks]

M1: States/uses formula: Volume = Moles * 24.0 [1].

M2: Correct calculation and answer: $2.00 * 24.0 = 48.0 \text{ dm}^3$ (Accept 48 dm³) [1].

(e) Reasons for less than 100% yield [3 Marks]

M1: The reaction may be **reversible** and thus does not go to completion [1].

M2: Some product may be **lost during separation / transfer** (e.g. left on filter paper or in beaker) [1].

M3: Side reactions may occur or reactants may not be pure [1].

Question 4 Mark Scheme (Total: 23 Marks)**(a) Electrolysis of dilute H₂SO₄ [8 Marks]**

- M1:** Electrolyte contains **H⁺ and OH⁻ ions** from water, and **H⁺ and SO₄(2⁻) ions** from sulfuric acid [1].
- M2:** Cathode (Negative Electrode): Positive **H⁺ ions migrate to the cathode** [1].
- M3:** Hydrogen ions gain electrons (are reduced) to form hydrogen gas: **2H⁺ + 2e⁻ → H₂** [1].
- M4:** Anode (Positive Electrode): Negative **OH⁻ and SO₄(2⁻) ions migrate to the anode** [1].
- M5:** Hydroxide (OH⁻) ions are **preferentially discharged** because they are easier to oxidize than sulfate (SO₄(2⁻)) ions [1].
- M6:** Hydroxide ions lose electrons (are oxidized) to form oxygen gas and water: **4OH⁻ → O₂ + 2H₂O + 4e⁻** (Accept 4OH⁻ - 4e⁻ → O₂ + 2H₂O) [1].
- M7:** The volume of hydrogen gas produced is **double** the volume of oxygen gas produced [1].
- M8:** This is because discharging 4OH⁻ ions transfers 4 electrons, which reduces 4H⁺ ions to produce 2 molecules of H₂ for every 1 molecule of O₂ [1].

(b) Required Practical 3: Electrolysis of brine [6 Marks]

- M1:** Anode product: **Chlorine gas (Cl₂)** [1].
- M2:** Cathode product: **Hydrogen gas (H₂)** [1].
- M3:** Chlorine gas forms at the anode because chloride ions (Cl⁻) are halide ions, which are preferentially discharged over hydroxide ions [1].
- M4:** Hydrogen gas forms at the cathode because hydrogen ions (H⁺) are preferentially discharged over sodium ions (Na⁺) since hydrogen is less reactive than sodium [1].
- M5:** Sodium ions (Na⁺) and hydroxide ions (OH⁻) remain in the solution [1].
- M6:** The useful substance left in the solution is **sodium hydroxide (NaOH)** solution [1].

(c) Strong vs weak acid pH change log proof [6 Marks]

M1: The pH scale is logarithmic: each change of 1 pH unit represents a **10-fold change in hydrogen ion concentration [H⁺]** [1].

M2: The pH difference is: **5.00 - 2.00 = 3 units** [1].

M3: Difference in hydrogen ion concentration is: **10³ = 1000 times** [1].

M4: The hydrochloric acid solution has a hydrogen ion concentration 1000 times greater than that of the weak acid solution [1].

M5: A strong acid is **completely ionised / dissociated** in aqueous solution, releasing all its hydrogen ions [1].

M6: A weak acid is only **partially ionised / dissociated** in aqueous solution, so only a small percentage of its molecules release hydrogen ions [1].

(d) Required Practical 1: Salt preparation [3 Marks]

M1: Balanced equation: **CuO(s) + 2HCl(aq) → CuCl₂(aq) + H₂O(l)** [1].

M2: Filtration: Filter the reaction mixture to remove excess copper(II) oxide (black solid residue) to obtain a blue copper(II) chloride solution as the filtrate [1].

M3: Crystallisation: Heat the filtrate gently in an evaporating basin to evaporate water until the crystallisation point is reached, then leave to cool and crystallise, filter the crystals and pat dry [1].

Question 5 Mark Scheme (Total: 14 Marks)**(a) Energy profile diagram [6 Marks]**

- M1:** Draw reactants level higher than products level [1].
- M2:** Labeled reactants line ($\text{Mg} + 2\text{HCl}$) and products line ($\text{MgCl}_2 + \text{H}_2$) [1].
- M3:** Upward arrow from reactants level to peak of curve represents **activation energy (E_a)** [1].
- M4:** Downward arrow from reactants level to products level represents **overall energy change (ΔH)** [1].
- M5:** Exothermic because the products are at a lower energy level than the reactants [1].
- M6:** Overall energy is released to the surroundings / overall energy change is negative [1].

(b) Bond energy calculation [8 Marks]

- M1:** Identifies bonds broken: 1 H-H bond and 1 Cl-Cl bond [1].
- M2:** Calculates total energy to break bonds: $436 + 242 = 678 \text{ kJ/mol}$ [1].
- M3:** Identifies bonds made: 2 H-Cl bonds [1].
- M4:** Calculates total energy released in bond making: $2 * 431 = 862 \text{ kJ/mol}$ [1].
- M5:** Calculates overall energy change: energy to break - energy to make = $678 - 862 = -184 \text{ kJ/mol}$ [1].
- M6:** Obtains correct final value: **-184 kJ/mol** [1].
- M7:** States reaction is exothermic because overall energy change is negative [1].
- M8:** Explains that bond breaking is an **endothermic** process (requires energy) and bond making is an **exothermic** process (releases energy), and more energy is released than is required [1].

Reject:

Any unit other than kJ/mol or kJ.