

Mark scheme – Qualitative Analysis

Question	Answer/Indicative content	Marks	Guidance
1	<p><i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i></p> <p>Level 3 (5–6 marks) The candidate gives a clear description of all three tests with correct observations. AND Equations are mostly correct. AND Some fine detail included in answer.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) The candidate describes all three tests with correct observations.</p> <p>OR</p> <p>Describes two tests with a few omissions. AND Includes at least one correct equation.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence</i></p> <p>Level 1 (1–2 marks) The candidate attempts to describe two tests and observations, but explanations are incomplete. OR Gives a thorough description and explanation of one of the tests and attempts one equation.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>	<p>6 (AO1.2×2) (AO2.7×2) (AO3.4×2)</p>	<p>Indicative scientific points</p> <p><u>Tests for anions</u></p> <p><i>Carbonate test:</i></p> <p>Add HNO₃(aq)/HCl(aq)/H₂SO₄(aq)/H⁺(aq) fizzing/ forms CO₂(g) → Carbonate identified</p> <p><i>Sulfate test:</i></p> <p>Add Ba(NO₃)₂(aq) OR BaCl₂(aq) White precipitate → Sulfate identified</p> <p><i>Bromide test</i></p> <p>Add AgNO₃(aq) Cream precipitate → Bromide identified</p> <p><u>Equations (ionic or full)</u></p> <p>IGNORE state symbols (even if wrong)</p> <p><i>Carbonate</i></p> <p>2H⁺ + CO₃²⁻ → CO₂ + H₂O OR 2H⁺ + NiCO₃ → Ni²⁺ + CO₂ + H₂O OR 2HNO₃ + NiCO₃ → Ni(NO₃)₂ + H₂O + CO₂ OR 2HCl + NiCO₃ → NiCl₂ + H₂O + CO₂ OR H₂SO₄ + NiCO₃ → NiSO₄ + H₂O + CO₂</p> <p><i>Sulfate</i></p> <p>Ba²⁺ + SO₄²⁻ → BaSO₄ OR Ba(NO₃)₂ + NiSO₄ → BaSO₄ + Ni(NO₃)₂ OR BaCl₂ + NiSO₄ → BaSO₄ + NiCl₂</p> <p><i>Bromide</i></p> <p>Ag⁺ + Br⁻ → AgBr OR 2AgNO₃ + NiBr₂ → 2AgBr + Ni(NO₃)₂</p> <p><u>Fine Detail (NOT inclusive)</u></p> <p><i>Sequence of tests on samples</i></p> <p>Carbonate → Sulfate → Bromide</p> <p><i>Solubility of AgBr</i></p> <p>Soluble in concentrated ammonia</p>

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					<p>State symbols in ionic or full equations e.g.</p> <ul style="list-style-type: none"> $2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ OR $2\text{H}^+(\text{aq}) + \text{NiCO}_3(\text{s}) \rightarrow \text{Ni}^{2+}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$ $\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \rightarrow \text{AgBr}(\text{s})$ <p>Examiner's Comments</p> <p>* Very few candidates managed to score full marks for this question. Even the highest-attaining candidates struggled with writing balanced chemical equations. The most successful candidates used ionic equations with state symbols in their responses. A large proportion of candidates gave unnecessary details such as testing for CO_2 using limewater or the colours of other silver halide precipitates. The best responses broken down their response to cover each test in turn, giving clear and concise details for each.</p>
			Total	6	
2			<p>Test for Br^- (anion) 2 marks</p> <p><i>Reagent AND observation</i> Silver nitrate/AgNO_3 AND cream (precipitate) ✓</p> <p><i>Equation</i> $\text{Ag}^+ + \text{Br}^- \rightarrow \text{AgBr}$ ✓ <i>State symbols not required</i></p>	5 AO3.3×5	<p>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc. MUST BE USED</p> <p>-----</p> <p>IGNORE confusion between cation and anion IGNORE nitric acid ALLOW 'bromine' for bromide in text</p> <p>IGNORE responses about solubility in NH_3</p> <p>ALLOW full equation: e.g. $\text{AgNO}_3 + \text{NH}_4\text{Br} \rightarrow \text{AgBr} + \text{NH}_4\text{NO}_3$</p> <p>-----</p> <p>ALLOW displacement by Cl_2</p> <p><i>Reagent</i> Cl_2/chlorine</p> <p>AND</p> <p><i>Observation</i> Orange (solution) ✓ ALLOW shade of orange DO NOT ALLOW precipitate</p>

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			<p>-----</p> <p>Test for NH₄⁺ (cation) 3 marks</p> <p><i>Reagent and conditions</i> (Heat with) NaOH/KOH/Ca(OH)₂/OH⁻/hydroxide BUT NOT ammonia ✓</p> <p><i>Observation (Independent mark)</i> pH/indicator paper turns blue / purple / alkaline ✓</p> <p><i>Equation</i> NH₄⁺ + OH⁻ → NH₃ + H₂O ✓ <i>State symbols not required</i></p>	<p><i>Equation</i> 2Br⁻ + Cl₂ → Br₂ + 2Cl⁻ ✓ ALLOW full equation, e.g. 2NaBr + Cl₂ → Br₂ + 2NaCl</p> <p>-----</p> <p>ALLOW full equation: i.e. NH₄Br + NaOH → NaBr + NH₃ + H₂O</p> <p>ALLOW NH₄Br + NaOH → NaBr + NH₄OH</p> <p>Examiner's Comments</p> <p>This question was best discriminator of the paper and rewarded the well-prepared candidates who were competent in writing equations. Most candidates were given the 2 marks for the bromide test with silver nitrate and the related equation (usually shown ionically). Many found the test for the ammonium ion more challenging to describe. The alkaline nature of ammonia was well-known and the indicator colour change to blue was often seen. Many candidates omitted the NaOH reagent and tested the compound with indicator, thinking that the ammonium ion itself is alkaline. Few candidates were able to write the equation for the ammonium test. Lower attaining students often outlined electrolysis as a test and many candidates wrote about the carbonate and sulfate tests prior to the halide test.</p>
		Total	5	
3	i	<p>Barium chloride does not conduct electricity when solid AND because it has ions which are fixed (in position / in lattice) ✓</p> <p>Barium chloride conducts when in aqueous solution AND because it has mobile ions ✓</p>	2	<p>IGNORE use of 'free' instead of 'mobile' ALLOW ions are not free to move ALLOW ions are held (in position / in lattice) ALLOW ions are not mobile IGNORE charge carriers DO NOT ALLOW electrons moving ALLOW one mark for comparison that does not identify (s) and (aq).</p> <p>Examiner's Comments</p> <p>Many precise answers gained full marks by</p>

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					describing the fixed position of ions in a lattice and the mobility of ions in aqueous solution. Delocalised or free electrons were occasionally mentioned. Vague answers often used the terms 'free' instead of mobile, 'charge carrier' instead of ion and 'carry a charge' instead of conduct electricity.
		ii	<p>Test for sulfate / SO_4^{2-} ✓</p> <p><u>White</u> precipitate forms (when barium chloride solution is mixed with a solution containing sulfate ions) ✓</p>	2	<p>IGNORE hydrochloric acid</p> <p>ALLOW white solid</p> <p>IGNORE cloudy</p> <p>DO NOT ALLOW test result linked to incorrect anion</p> <p>Examiner's Comments</p> <p>There was some confusion with the displacement reactions of halogens, the test for halide ions and the use of silver nitrate but the majority of students could recall the use of aqueous barium chloride to test for sulfate ions. Occasionally candidates described the use of dilute hydrochloric acid to remove carbonate ions from solution before their creditworthy description of the sulfate test.</p>
		iii	<p>FIRST CHECK THE ANSWER ON THE ANSWER LINE</p> <p>IF answer = 2 award 2 marks</p> <p>$M(\text{BaCl}_2) = ((137.3 + (35.5 \times 2)) = \underline{208.3} \text{ (g mol}^{-1}\text{)} ✓$</p> <p>$244.3 - 208.3 = 36$</p> <p>AND</p> <p>$36/18 = 2 ✓$</p>	2	<p>ALLOW 208 (g mol⁻¹)</p> <p>ALLOW ECF for incorrectly calculated molar mass provided the final answer is rounded to nearest whole number</p> <p>Examiner's Comments</p> <p>Very well answered, the majority of candidates scored full marks for this simple calculation.</p>
			Total	6	
4		i	Silver nitrate OR $\text{AgNO}_3 ✓$	1	<p>ALLOW Ag^+</p> <p>IF name correct, IGNORE an incorrect formula</p> <p>IGNORE acidified/HNO_3</p>

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					<p>Examiner's Comments</p> <p>Most candidates responded correctly with either the name of the reagent: silver nitrate, or its formula: AgNO₃.</p>
		ii	<p>Chloride: white (precipitate) AND Bromide: cream (precipitate) AND iodide: yellow (precipitate) ✓</p>	1	<p>All three required for the mark</p> <p>Examiner's Comments</p> <p>The colours of the silver halide precipitates were well known and very few candidates failed to score here. Where mistakes were made, it was to put the three colours in the wrong order or to show the colours of halogens in solution.</p>
			Total	2	
5		i	<p>(1s²) 2s² 2p⁶ 3s² 3p⁶ 3d¹⁰ 4s² 4p⁶ ✓</p>	1	<p>ALLOW ... 4s² 3d¹⁰4p⁶ ALLOW subscripts AND 3D IGNORE 1s² seen twice</p> <p>Examiner's Comments</p> <p>Most candidates were awarded the mark available for the electron configuration of the bromide ion, but weaker responses included the electronic configuration of a bromine atom or of the ion, Br⁺.</p>
		ii	<p>Cream AND precipitate ✓</p>	1	<p>ALLOW solid OR ppt for precipitate IGNORE 'does not dissolve' OR 'partially dissolves'</p> <p>Examiner's Comments</p> <p>Many candidates focused exclusively in their answers on the solubility of silver bromide in aqueous ammonia, writing as a result that the precipitate would remain, or that it would not dissolve and so not gaining the mark by omitting the colour of the precipitate.</p>
		iii	<p>Ag⁺(aq) + Br⁻(aq) → AgBr(s) ✓</p>	1	<p>Equation AND state symbols required</p> <p>Examiner's Comments</p> <p>The majority of candidates answered this question successfully with the only recurring error made being to omit some or all of the state symbols.</p>
			Total	3	

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6	i	$\text{NaClO} + 2\text{HCl} \rightarrow \text{NaCl} + \text{Cl}_2 + \text{H}_2\text{O}$ correct formulae of reactants, NaCl and chlorine (1) water and balancing (1)	2	allow $\text{NaClO}_3 + 6\text{HCl} \rightarrow \text{NaCl} + 3\text{Cl}_2 + 3\text{H}_2\text{O}$ for 1 mark
	ii	Test: add (a few drops of aqueous) silver nitrate (1) Result: white ppt (1)	2	ignore addition of dilute nitric acid before the AgNO_3 ignore redissolving in excess NH_3 or darkening of the ppt
	iii	separating funnel (1)	1	allow dropping pipette
		Total	5	
7	i	$\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}$ OR $\text{Ag}^+ + \text{Br}^- \rightarrow \text{AgBr}$ OR $\text{Ag}^+ + \text{I}^- \rightarrow \text{AgI}$	1	
	ii	Bond enthalpy decreases $\text{C}-\text{C} > \text{C}-\text{Br} > \text{C}-\text{I}$	1	allow chlorine–carbon bonds are strongest.
	iii	Heat the test tubes in a water bath.	1	
		Total	3	