# GCSE CHEMISTRY MARK SCHEME

**Total Marks: 100**
**Version 1.0**

Practice Paper 5 - Higher Tier (Unofficial)

## MARKING GUIDANCE

- **Mark Schemes** should be applied positively. Candidates must be rewarded for what they have shown they can do.
- All examiners should instruct candidates that their answers must be written in the spaces provided.
- Mark points are indicated by **[1]** in the text. Bold text shows the key chemical concepts or terms required for the mark.
- Where error carried forward **(ECF)** is allowed, this is explicitly indicated in the mark scheme with a green box.
- Answers that must be rejected are indicated in red boxes.



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# GCSE CHEMISTRY MARK SCHEME

**Topic 1 Total: 16 Marks**

Topic 1: Atomic Structure & the Periodic Table

## Question 1 Mark Scheme (Total: 16 Marks)

### (a) Comparison of transition metals and Group 1 metals [6 Marks]

**M1:** **Physical difference 1:** Transition metals have **higher densities** than Group 1 metals / Group 1 metals are low density (some float on water) [1].

**M2:** **Physical difference 2:** Transition metals have **higher melting points / boiling points** than Group 1 metals [1].

**M3:** **Chemical difference 1:** Transition metals are **much less reactive** than Group 1 metals (e.g. react slowly or not at all with water/oxygen) [1].

**M4:** **Chemical difference 2:** Transition metals can form **ions with different charges** (e.g. $Fe^{2+}$, $Fe^{3+}$), whereas Group 1 metals only form 1+ ions [1].

**M5:** **Chemical difference 3:** Transition metals form **coloured compounds**, whereas Group 1 metals form white/colourless compounds [1].

**M6:** **Industrial application:** Transition metals are used as **catalysts** in industrial processes (e.g. iron in the Haber process / nickel in margarine production) [1].

*(Note: Accept other valid properties, e.g. transition metals are harder/stronger. Max 6 marks, must include at least 2 physical, 2 chemical, and 1 industrial catalyst application).*

### (b) Electronic configurations [4 Marks]

#### (i) Iron configuration [2 Marks]

**M1:** Shell-by-shell configuration: **2, 8, 14, 2** [1].

**M2:** Accept subshell configuration: **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$** [1].

#### (ii) Zinc configuration [2 Marks]

**M1:** Shell-by-shell configuration: **2, 8, 18, 2** [1].

**M2:** Accept subshell configuration: **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$** [1].

## (c) Trends in Group 0 (Noble Gases) [6 Marks]

**M1:** **Boiling point increases** down the group [1].

**M2:** **Density increases** down the group [1].

**M3:** Atomic size / number of shells / number of electrons **increases** down the group [1].

**M4:** The **intermolecular forces** (attractive forces between atoms) become **stronger / increase** [1].

**M5:** For boiling point: **more energy is required** to overcome these stronger intermolecular forces during boiling [1].

**M6:** For density: the **mass of the atoms increases** significantly more than the increase in their atomic volume / spacing [1].



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# GCSE CHEMISTRY MARK SCHEME

**Topic 2 Total: 22 Marks**

Topic 2: Bonding, Structure & Properties

## Question 2 Mark Scheme (Total: 22 Marks)

### (a) Structure, bonding, and properties of carbon nanotubes [6 Marks]

**M1:** A carbon nanotube is a single layer of graphene / graphite sheet **rolled into a cylinder** [1].

**M2:** Each carbon atom is **covalently bonded to three other** carbon atoms in hexagonal rings [1].

**M3:** **Tensile strength explanation:** The covalent bonds are **very strong** [1].

**M4:** It requires a **large amount of energy** to break these strong covalent bonds, giving it high tensile strength [1].

**M5:** **Electrical conductivity explanation:** Each carbon atom has one **delocalised electron** [1].

**M6:** These delocalised electrons are **free to move** along the cylinder / structure and carry charge [1].

### (b) Structure of Fullerene C60 and comparative melting points [6 Marks]

**M1:** Fullerene C60 is a **simple molecular structure** consisting of hollow spherical cages containing 60 carbon atoms [1].

**M2:** The carbon atoms within the cage are bonded in hexagons and pentagons [1].

**M3:** Diamond is a **giant covalent structure** where each carbon atom is bonded to **four other** carbon atoms tetrahedrally [1].

**M4:** Melting Fullerene C60 requires overcoming **weak intermolecular forces** between the individual molecules [1].

**M5:** Melting diamond requires breaking **strong covalent bonds** between atoms throughout the structure [1].

**M6:** **Much less energy** is needed to overcome weak intermolecular forces in C60 than to break strong covalent bonds in diamond [1].

## (c) Technological uses of nanotubes and fullerenes [4 Marks]

### Carbon nanotubes [2 Marks]

**M1:** **Application:** reinforcing composites / sports equipment (e.g. tennis rackets, bicycle frames) OR electrical circuits/nanowires [1].

**M2:** **Property link:** High tensile strength and low density OR high electrical conductivity [1].

### Fullerenes [2 Marks]

**M1:** **Application:** targeted drug delivery inside the body OR industrial catalyst OR lubricants [1].

**M2:** **Property link:** Hollow cage structures can cage/trap drug molecules OR high surface area to volume ratio OR spherical shape allowing molecules to roll past each other [1].

## (d) Hardness of brass vs pure copper [6 Marks]

**M1:** Pure copper consists of a **regular arrangement of identical-sized** copper atoms [1].

**M2:** In pure copper, the layers of atoms can **easily slide over one another** when a force is applied (making it malleable) [1].

**M3:** Brass is an alloy that contains zinc atoms which have a **different size** than copper atoms [1].

**M4:** The introduction of different-sized zinc atoms **disrupts the regular arrangement / layers** of copper atoms [1].

**M5:** This disruption makes it **more difficult for the layers to slide** over each other [1].

**M6:** Therefore, brass is **harder / stronger / less malleable** than pure copper [1].

# GCSE CHEMISTRY MARK SCHEME

**Topic 3 Total: 25 Marks**

Topic 3: Quantitative Chemistry

## Question 3 Mark Scheme (Total: 25 Marks)

### (a) Visual observations for displacement [2 Marks]

Any two visual observations from:

- The **blue colour of the solution fades** / turns lighter blue / becomes colourless [1].
- A **red-brown / orange solid** (copper metal) deposits / precipitates on the bottom or on the metal surface [1].
- The magnesium ribbon **dissolves / disappears / gets smaller** [1].

**Reject:**

Bubbling / fizzing / gas production (this is a metal displacement, not an acid reaction).

### (b) Limiting reactant calculation and theoretical yield [6 Marks]

**M1:** Moles of Mg = 3.00 g / 24.3 g/mol = **0.1235 mol** [1].

**M2:** Molar mass of CuSO4 = 63.5 + 32.1 + (16.0 x 4) = 159.6 g/mol. Moles of CuSO4 = 16.0 g / 159.6 g/mol = **0.1003 mol** [1].

**M3:** From the balanced equation: the react ratio is 1:1, so we require equal moles of reactants [1].

**M4:** Since 0.1003 mol (CuSO4) is less than 0.1235 mol (Mg), **CuSO4 is the limiting reactant** [1].

**M5:** Theoretical moles of Cu produced = moles of limiting reactant = **0.1003 mol** [1].

**M6:** Theoretical mass of Cu = 0.1003 mol x 63.5 g/mol = **6.37 g** (must be written to 3 significant figures; accept 6.36 to 6.38 g) [1].

**Error Carried Forward (ECF):**

If the candidate incorrectly identifies magnesium as the limiting reactant (e.g. through a calculation error), they can score M5 and M6 by multiplying their calculated moles of magnesium by 63.5 to find the theoretical mass of Cu (e.g. 0.1235 x 63.5 = 7.84 g).



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# GCSE CHEMISTRY MARK SCHEME

Topic 3: Quantitative Chemistry

## (c) Titration concentration calculation [6 Marks]

**M1:** Moles of HCl used = volume (dm3) x conc = (22.4 / 1000) x 0.150 = **3.36 x 10^-3 mol** [1].

**M2:** According to the balanced equation: 1 mole of Na2CO3 reacts with 2 moles of HCl. Moles of Na2CO3 in 25.0 cm3 = 3.36 x 10^-3 / 2 = **1.68 x 10^-3 mol** [1].

**M3:** Concentration of Na2CO3 in mol/dm3 = moles / volume (dm3) = 1.68 x 10^-3 / (25.0 / 1000) = **0.0672 mol/dm3** [1].

**M4:** Molar mass (Mr) of Na2CO3 = (23.0 x 2) + 12.0 + (16.0 x 3) = **106.0 g/mol** [1].

**M5:** Concentration of Na2CO3 in g/dm3 = conc (mol/dm3) x Mr = 0.0672 x 106.0 = **7.12 g/dm3** (accept 7.12 to 7.13 g/dm3) [1].

**M6:** Standard of working: All steps are clearly presented and answers are rounded to **3 significant figures** [1].

> **Error Carried Forward (ECF):**
> Apply ECF throughout. If M1 or M2 is calculated incorrectly, M3 can be awarded if the method is correct. If M3 is incorrect, M5 can still be awarded if the incorrect concentration is correctly multiplied by the Mr of Na2CO3 (106.0) to give g/dm3.

## (d) Percentage yield [3 Marks]

**M1:** Formula: percentage yield = (actual yield / theoretical yield) x 100 [1].

**M2:** Calculation: (5.08 / 6.37) x 100 = **79.7%** (accept 79.6% to 79.8%) [1].

**M3:** Answer is rounded to **3 significant figures** [1].

> **Error Carried Forward (ECF):**
> If candidate calculated an incorrect theoretical yield in part (b), they can get full marks here if they use it correctly. For example, if they used 7.84 g (from Mg): (5.08 / 7.84) x 100 = 64.8%.

# GCSE CHEMISTRY MARK SCHEME

**Topic 3 Total: 25 Marks**

Topic 3: Quantitative Chemistry

## (e) Percentage uncertainty [2 Marks]

**M1:** Formula: percentage uncertainty = (uncertainty / measured volume) x 100 = (0.06 / 25.0) x 100 [1].

**M2:** Calculation: **0.24%** [1].

## (f) Atom economy calculation [6 Marks]

**M1:** Atom economy formula: (total Mr of desired product / total Mr of all reactants) x 100 [1].

**M2:** Mass of desired product (2NaCl): 2 x (23.0 + 35.5) = 2 x 58.5 = **117.0 g** [1].

**M3:** Mr of reactants: Na2CO3 = (23.0 x 2) + 12.0 + (16.0 x 3) = 106.0. 2HCl = 2 x (1.0 + 35.5) = 73.0 [1].

**M4:** Total mass of reactants = 106.0 + 73.0 = **179.0 g** [1]. *(Note: Accept total mass of products as they are equal due to conservation of mass: 2NaCl + H2O + CO2 = 117.0 + 18.0 + 44.0 = 179.0 g).*

**M5:** Calculation: (117.0 / 179.0) x 100 = **65.4%** (accept 65.36% to 65.4%) [1].

**M6:** Answer is rounded to **3 significant figures** [1].

# GCSE CHEMISTRY MARK SCHEME



Topic 4: Chemical Changes

## Question 4 Mark Scheme (Total: 23 Marks)

### (a) Electrolysis of aqueous copper(II) chloride [8 Marks]

#### (i) Anode half-equation [2 Marks]

**M1:** Correct formulas and balancing of chemical species: **2Cl- → Cl2 + 2e-** (or 2Cl- - 2e- → Cl2) [1].

**M2:** Correct state symbols: **2Cl-(aq) → Cl2(g) + 2e-** [1].

#### (ii) Cathode half-equation [2 Marks]

**M1:** Correct formulas and balancing: **Cu2+ + 2e- → Cu** [1].

**M2:** Correct state symbols: **Cu2+(aq) + 2e- → Cu(s)** [1].

#### (iii) Selective discharge explanation [4 Marks]

**M1:** At the cathode, both **Cu2+ and H+ ions** (from water) are attracted [1].

**M2:** Copper is **less reactive than hydrogen**, so Cu2+ ions are discharged / reduced in preference to H+ ions [1].

**M3:** At the anode, both **Cl- and OH- ions** (from water) are attracted [1].

**M4:** Chloride is a **halide ion and is in high concentration**, so Cl- ions are discharged / oxidised in preference to OH- ions [1].





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## (b) Strong vs weak acids and pH logarithmic proof [6 Marks]

### (i) Acid ionisation definitions [2 Marks]

**M1:** A strong acid is **completely dissociated / ionised** in aqueous solution [1].

**M2:** A weak acid is only **partially dissociated / ionised** in aqueous solution [1].

### (ii) pH logarithmic proof [4 Marks]

**M1:** The pH scale is logarithmic with base 10: **pH = -log10[H+]** [1].

**M2:** This relationship can be written as **[H+] = 10^(-pH)** [1].

**M3:** If the pH changes by 1.0 unit (e.g. from pH_A to pH_B, where pH_B = pH_A - 1), the concentration ratio is **10^(-(pH_A - 1)) / 10^(-pH_A)** [1].

**M4:** This simplifies to **10^1 = 10**, proving that a decrease of 1 unit in pH increases the hydrogen ion concentration by a **factor of ten / tenfold** [1].

# GCSE CHEMISTRY MARK SCHEME

**Topic 4 Total: 23 Marks**

Topic 4: Chemical Changes

## (c) Active copper electrolysis [9 Marks]

### (i) Explanation of mass changes at electrodes [5 Marks]

**M1:** **At the copper anode (+):** copper atoms lose electrons / are oxidised and dissolve as copper(II) ions (Cu2+), causing a **decrease in anode mass** [1].

**M2:** Anode oxidation reaction: **Cu(s) → Cu2+(aq) + 2e-** [1].

**M3:** **At the copper cathode (-):** copper(II) ions in solution gain electrons / are reduced and deposit as copper metal, causing an **increase in cathode mass** [1].

**M4:** Cathode reduction reaction: **Cu2+(aq) + 2e- → Cu(s)** [1].

**M5:** The **rate of dissolution of Cu at the anode is equal to the rate of deposition of Cu at the cathode**, meaning the concentration of Cu2+ in solution and the blue color remain constant [1].

### (ii) Ionic half-equations [4 Marks]

**M1:** Anode: **Cu → Cu2+ + 2e-** [1].

**M2:** Cathode: **Cu2+ + 2e- → Cu** [1].

**M3:** Correct state symbols for both: **Cu(s) → Cu2+(aq) + 2e-** and **Cu2+(aq) + 2e- → Cu(s)** [1].

**M4:** Correct charge balance and electron addition in both equations [1].

# GCSE CHEMISTRY MARK SCHEME

**Topic 5 Total: 14 Marks**

Topic 5: Energy Changes & Rates of Reaction

## Question 5 Mark Scheme (Total: 14 Marks)

### (a) Rate changes over time and collision theory [5 Marks]

**M1:** The rate of reaction is **fastest at the start** [1].

**M2:** This is because the concentration of reactant particles (acid) is at its highest, leading to the **highest frequency of successful collisions** [1].

**M3:** The rate of reaction **slows down over time** [1].

**M4:** This is because reactant particles are used up, decreasing the concentration, which leads to a **lower frequency of successful collisions** [1].

**M5:** The reaction **stops (rate becomes zero)** when one of the reactants (the limiting reactant, HCl) is completely used up (frequency of collisions is zero) [1].

### (b) Mean rate of reaction calculation [4 Marks]

**M1:** Volume of gas produced in first 20s = 38 cm3 - 0 cm3 = **38 cm3** [1].

**M2:** Equation: volume / time = 38 / 20 [1].

**M3:** Calculation: **1.9** [1].

**M4:** Correct units: **cm3/s** (or cm3 s-1) [1].

### (c) Alcohol combustion calorimeter discrepancies and improvements [3 Marks]

**M1:** **Reason for discrepancy:** Heat is **lost to the surroundings** (air, burner, thermometer) / incomplete combustion occurs (forming soot/CO instead of $CO_2$/$H_2O$) / some alcohol evaporates before combustion [1].

**Suggested improvements (Any two from):** [2 Marks, 1 mark for each modification]

- Use a **draft shield / wind screen** around the apparatus to reduce convection currents [1].
- Use a **lid** on the copper calorimeter to reduce evaporative/convective heat loss from water [1].
- **Minimise the distance** between the flame and the bottom of the calorimeter [1].
- Use a **bomb calorimeter** (insulated container with electrical ignition and pure oxygen supply) for precise measurement [1].

### (d) Balanced chemical equation for complete combustion of ethanol [2 Marks]

**M1:** Correct formulas for all reactants and products ($C_2H_5OH$, $O_2$, $CO_2$, $H_2O$) [1].

**M2:** Correct balancing of the equation: **$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$** [1].