OCR A A-level exam review: Paper 1 2020-2023

Here is a breakdown of the challenging questions and topics highlighted by the examiners from OCR Paper 1 2020-2023. I have included a few similar questions from AQA.

Conceptual Understanding & Application

- **Distinguishing Between d-block and Transition Elements (2023, Q22a*):** Many candidates struggled to precisely define "d-block element" (often incorrectly referring to the "outermost electron" instead of the "highest energy" or "valence electron") and frequently omitted the crucial role of ions in the definition of a "transition element." While able candidates could provide correct electron configurations for zinc and scandium as d-block but not transition elements, common errors included incorrect configurations for copper and chromium atoms or their ions (e.g., retaining 4s electrons in ions).
- **Explaining Ionisation Energy Trends (2023, Q16b; 2022, Q18d):**
    - When explaining why the second ionisation energy of Strontium (Sr) is greater than its first, many candidates incorrectly discussed electron repulsion in the s-orbital instead of recognizing that the electron is being removed from a +1 ion. They also frequently used "atomic radius" instead of "ionic radius" when discussing the Sr+ ion.
    - Explaining why Beryllium (Be) has a higher first ionisation energy than Boron (B) was challenging. Few correctly identified that Be's electron is removed from an s-orbital while B's is from a p-orbital, linking this to the s-orbital being lower in energy and more shielded. Many incorrectly applied concepts like full subshells or electron pair repulsion.
    AQA Questions: Paper 1 Q 4.2, 2018
- **Enthalpy Changes - Qualitative Explanations (2021, Q16c(iv)):** Explaining the effect of ionic charge and radius on lattice enthalpy, enthalpy of hydration, and subsequently enthalpy of solution, proved difficult. Only a few could correctly describe how lattice and hydration enthalpies become more exothermic down a group and link this to the overall enthalpy of solution. Many candidates confused these concepts with trends in ionisation energy or electronegativity. The terminology used to describe exothermic changes (e.g., using "smaller" instead of "less exothermic") was also an issue.
- **Electrode Potentials and Equilibrium Shifts (2021, Q19b(ii); 2020, Q19b):**
    - Linking electrode potentials to predict equilibrium shifts was a key challenge. Many candidates failed to specify which redox system they were referring to or only mentioned one equilibrium shift without connecting it to a specific system.
    - Lower-achieving candidates in 2020 struggled to state that the direction of a redox reaction depends on the relative E° values.
    AQA Questions: Paper 1 Q11, 2020; Paper 1 Q8.4, 2022

- **Buffer Solutions - Formation and pH Changes (2023, Q20f; 2022, Q19b(i)):**
  - Explaining *why* a buffer solution forms when a weak acid is partially neutralised by a strong base was poorly answered. Very few correctly stated that it requires the formation of the conjugate base (salt) with some of the weak acid remaining in excess.
  - Explaining why the pH of a buffer solution does *not* change significantly upon the addition of a small amount of water was also challenging. Only the most able candidates correctly linked this to the ratio of [HA] to [A−] remaining essentially unchanged. Many resorted to general statements about buffers resisting pH change or water being neutral.
- **Understanding Neutrality and Kw (2023, Q20a(ii)):** Explaining why water is neutral even when Kw (and thus pH of neutrality) changes with temperature was difficult. Only a few candidates correctly stated that in neutral water, the concentration of hydrogen ions equals the concentration of hydroxide ions ([H+]=[OH−]). Many incorrectly assumed that a pH close to 7 automatically means neutral, regardless of temperature.

Calculations

- **Multi-step Calculation involving Stoichiometry, Percentage Purity, and Mass (2022, Q21c(i)):** This question, requiring calculation of the mass of limestone (impure calcium carbonate) needed to produce a certain mass of fertiliser, was found very difficult. Most errors involved incorrect stoichiometric ratios (e.g., dividing by 5 instead of multiplying) and incorrectly accounting for the 95.0% purity of the limestone (using 95/100 instead of 100/95).
- **Buffer pH and Ka Calculations (2023, Q20e(ii); 2022, Q19b(ii); 2021, Q22c; 2020, Q18c(ii)):**
  - Calculating the acid dissociation constant (Ka) for a buffer solution prepared by dissolving potassium hydroxide in butanoic acid (2023) was difficult. While many could find [H+] from pH and moles of KOH, a common error was failing to subtract the moles of KOH from the initial moles of HA to find the moles of HA remaining at equilibrium. Some incorrectly used [H+] as [HA] or attempted to use the weak acid dissociation expression ($[H+]^2/[HA]$).
  - In 2022, calculating the pH of a buffer formed by glycolic acid and KOH also saw many candidates struggle to determine the correct concentrations of the acid and conjugate base present in the buffer mixture, leading to common incorrect answers.
  - Similar issues arose in 2021 with calculating buffer pH, where many did not account for the final amount of weak acid after partial neutralisation, and lower-attaining candidates often defaulted to a simple weak acid pH calculation.
    AQA Questions: Paper 1 (all the following):Q 10.4, 2023; Qs 4.3 to 4.5, 2022; Q5.2, 2018

- **Rate Constant Determination from Experimental Data (2023, Q17*; 2022, Q16a(ii)):**
  - In 2023, determining reaction orders when more than one reactant concentration changed between experiments proved challenging. This often led to incorrect orders, particularly for [BrO3−] and [H+]. Omission of units for the rate constant was also frequent.
  - In 2022, while many could determine the second-order dependence for [NO], explaining the first-order dependence for [CO] (which required considering the [NO] order) was more difficult.
- **Enthalpy Calculations (Hess's Law, Q=mcΔT variations, Born-Haber Cycles):**
  - **Hess's Law (2023, Q18b; 2022, Q17b(ii)):** These consistently challenged students. Many failed to construct the correct enthalpy cycle or apply the correct stoichiometry (multipliers) and signs for the enthalpy changes involved.
    AQA Questions: Paper 1 Q 1.4, 2021
  - **Q=mcΔT variation (2022, Q17a(i)):** Calculating the maximum temperature reached in a reaction, given ΔH, was often incorrect. Errors included not using the stoichiometry to determine the energy released for the moles reacting, incorrect mass values (e.g., using mass of solute instead of solution, or not using density to find mass of solution), and unit errors (kJ vs J for specific heat capacity).
    AQA Questions: Paper 2 Q 8.2, 2023
  - **Born-Haber Cycle (2020, Q16d(ii), Q16d(iii)):** Common errors included forgetting to double values for atomisation or electron affinity where two moles of ions were formed, or not halving hydration enthalpies when appropriate.
    AQA Questions: Paper 1 Q 5, 2023
- **Kp and Kc Calculations (2021, Q20c; 2020, Q20b):**
  - For Kp (2021), some candidates did not successfully calculate equilibrium moles. Others made errors in calculating partial pressures (e.g., dividing mole fraction by total pressure) or missed stoichiometric powers in the Kp expression.
  - For Kc (2020), some did not use the correct change in concentration, and lower-attaining students often incorrectly included water in the Kc expression for reactions in aqueous solution.
  - *AQA Questions:* Paper 1 Q 5.2, 2021
- **Calculations from Graphs (Rates, Arrhenius, ΔG vs T):**
  - **Half-life from concentration-time graph (2020, Q20a(ii)):** While higher-achieving students could determine one half-life, very few could find a second successive half-life if the graph didn't clearly show it, though some correctly identified alternative half-lives from different starting concentrations.
  - **Initial rate from tangent and gradient (2020, Q20a(iii)):** Drawing an accurate tangent at t=0 and correctly calculating its gradient (including accounting for axis scales and powers of ten) was challenging.
  - **Activation Energy/Temperature from Arrhenius plot/equation (2021, Q21b(i), Q20b(iii)):** Errors included misreading scales (e.g., 10−3 on the 1/T axis), calculating gradients out of tolerance, or attempting complex rearrangements of the Arrhenius equation instead of directly using the provided graph to find values.

- **ΔG vs T graph (2023, Q18c(ii)):** While drawing a line of best fit was often done, accurately determining ΔS (from the gradient) and ΔH (from the y-intercept) or the temperature of feasibility (x-intercept) was harder. Errors included incorrect scale reading for the gradient, using very small triangles for gradient calculation, or not using the graphical intercepts and instead substituting values into the ΔG equation.

Interpretation of Experimental Procedures & Observations

- **Selective Precipitation and Complex Ion Formation (2022, Q1):** A multiple-choice question involving the addition of AgNO3(aq) followed by excess dilute NH3(aq) to a mixture of halide ions proved difficult. Only the most able candidates correctly identified that AgBr and AgI would remain as precipitates, as many incorrectly thought AgCl would remain despite it redissolving in dilute ammonia.
- **Titration Colour Change (2023, Q21a(i)):** Stating the correct colour change at the end-point of a redox titration (e.g., KMnO4) was surprisingly challenging, with many inverting the colours or suggesting incorrect ones.
- **Redox Steps in an Experimental Method (2023, Q21b):** Explaining the chemical reasons for specific steps in an analytical procedure involving redox reactions was difficult. For instance, very few students could link the cooling and filtration of excess zinc (Step 2) to zinc's ability to also reduce manganate(VII) ions, thus necessitating its removal before titration. Many focused on physical changes like crystallisation rather than the redox chemistry.
- **Unfamiliar Reactions and Stoichiometry (2023, Q20c(ii), Q22d; 2022, Q21c(ii)):**
  - Predicting and explaining why reacting 1.00g of strontium carbonate and 1.00g of calcium carbonate with excess nitric acid would produce *different* volumes of gas proved hard. Few linked this to the different molar masses of the carbonates, leading to different numbers of moles for the same mass, and thus different moles (and volumes) of gas produced. Many digressed into reactivity or solubility arguments.
  - Constructing a balanced equation for an unfamiliar redox reaction (e.g., $Cr_2O_7^{2-}$ with Vanadium(III) ions in 2023, or the reaction of the mineral Huntite with HCl in 2022) was very challenging, even when the products were given. Balancing, often requiring half-equations or oxidation number methods, was a hurdle.
- **Rates of Reaction - Observations for Relative Reactivity (2022, Q21a(i)):** Suggesting *two distinct observations* that would indicate one Group 2 metal is more reactive than another (e.g., with dilute acid) was not well answered. Many responses focused on the quantity of gas produced rather than the *rate* of gas production or other indicators of reaction speed.

Specific Chemical Knowledge

- **Transition Metal Chemistry (Level of Response Questions, Equations, Stereoisomers):**
  - Identifying unknown transition metal compounds and writing correct equations for their reactions was a feature of challenging Level of Response questions (e.g., 2020, Q22a).
    AQA Questions: Paper 1 Q 4.7, 2021
  - Understanding and drawing stereoisomers (optical and cis-trans) of complex ions, and writing equations for ligand substitution, differentiated candidates (e.g., 2021, Q17b(ii); 2022, Q22a(ii)). Correctly identifying the empirical formula of a complex ion also proved tricky (2022, Q22a(ii)).
  - *AQA Questions:* Paper 1 Qs 9.5 and 9.6, 2021; Q 1.7, 2023
  - Recalling colours of complex ions or precipitates was often necessary but not always accurately done (e.g., 2023, Q22b(ii)).
- **Group 17 Chemistry (State Symbols, Explaining Reactivity) (2020, Q16d(i), Q21a):**
  - A simple point like the correct state symbol for Bromine ($Br_2(l)$) was missed by many.
  - Explaining halogen reactivity trends in terms of the ability to gain electrons, supported by ionic equations, was challenging for lower-attainers. Some confused colours of halogens with halide ions or linked electron gain to ionisation energy instead of electron affinity.
- **Formulae of Unfamiliar Compounds (e.g., manganese oxides, minerals):**
  - Multiple choice questions requiring the determination of an empirical formula from reacting masses (e.g., manganese oxide, 2023, Q2) were challenging.
  - Writing a balanced equation for the reaction of an unfamiliar mineral like Huntite ($Mg_3Ca(CO_3)_4$) with acid (2022, Q21c(ii)) required careful deduction of product formulae and balancing, which few managed perfectly.
- **Redox Reactions of Copper (2022, Q22c):** Identifying products and writing balanced equations for various reactions of copper and its compounds, including its reaction with concentrated sulfuric acid (which produces SO_2, not hydrogen) and the formation of copper(I) iodide, was difficult for many. Incorrect formulae (e.g., CuI_2 for copper(I) iodide) were common, and many did not attempt to assign changes in oxidation states.