GCSE CHEMISTRY

Practice Paper 1 - Master Mark Scheme (Unofficial)

Total Marks: 100
Version 1.0

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.
- **Ignore:** Refers to details that are irrelevant and neither score nor penalise.

GCSE CHEMISTRY MARK SCHEME

Topic 1 Total: 16 Marks

Topic 1: Atomic Structure & Bonding

Question 1 Mark Scheme (Total: 10 Marks)

(a) Alpha particle scattering simulation evidence [3 Marks]

M1: Most alpha particles (9,880) passing straight through shows that the atom is **mostly empty space** [1].

M2: A tiny fraction of alpha particles (2) bouncing back shows that the mass and positive charge is concentrated in a **tiny, dense center / nucleus** [1].

M3: The deflection of positive alpha particles (118) confirms that this nucleus has a **positive charge**, causing electrostatic repulsion [1].

> **Reject:**
>
> Any reference to electrons being inside the nucleus.

(b) Chadwick's discovery [2 Marks]

M1: **Neutron** [1].

M2: It has **no electrical charge / is neutral**, meaning it did not interact with or get deflected by electric or magnetic fields, making it difficult to detect [1].

> **Reject:**
>
> Vague statements that neutrons are inside the nucleus (as this does not explain the difficulty of detection).

(c) Electronic configurations [2 Marks]

A1: (i) Potassium atom (atomic number = 19): **2,8,8,1** [1].

A2: (ii) Chlorine atom (atomic number = 17): **2,8,7** [1].

(d) Potassium vs Sodium reactivity [3 Marks]

M1: Potassium has **more electron shells** / the outer electron in potassium is further from the nucleus [1].

M2: There is **weaker electrostatic attraction** between the nucleus and the outer electron in potassium / there is **more shielding** [1].

M3: Therefore, the outer electron is **lost more easily** in potassium than in sodium [1].

> **Reject:**
>
> Mention of gaining or sharing electrons. Mention of "stable octet" or "full outer shell" as the driving force.

Question 2 Mark Scheme (Total: 6 Marks)

(a) Sodium chloride electron transfer [4 Marks]

M1: Sodium atom (2,8,1) **loses its one outer electron** to form a sodium ion, Na+ (2,8) [1].

M2: Chlorine atom (2,8,7) **gains this one electron** to form a chloride ion, Cl- (2,8,8) [1].

M3: The reaction forms **oppositely charged ions**, which attract each other [1].

M4: These ions are held together in a **giant ionic lattice** by **strong electrostatic forces of attraction** [1].

> **Reject:**
>
> Any reference to sharing of electrons / covalent bonding.

(b) Sodium and chlorine equation [2 Marks]

M1: Correct formulas and balancing: **2Na + Cl2** → **2NaCl** (Accept Na + 1/2 Cl2 → NaCl) [1].

M2: Correct state symbols: **2Na(s) + Cl2(g)** → **2NaCl(s)** [1].

GCSE CHEMISTRY MARK SCHEME

Topic 2 Total: 22 Marks

Topic 2: Bonding & Properties

Question 3 Mark Scheme (Total: 8 Marks)

(a) Conductivity of Solid vs Aqueous Copper(II) Sulfate [3 Marks]

A1: Sample Y (aqueous copper(II) sulfate) conducts electricity, whereas Sample X (solid copper(II) sulfate) does not [1].

M1: In solid copper(II) sulfate (Sample X), the **ions are locked in fixed positions** in a giant ionic lattice and **cannot move** [1].

M2: In aqueous copper(II) sulfate (Sample Y), the lattice is broken and the **ions are free to move** and carry charge throughout the solution [1].

> **Reject:**
> Any reference to delocalized electrons carrying charge in copper(II) sulfate.

(b) (i) Cathode process [3 Marks]

M1: Positive copper ions (Cu2+) are **attracted to the negative electrode / cathode** [1].

M2: The copper ions **gain electrons / are reduced** to form copper atoms [1].

A1: Equation: **Cu2+ + 2e- → Cu** [1].

(b) (ii) Anode process [2 Marks]

M3: Hydroxide ions (OH-) from the water are **attracted to the positive electrode / anode**, where they **lose electrons / are oxidized** to form oxygen gas and water [1].

A2: Equation: **4OH- → O2 + 2H2O + 4e-** (Accept 4OH- - 4e- → O2 + 2H2O) [1].

> **Reject:**
> Sulfate ions are discharged (hydroxide ions are discharged preferentially).

Turn over →

GCSE CHEMISTRY MARK SCHEME

Topic 2 Total: 22 Marks

Topic 2: Bonding & Properties

Question 4 Mark Scheme (Total: 14 Marks)

(a) Diamond vs Graphite comparison [6 Marks]

> **Indicative Content:**
>
> - **Bonding Structure:** In diamond, each carbon atom is covalently bonded to four other carbon atoms in a **rigid tetrahedral lattice**. In graphite, each carbon atom is covalently bonded to three other carbon atoms in **flat hexagonal layers**.
> - **Delocalized Electrons:** In diamond, all four outer electrons are localized in covalent bonds; there are **no delocalized electrons**. In graphite, each carbon atom has **one delocalized electron** free to move between layers.
> - **Hardness:** Diamond is extremely hard because it has a continuous **3D network of strong covalent bonds** requiring high energy to break. Graphite is soft/slippery because layers are held by **weak intermolecular forces** allowing layers to slide.
> - **Electrical Conductivity:** Diamond is an insulator because there are no free ions or delocalized electrons to carry charge. Graphite is a conductor because its **delocalized electrons can flow** throughout the structure.

Level 3 (5-6 Marks): A detailed, coherent comparison covering all four aspects: bonding structure, presence of delocalized electrons, hardness, and electrical conductivity for both diamond and graphite. Clearly links structural features to the macro-properties.

Level 2 (3-4 Marks): Relevant structural features identified for both allotropes, with some explanation linking them to hardness and/or conductivity. May lack detail in orbital bonding descriptions.

Level 1 (1-2 Marks): Simple statements about the properties of diamond and graphite, lacking clear comparison or detailed structural explanation.

> **Reject:**
>
> Breaking covalent bonds when melting or sliding layers of graphite.
> Reference to molecules in diamond or graphite.

Turn over →

(b) Evaluation of Student's Claims for A, B, C [6 Marks]

M1: Substance A claim is **incorrect** [1].

M2: Metals have high melting points but they conduct electricity as both solids and liquids. Substance A does not conduct in either state, indicating it is a **giant covalent structure** [1].

M3: Substance B claim is **incorrect** [1].

M4: Simple molecular compounds have low melting points and do not conduct electricity in any state. Substance B has a high melting point and conducts electricity when liquid, indicating it is a **giant ionic lattice** [1].

M5: Substance C claim is **incorrect** [1].

M6: Giant covalent structures have extremely high melting and boiling points. Substance C has very low melting and boiling points and does not conduct, indicating it is a **simple molecular substance** [1].

(c) Nanoparticles [2 Marks]

M1: (i) Nanoparticles have a much **higher surface area to volume ratio** compared to the bulk material [1].

M2: (ii) Nanoparticles are small enough to **pass through skin cells / cell membranes** into the body, which could cause cellular damage / unknown long-term toxicity [1].

> **Reject:**
> Vague statements like "they are dangerous" or "they react too fast".

Question 5 Mark Scheme (Total: 12 Marks)

(a) Limiting reactant definition [1 Mark]

The reactant that is **completely used up / completely consumed** during the reaction (which limits the amount of product that can be formed) [1].

> **Reject:**
> "the reactant that runs out first" or "the reactant with the smaller mass" or "the reactant that reacts the fastest".

(b) Actual yield discrepancies [2 Marks]

M1 (Lower yield): **Loss of product** during physical transfer stages / filtration / washing [1].

M2 (Higher yield): The precipitate is still **wet / retains water** / was not dried completely (so the water adds to the measured mass) [1].

> **Reject:**
> "human error" or "spillage" without explaining that product is lost.
> "impure reactants" as an explanation for higher mass unless specifically linked to precipitation.

Turn over →

(c) Limiting Reactant Molar Proof & Theoretical Yield [5 Marks]

M1: Calculate starting moles of both reactants:

Moles of Fe2O3 = 24.0 / 160 = 0.150 mol
Moles of C = 5.40 / 12 = 0.450 mol [1]
(Both moles must be correct to award this mark)

M2: Determine stoichiometric ratio requirements:

According to the equation, 2 mol of Fe2O3 reacts with 3 mol of C (a 1:1.5 ratio). Therefore, 0.150 mol of Fe2O3 requires (0.150 x 1.5) = **0.225 mol of C** [1]. *(Alternatively, show that 0.450 mol of C requires 0.300 mol of Fe2O3)*

M3: Draw limiting reactant conclusion:

Since 0.450 mol of C is available and only 0.225 mol is required, carbon is in excess. This proves that **iron(III) oxide (Fe2O3) is the limiting reactant** [1].

M4: Determine moles of Fe product:

From the equation, 2 mol of Fe2O3 produces 4 mol of Fe (a 1:2 ratio). Therefore, moles of Fe produced = 0.150 mol x 2 = **0.300 mol** [1].

A1: Calculate theoretical yield mass:

Theoretical yield of Fe = 0.300 mol x 56 g/mol = 16.8 g [1].

Error Carried Forward (ECF) Policy:

- If the student calculates incorrect molar masses or incorrect moles in M1, award M2, M3, M4, and A1 as ECF based on their values, provided the chemical logic is mathematically correct.
- If a mathematical error in M2 leads to the wrong limiting reactant conclusion in M3, award M4 and A1 as ECF based on their identified limiting reactant.

Reject:

Selecting carbon as the limiting reactant simply because its starting mass (5.40 g) is smaller than the iron(III) oxide mass (24.0 g) without calculating moles.
Intermediate rounding to 1 significant figure that results in an incorrect final yield.

(d) Percentage Atom Economy Calculation [3 Marks]

M1: Calculate relative masses using balancing coefficients:

Total Mr of desired product (4Fe) = 4 x 56 = 224

Total Mr of all reactants ($2Fe_2O_3$ + 3C) = (2 x 160) + (3 x 12) = 320 + 36 = 356 [1]

(Both values must be correct to award this mark)

M2: Setup atom economy equation:

Percentage atom economy = (224 / 356) x 100 [1]

A1: Final answer rounded to 3 significant figures:

= 62.9% [1]

(Accept 62.92% or 63% only if it is clearly derived from correct work)

> **Error Carried Forward (ECF):**
>
> If incorrect total Mr values are calculated in M1, award M2 and A1 as ECF based on those values.

> **Reject:**
>
> Calculation of atom economy using single formula masses (e.g. Mr of Fe / (Mr of Fe_2O_3 + Mr of C)) which ignores the balancing coefficients from the equation.

(e) Aim of high atom economy [1 Mark]

To **minimise the production of waste** / make the process more **sustainable** / save money on raw materials / reduce the cost of waste disposal [1].

> **Reject:**
>
> "increases the percentage yield" or "makes the reaction faster" or "increases the rate of reaction".

Turn over →

Question 6 Mark Scheme (Total: 13 Marks)

(a) Molar gas volume conditions [2 Marks]

M1: **Temperature** (accept room temperature / 20 °C / 293 K) [1].

M2: **Pressure** (accept atmospheric pressure / 1 atm / 101.3 kPa) [1].

> **Reject:**
>
> "concentration" or "volume" or "amount of gas".

(b) Titration methodology [2 Marks]

(i) Purpose of rough titration [1 Mark]

To find the **approximate volume** of acid required to neutralise the alkali so that in subsequent runs the acid can be added dropwise near the end point [1].

> **Reject:**
>
> "to get the correct answer" or "to prevent errors".

(ii) Concordant titres definition [1 Mark]

Titres that are within **0.10 cm3** of each other, indicating that the experimental measurements are highly **precise / reproducible** [1].

> **Reject:**
>
> "results that are close" or "similar results" without specifying the concordancy range of 0.10 cm3.

(c) Unstructured Titration Calculation [6 Marks]

(Full marks awarded for the correct final answer of 3.20 g/dm3 even with minimal working)

M1: Calculate moles of sulfuric acid:

Volume of H2SO4 = 20.0 / 1000 = 0.0200 dm3

Moles of H2SO4 = 0.0200 dm3 x 0.0500 mol/dm3 = 0.00100 mol [1]

M2: Determine moles of sodium hydroxide:

Moles of NaOH = 0.00100 mol x 2 = 0.00200 mol [1]

(Based on the 1:2 stoichiometric ratio in the equation)

M3: Convert NaOH volume to dm3:

Volume of NaOH = 25.0 / 1000 = 0.0250 dm3 [1]

M4: Calculate concentration of NaOH in mol/dm3:

Concentration of NaOH = 0.00200 mol / 0.0250 dm3 = 0.0800 mol/dm3 [1]

M5: Calculate relative formula mass of NaOH:

Mr of NaOH = 23 + 16 + 1 = 40 [1]

A1: Calculate concentration of NaOH in g/dm3:

Concentration of NaOH = 0.0800 mol/dm3 x 40 g/mol = 3.20 g/dm3 [1]

(Accept 3.2 g/dm3 or 3.20 g/dm3. Final answer must be rounded to 3 significant figures)

Error Carried Forward (ECF):

- Full ECF applies at each step.
- If the student fails to use the 1:2 stoichiometric ratio (uses a 1:1 ratio instead, scoring 0 for M2), the moles of NaOH = 0.00100 mol. Concentration in mol/dm3 = 0.0400 mol/dm3. Final concentration in g/dm3 = 1.60 g/dm3. This incorrect pathway will score 5 marks out of 6 (losing only M2).

Reject:

Using the Mr of sulfuric acid (98) instead of sodium hydroxide (40) to convert the concentration.

Dividing the moles of NaOH by the volume of H2SO4 (20.0 cm3) in step M4.

Turn over →

(d) Magnesium Reacting with Acid Gas Volume [3 Marks]

M1: Calculate moles of Mg:

Moles of Mg = 0.243 g / 24.3 g/mol = 0.0100 mol [1]

M2: Determine moles of H_2 gas and calculate volume in dm3:

Moles of H_2 = 0.0100 mol (due to 1:1 stoichiometric ratio)

Volume of H_2 = 0.0100 mol x 24.0 dm3/mol = 0.240 dm3 [1]

A1: Convert volume to cm3:

Volume of H_2 = 0.240 dm3 x 1000 = 240 cm3 [1]

Error Carried Forward (ECF):

- If the student calculates incorrect moles of Mg in M1, allow ECF for M2 and A1.
- If the student uses the wrong stoichiometric ratio (e.g. 1:2, leading to 0.0200 mol of H_2 and 480 cm3 of H_2), award M1 and allow ECF for M2 and A1, scoring 2 marks out of 3.

Reject:

Giving the final answer in dm3 (0.240 dm3) instead of cm3.

Using the molar mass of magnesium chloride (95.3 g/mol) in any step.

Question 7 Mark Scheme (Total: 9 Marks)

(a) Extraction of Iron vs Aluminium [2 Marks]

M1: Carbon is **more reactive than iron**, so carbon can displace iron / reduce iron oxide [1].

M2: Carbon is **less reactive than aluminium**, so carbon cannot displace aluminium / reduce aluminium oxide [1].

(b) Zinc displacement reaction [3 Marks]

(i) Ionic equation [2 Marks]

M1: Correct species and balancing: **Zn + Cu2+ → Zn2+ + Cu** [1].

M2: Correct state symbols: **Zn(s) + Cu2+(aq) → Zn2+(aq) + Cu(s)** [1].

(ii) Oxidation species [1 Mark]

Zinc / Zn is oxidised because it **loses electrons** (to form Zn2+) [1].

> **Reject:**
>
> "zinc gains positive charge" without reference to electron loss.

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Topic 4 Total: 23 Marks

Topic 4: Chemical Changes

(c) Acid ionisation and pH logarithmic relationship [4 Marks]

(i) Strong vs Weak acid ionisation [2 Marks]

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

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

(ii) Base-10 pH logarithmic proof [2 Marks]

M1: Rearranging the relationship $\mathrm{pH} = -\log_{10}[\mathrm{H^+}]$ gives $\mathbf{[H^+] = 10^{-pH}}$ [1].

M2: Show the ratio relationship:

Let initial pH be pH_1 and new pH be $\mathrm{pH}_2 = \mathrm{pH}_1 - 1$.

$[\mathrm{H^+}]_2 / [\mathrm{H^+}]_1 = 10^{(-\mathrm{pH}_2)} / 10^{(-\mathrm{pH}_1)}$

$[\mathrm{H^+}]_2 / [\mathrm{H^+}]_1 = 10^{-(\mathrm{pH}_1 - 1)} / 10^{(-\mathrm{pH}_1)} = 10^{(-\mathrm{pH}_1 + 1)} / 10^{(-\mathrm{pH}_1)} = 10^1 = \mathbf{10}$ [1].

Therefore, decreasing the pH by 1 unit increases the hydrogen ion concentration by a factor of 10.

(Accept alternative logically complete mathematical proofs using logarithm rules)

Question 8 Mark Scheme (Total: 8 Marks)

(a) Warming the acid [1 Mark]

To **increase the rate of reaction** / make the reaction faster [1].

> **Reject:**
>
> "to start the reaction" or "to dissolve the copper oxide" on its own.

(b) Excess reactant details [2 Marks]

(i) Observation when copper oxide is in excess [1 Mark]

A **black solid remains** at the bottom of the beaker (that does not dissolve upon stirring) [1].

(ii) Purpose of excess reactant [1 Mark]

To ensure that **all of the sulfuric acid reacts / is completely neutralised** [1].

GCSE CHEMISTRY MARK SCHEME

Topic 4 Total: 23 Marks

Topic 4: Chemical Changes

(c) Crystallisation procedure [3 Marks]

M1: **Filter the mixture** (to remove the excess unreacted copper(II) oxide) [1].

M2: **Heat the filtrate / solution** in an evaporating basin to evaporate some of the water **until the crystallisation point is reached** [1].

> **Reject:**
> "heat to dryness" or "evaporate all the water".

M3: **Leave the solution to cool and crystallise**, then filter / decant the crystals and **pat them dry** (with filter paper / in a warm oven) [1].

(d) Discrepancies in actual vs theoretical yield [2 Marks]

Any two reasons from:

- Some product was **lost during transfer steps** (e.g. left on filter paper / beaker walls) [1].
- Some crystals **remained dissolved in the cold filtrate** and were not collected [1].
- Incomplete crystallisation occurred [1].
- The reaction did not go to 100% completion (e.g. if heating was insufficient) [1].

> **Reject:**
> Vague answers like "human error" or "spills".

Question 9 Mark Scheme (Total: 6 Marks)

(a) Cathode product and half-equation [2 Marks]

M1: **Hydrogen / H_2** (gas) [1].

A1: Equation: $2H^+(aq) + 2e^- \rightarrow H_2(g)$ (allow $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$) [1].

(b) Anode product details [4 Marks]

(i) Gas identified and preference explanation [2 Marks]

M1: **Chlorine / Cl_2** (gas) [1].

M2: **Chloride ions (Cl^-)** are discharged in preference to hydroxide ions (OH^-) because chloride is a halide ion / present in high concentration [1].

(ii) Chloride discharge half-equation [2 Marks]

M1: Correct formulas of reactant and product (Cl^- and Cl_2) [1].

M2: Correct balancing: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ (allow $2Cl^-(aq) - 2e^- \rightarrow Cl_2(g)$) [1].

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Topic 5 Total: 14 Marks

Topic 5: Energy Changes

Question 10 Mark Scheme (Total: 14 Marks)

(a) Activation energy definition [1 Mark]

The **minimum energy** that colliding particles must have in order to react / start a reaction [1].

(b) Exothermic dissolution explanation [2 Marks]

M1: **Exothermic** [1].

M2: Chemical energy is **transferred as thermal energy to the surroundings / water** (or energy is released to the surroundings) [1].

(c) Temperature change investigation design [2 Marks]

M1: Measure a fixed volume of water into a **polystyrene cup** (which acts as an insulator / reduces heat loss) [1].

M2: Record the initial temperature of the water, add a weighed mass of ammonium chloride, stir, and record the maximum or minimum temperature reached (to calculate the change) [1].

(d) Catalyst mechanism [2 Marks]

M1: A catalyst provides an **alternative reaction pathway** [1].

M2: This pathway has a **lower activation energy** (so more particles have enough energy to react when they collide) [1].

(e) Exothermic energy profile representation [3 Marks]

M1: **Reactants are drawn at a higher energy level than the products** [1].

M2: Activation energy is shown as a **vertical arrow pointing upwards** from the reactants level to the highest point / peak of the curve [1].

M3: Overall energy change is shown as a **vertical arrow pointing downwards** from the reactants level to the products level [1].

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Topic 5 Total: 14 Marks

Topic 5: Energy Changes

(f) Bond Energy Calculations [4 Marks]

(i) Reactants bond breaking energy [1 Mark]

Calculation: 436 + 242 = **678** (kJ/mol) [1].

(ii) Products bond making energy [1 Mark]

Calculation: 2 x 431 = **862** (kJ/mol) [1].

(iii) Overall energy change and reaction classification [2 Marks]

M1: Overall energy change = 678 - 862 = **-184** (kJ/mol) [1].

(Accept 184 kJ/mol released or -184 kJ/mol)

M2: **Exothermic**, because the overall energy change is negative / energy is released / more energy is released in bond-making than is absorbed in bond-breaking [1].

END OF MARK SCHEME