# Mark scheme – Qualitative Analysis

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | | | *Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question*.<br><br>**Level 3 (5–6 marks)**<br>The candidate gives a clear description of all three tests with correct observations.<br>**AND**<br>Equations are mostly correct.<br>**AND**<br>Some fine detail included in answer.<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated*.<br><br>**Level 2 (3–4 marks)**<br>The candidate describes all three tests with correct observations.<br><br>**OR**<br><br>Describes two tests with a few omissions.<br>**AND**<br>Includes at least one correct equation.<br><br>*There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence*<br><br>**Level 1 (1–2 marks)**<br>The candidate attempts to describe two tests and observations, but explanations are incomplete.<br>**OR**<br>Gives a thorough description and explanation of one of the tests and attempts one equation.<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant*.<br><br>**0 marks**<br>*No response or no response worthy of credit*. | 6<br>(AO1.2×2)<br>(AO2.7×2)<br>(AO3.4×2) | **Indicative scientific points**<br><u>Tests for anions</u><br>*Carbonate test*:<br><br>Add $HNO_3(aq)/HCl(aq)/H_2SO_4(aq)/H^+(aq)$<br>fizzing/ forms $CO_2(g)$ → Carbonate identified<br><br>*Sulfate test*:<br><br>Add $Ba(NO_3)_2(aq)$ **OR** $BaCl_2(aq)$<br>White precipitate → Sulfate identified<br><br>*Bromide test*<br><br>Add $AgNO_3(aq)$<br>Cream precipitate → Bromide identified<br><br>**<u>Equations (ionic or full)</u>**<br><br>**IGNORE** state symbols (even if wrong)<br><br>*Carbonate*<br><br>$2H^+ + CO_3^{2-} \rightarrow CO_2 + H_2O$<br>**OR** $2H^+ + NiCO_3 \rightarrow Ni^{2+} + CO_2 + H_2O$<br>**OR** $2HNO_3 + NiCO_3 \rightarrow Ni(NO_3)_2 + H_2O + CO_2$<br>**OR** $2HCl + NiCO_3 \rightarrow NiCl_2 + H_2O + CO_2$<br>**OR** $H_2SO_4 + NiCO_3 \rightarrow NiSO_4 + H_2O + CO_2$<br><br>*Sulfate*<br><br>$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$<br>**OR** $Ba(NO_3)_2 + NiSO_4 \rightarrow BaSO_4 + Ni(NO_3)_2$<br>**OR** $BaCl_2 + NiSO_4 \rightarrow BaSO_4 + NiCl_2$<br><br>*Bromide*<br><br>$Ag^+ + Br^- \rightarrow AgBr$<br>**OR** $2AgNO_3 + NiBr_2 \rightarrow 2AgBr + Ni(NO_3)_2$<br><br>**<u>Fine Detail (NOT inclusive)</u>**<br>*Sequence of tests on samples*<br><br>Carbonate → Sulfate → Bromide<br><br>*Solubility of AgBr*<br><br>Soluble in concentrated ammonia |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | *State symbols in ionic or full equations e,g.*<br>• $2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$ **OR** $2H^+(aq) + NiCO_3(s) \rightarrow Ni^{2+}(aq) + CO_2(g) + H_2O(l)$<br>• $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$<br>• $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$<br>**Examiner's Comments**<br>* 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. |
| | | | **Total** | **6** | |
| 2 | | | **Test for $Br^-$ (anion)** **2 marks**<br>*Reagent **AND** observation*<br>Silver nitrate/$AgNO_3$ **AND** cream (precipitate) ✓<br>*Equation*<br>$Ag^+ + Br^- \rightarrow AgBr$ ✓<br>*State symbols not required* | 5<br>AO3.3×5 | FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc. MUST BE USED<br>---<br>**IGNORE** confusion between cation and anion<br>**IGNORE** nitric acid<br>**ALLOW** 'bromine' for bromide in text<br>**IGNORE** responses about solubility in $NH_3$<br>**ALLOW** full equation:<br>e.g. $AgNO_3 + NH_4Br \rightarrow AgBr + NH_4NO_3$<br>---<br>**ALLOW displacement by $Cl_2$**<br>*Reagent* $Cl_2$/chlorine<br>**AND**<br>*Observation* Orange (solution) ✓<br>**ALLOW** shade of orange<br>**DO NOT ALLOW** precipitate |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | *Equation* $2Br^- + Cl_2 \rightarrow Br_2 + 2Cl^-$ ✓<br>**ALLOW** full equation, e.g. $2NaBr + Cl_2 \rightarrow Br_2 + 2NaCl$ |
| | | | ---------- | | ---------- |
| | | | **Test for $NH_4^+$ (cation)** **3 marks** | | |
| | | | *Reagent and conditions*<br>(Heat with) NaOH/KOH/$Ca(OH)_2$/$OH^-$/hydroxide<br>**BUT NOT** ammonia ✓<br>*Observation (Independent mark)*<br>pH/indicator paper turns blue / purple / alkaline ✓<br>*Equation*<br>$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ ✓<br>*State symbols not required* | | **ALLOW** full equation:<br>i.e. $NH_4Br + NaOH \rightarrow NaBr + NH_3 + H_2O$<br><br>**ALLOW** $NH_4Br + NaOH \rightarrow NaBr + NH_4OH$<br><br>**Examiner's Comments**<br><br>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. |
| | | | **Total** | **5** | |
| 3 | | i | Barium chloride does not conduct electricity when solid<br>**AND**<br>because it has ions which are fixed (in position / in lattice) ✓<br><br>Barium chloride conducts when in aqueous solution<br>**AND**<br>because it has mobile ions ✓ | **2** | **IGNORE** use of 'free' instead of 'mobile'<br>**ALLOW** ions are not free to move<br>**ALLOW ions** are held (in position / in lattice)<br>**ALLOW ions** are not mobile<br>**IGNORE** charge carriers<br>**DO NOT ALLOW** electrons moving<br>**ALLOW** one mark for comparison that does not identify (s) and (aq).<br><br>**Examiner's Comments**<br><br>Many precise answers gained full marks by |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 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 | Test for sulfate / $SO_4^{2-}$ ✓<br>White precipitate forms (when barium chloride solution is mixed with a solution containing sulfate ions) ✓ | **2** | **IGNORE** hydrochloric acid<br><br>**ALLOW** white solid<br>**IGNORE** cloudy<br>**DO NOT ALLOW** test result linked to incorrect anion<br><br>**Examiner's Comments**<br><br>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. |
| | | iii | **FIRST CHECK THE ANSWER ON THE ANSWER LINE**<br>**IF** answer = 2 award 2 marks<br><br>$M(BaCl_2)$ = ((137.3 + (35.5 × 2)) = 208.3 ($g\ mol^{-1}$) ✓<br><br>244.3 - 208.3 = 36<br>**AND**<br>36/18 = 2 ✓ | **2** | **ALLOW** 208 ($g\ mol^{-1}$)<br><br>**ALLOW ECF** for incorrectly calculated molar mass provided the final answer is rounded to nearest whole number<br><br>**Examiner's Comments**<br><br>Very well answered, the majority of candidates scored full marks for this simple calculation. |
| | | | **Total** | **6** | |
| 4 | | i | Silver nitrate **OR** $AgNO_3$ ✓ | 1 | **ALLOW** $Ag^+$<br>**IF** name correct, **IGNORE** an incorrect formula<br><br>**IGNORE** acidified/$HNO_3$ |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | **Examiner's Comments**<br><br>Most candidates responded correctly with either the name of the reagent: silver nitrate, or its formula: $AgNO_3$. |
| | | ii | Chloride: white (precipitate)<br>**AND** Bromide: cream (precipitate)<br>**AND** iodide: yellow (precipitate) ✓ | 1 | All **three** required for the mark<br><br>**Examiner's Comments**<br><br>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. |
| | | | **Total** | **2** | |
| 5 | | i | $(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$ ✓ | 1 | **ALLOW** … $4s^2\ 3d^{10}4p^6$<br>**ALLOW** subscripts **AND** 3D<br>**IGNORE** $1s^2$ seen twice<br><br>**Examiner's Comments**<br><br>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, $Br^+$. |
| | | ii | Cream **AND** precipitate ✓ | 1 | **ALLOW** solid **OR** ppt for precipitate<br>**IGNORE** 'does not dissolve' OR 'partially dissolves'<br><br>**Examiner's Comments**<br><br>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. |
| | | iii | $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ ✓ | 1 | Equation **AND** state symbols required<br><br>**Examiner's Comments**<br><br>The majority of candidates answered this question successfully with the only recurring error made being to omit some or all of the state symbols. |
| | | | **Total** | **3** | |

| | | | | | |
|---|---|---|---|---|---|
| 6 | | i | $NaClO + 2HCl \rightarrow NaCl + Cl_2 + H_2O$<br><br>correct formulae of reactants, NaCl and chlorine (1)<br>water and balancing (1) | 2 | **allow** $NaClO_3 + 6HCl \rightarrow NaCl + 3Cl_2 + 3H_2O$ for 1 mark |
| | | ii | Test: add (a few drops of aqueous) silver nitrate (1)<br><br>Result: white ppt (1) | 2 | **ignore** addition of dilute nitric acid before the $AgNO_3$<br><br>**ignore** redissolving in excess $NH_3$ or darkening of the ppt |
| | | iii | separating funnel (1) | 1 | **allow** dropping pipette |
| | | | **Total** | **5** | |
| 7 | | i | $Ag^+ + Cl^- \rightarrow AgCl$<br>**OR**<br>$Ag^+ + Br^- \rightarrow AgBr$<br>**OR**<br>$Ag^+ + I^- \rightarrow AgI$ | 1 | |
| | | ii | Bond enthalpy decreases C−Cl > C−Br > C−I | 1 | **allow** chlorine–carbon bonds are strongest. |
| | | iii | Heat the test tubes in a water bath. | 1 | |
| | | | **Total** | **3** | |