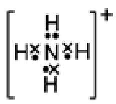
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			**B**	1	**Examiner's Comments** This question was answered well with most candidates correctly selecting the sequence shown in B.
			Total	**1**	
2			**D**	1	**Examiner's Comments** The correct answer was D. Many candidates were able to identify the green precipitate as $Fe(OH)_2$ and the white precipitate as $BaSO_4$. A few candidates suggested C, identifying $BaCl_2$ as the white precipitate, or B, identifying $Cu(OH)_2$ as the green precipitate.
			Total	**1**	
3		i	(Ammonia has) weaker hydrogen bonds (than ice/water) ✓ N has **one** lone pair **AND** O has **two** **OR** N less electronegative than O ✓	2	**ORA** but assume 'it' refers to ammonia Answer must be comparative between hydrogen bonding in ammonia and ice **ALLOW** Ammonia has less hydrogen bonds **ALLOW** response in terms of energy required to break hydrogen bonds e.g. less energy needed to break hydrogen bonds (in ammonia) **DO NOT ALLOW** reference to breaking N-H and O-H bonds i.e. covalent bonds **IGNORE** reference to other intermolecular forces e.g. London forces, dipole-dipole interactions. **ALLOW** ammonia has **one** lone pair **AND** water/ice has **two** **Examiner's Comments** Despite being told in the question that

					ammonia contains hydrogen bonds, many gave responses in terms of ammonia having either London forces and permanent dipole-dipole forces which are weaker than hydrogen bonds. For example, ‘ammonia consists of permanent dipole-dipole interactions which are weaker than hydrogen bonding in ice’ and ‘NH_3 has 17 electrons and H_2O has 18 electrons. Due to NH_3 having fewer electrons, there are fewer London forces’. Lower-scoring candidates often confused hydrogen bonds and covalent bonds, consistent with what was seen in 1(b)(i). For example, ‘O-H bond is stronger than N-H bond’ and ‘more energy needed to break O-H bonds rather than N-H bonds’. Some of these candidates did score a mark for recognising that N is less electronegative than O. For others they understood that ammonia has weaker hydrogen bonds but then struggled to give a reason either in terms of lone pairs or electronegativity.
		ii	 **Bonded pairs** Electron pairs in 3 x N-H covalent bonds shown correctly using dots and crosses ✓ **Dative bond** shown with two crosses or two dots ✓	2	**ALLOW** shell circles **IGNORE** inner shell in N **Charge and brackets not required** **DO NOT ALLOW** additional electrons on either N or H for dative bond mark **<u>Examiner’s Comments</u>** Less than half of the candidates scored both marks. Most candidates drew 4 x N-H shared covalent bonds and therefore lost the dative bond mark. Some added an additional electron to either N or H. Some drew an additional shaped electron (e.g. using a triangle) on one of the bonding pairs, obviously not realising that both electrons in dative bond originate from N, so have the same symbol.

					Many diagrams were unclear making it hard distinguish between dots and crosses especially if adding circles for electron shells. A few lower-attaining candidates attempted to draw an ionic dot-cross diagrams.
		iii	**Reagent and conditions** (Heat with) hydroxide ✓ **Observation *(Independent mark)*** pH/litmus/indicator paper turns blue/purple ✓	2	**ALLOW** NaOH/KOH/$Ca(OH)_2$/OH^- **DO NOT ALLOW** Ammonium hydroxide OR ammonia **__Examiner's Comments__** Higher-attaining candidates often gave a very detailed responses with all stages, including warming the NaOH, use of damp litmus paper and some included an ionic equation. Quite a few lost a mark as they missed the addition of hydroxide, just warmed, but they still gained mark for testing with indicator paper. Some thought that the indicator paper would turn red or be bleached and a few gave incorrect ion test e.g. add silver nitrate, add acid. Over a third of candidates did not score on this question, with a significant proportion not even attempting it.
			Total	**6**	
4		i	$[\ Cu(NH_3)4(H_2O)_2\ ]^{2+}$ ✓ **TAKE CARE** with correct brackets, numbers and 2+ charge	1 (AO 2.4)	**ALLOW** +2 for charge **IGNORE** $[Cu(NH_3)_4]^{2+}$ H_2O and NH3 can be in either order, i.e. $[\ Cu(H_2O)_2(NH_3)_4\ ]^{2+}$ **__Examiner's Comments__** This reaction of copper(II) ions with aqueous ammonia and the formula of the complex ion formed are part of the specification. Within this novel context, the molar mass had been provided as a clue. Less than half the candidates correctly gave the correct formula and it was noticeable how well this part

					discriminated across abilities. This was another example of many candidates being unable to apply their knowledge and understanding to a novel context.
		ii	**Formula of precipitate** $Cu(OH)_2$ ✓ **IGNORE** name: copper(II) hydroxide -- **Formula of gas** ;NH_3 ✓ **IGNORE** name: ammonia -- **Test for ammonia** Available only from a reasonable attempt for identifying the gas as NH_3, e.g. NH_4, NH_4+, NH_2, ammonia, ammonium (Moist/damp) indicator/litmus (paper) turns blue ✓ Moist/damp **NOT** required. Initial colour of litmus **NOT** required but *blue* is **CON**	3 (AO 2.3 ×3)	ALLOW $Cu(OH)_2(H_2O)_4$ **ALLOW** charges on Cu **AND** OH e.g. $Cu^{2+}(OH^-)_2$ ✓ **DO NOT ALLOW** unbalanced charges. e.g. $Cu(OH^-)_2$ ✗ -- **DO NOT ALLOW** correct test for NH_3 based on incorrect ID of the gas **NO ECF** for a test on the wrong gas (has to be test for NH_3) **DO NOT ALLOW** bleaches indicator **CON** **<u>Examiner's Comments</u>** Addition of NaOH(aq) to the Tutton's salt results in two reactions: precipitation of copper(II) hydroxide and a reaction of an ammonium ion, used to show its presence as a qualitative test. As with Question 4 (c) (i), this part discriminated very well with many candidates able to be rewarded with some of the marks. The formula of copper(II) hydroxide, as $Cu(OH)_2$ or $Cu(OH)_2(H_2O)_2$ were both acceptable. This was correct more often than the responses related to the ammonium ion. The formula of the gas formed in the reaction of NaOH(aq) with the ammonium ion caused problems, with NH_3 and its subsequent test with moist indicator turning blue seen much less than the reaction of Cu^{2+}(aq) ions. Hydrogen (the 'squeaky pop test) and oxygen (relighting a glowing split) were common incorrect responses. This was another question in which referring back to the formula of the

					Tutton's salt would have revealed important clues.
		iii	**Reagent** $BaCl_2$ / barium chloride (solution) **OR** $Ba(NO_3)_2$ / barium nitrate (solution) **OR** Ba^{2+} (solution/aq) / barium ions ✓ **Observation** **white** precipitate/ppt ✓ Only available from soluble Ba^{2+} reagent **ALLOW** minor slips in formula of Ba^{2+} reagent, e.g. BaCl, $BaNO_3$	2 (AO 2.3 ×2)	**ALLOW** $Ba(OH)_2$ or other **soluble** Ba^{2+} compounds --- **IGNORE** test for other anions provided they do **NOT** interfere with SO_4^{2-} test **e.g.** **IGNORE** addition of HCl/HNO_3/**H^+** **BUT DO NOT ALLOW** H_2SO_4 *Interferes with SO_4^{2-} test* **IGNORE** Ag^+/$AgNO_3$ **after** SO_4^{2-} test **DO NOT ALLOW before** SO_4^{2-} test **IGNORE** bubbling any gas through limewater **IGNORE** responses linked to CrO_4^{2-} *Not in Tutton's salt that student prepares* **<u>Examiner's Comments</u>** Th final part of Question 4 required candidates to identify the anion in the Tutton's salt as sulfate, and to recall that Ba^{2+} ions is used for the sulfate test to form a white precipitate. Any soluble barium compound was credited with barium chloride and nitrate being the commonest seen. As with earlier parts, this part discriminated very well. Most candidates who knew that barium ions were needed also collected the mark for the white precipitate observation. Over half the candidates did not score here, the most common errors being to repeat the test for the ammonium ion, or to use silver nitrate, clear confusion with the halide test.
			Total	**6**	
5			**D**	1 (AO 2.3)	**<u>Examiner's Comments</u>** Most candidates answered this

					correctly with D. Errors came from candidates not realising HCl provided Cl^- ions that would react with $AgNO_3$ and therefore they did not recognise the formation of the white precipitate.
			Total	**1**	
6		i	$Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$ Balanced equation ✓ State symbols ✓	2 (AO 2.5 x 2)	**ALLOW** ionic equation $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **M2 dependent on M1** **IGNORE** NaCl balanced on both sides **<u>Examiner's Comments</u>** Less than half the candidates gained credit for this challenging question. There was lots of information to process. Many struggled to give the correct formula for the products, e.g. $NaNO_3$, Ba_2SO_4, or had issues with balancing. Some tried to involve the NaCl in the reaction, either recognising that it didn't react (acceptable on the mark scheme) or forming barium chloride or even Cl_2. Lots of candidates lost the mark for state symbols as they left $Ba(NO_3)_2$ as (s), not recognising that in step 1 the mixture was dissolved in water so should now be (aq).
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 26.6 % award 4 marks** -- *n*($BaSO_4$) $= \frac{3.28}{233.4}$ **OR** 0.014053… (mol) ✓ mass $Ba(NO_3)_2$ = 0.014053… × 261.3 **OR** 3.672…….(g) ✓ mass Na*Cl* = 5.00 – 3.672.. **OR** 1.3279… (g) ✓ % Na*Cl* $= \frac{1.3279 \times 100}{5.00}$ = 26.6(%) **3 SF** ✓	4 (AO 3.1 ×3) (AO 3.2)	**ALLOW ECF** from incorrect equation in 2(b)(i) and throughout **ALLOW 3SF** up to calculated value throughout **IGNORE** rounding errors past **3SF** *Calculator:* 0.01405312768 *Calculator:* 3.672082262 *Calculator:* 1.327917738 **ALLOW ECF** for use of calculated mass NaCl e.g. 0.014053…x 58.5 = 0.8221…. to give final % 16.4 to 3SF -- **Alternative approach for last 2**

					marks % $Ba(NO_3)_2$ = $\frac{3.672 \times 100}{5.00}$ = 73.44 … ✓ % NaC*l* = 100 – 73.44 = 26.6 % ✓ **Examiner's Comments** This was a tricky calculation, made more challenging if candidates hadn't been able to successfully complete (i). Many were able to calculate the moles of $BaSO_4$ but often rounded their answer to only 2 significant figures at this stage i.e. 0.014. Many assumed a direct ratio between $BaSO_4$ and NaCl so mass was found by multiplying moles by 58.5 (molar mass for NaCl) - if this was done then credit was given for ECF for the final marking point. OCR support The M1 section of the Mathematical Skills handbook contains useful information on handling data, including M1.1 use of significant figures.
		iii	Silver chloride/AgC*l* would be produced (as a precipitate) ✓ (Mass of NaC*l*) can be calculated from the mass/moles of AgC*l* ✓	2 (AO 3.4 × 2)	**ALLOW** Chloride reacts to give (white) ppt **IGNORE** incorrect formula of silver chloride **ALLOW** equation showing formation of AgCl(s) **ALLOW** Weigh AgC*l* and use to calculate %/mass/moles **Examiner's Comments** Another tricky question with less than half gaining credit. Many were able to recognise the addition of silver nitrate as the test for halide ions but did not realise that it could be used quantitatively. Many didn't read the question carefully and assumed Na_2SO_4 was still present, giving a mixture of two precipitates. Some, despite recognising the formation of AgCl, could not then see how to

					calculate the mass of NaCl i.e. "you won't have formation of $BaSO_4$". Some suggested that barium nitrate would also form a precipitate, perhaps confused by the (s) state symbol in the question.
			Total	**8**	
7			**Identification of halide** Add (aqueous) silver nitrate **OR** $AgNO_3$ **OR** Ag^+/silver ions ✓ **Observations - mark independently** Chloride/Cl^- gives white precipitate Bromide/Br^- gives cream precipitate Iodide/I^- gives yellow precipitate ✓ **Precipitate/solid seen at least once** **Equation for at least one halide** e.g. $Ag^+ + Cl^- \rightarrow AgCl$ **ALLOW** $Ag^+ + X^- \rightarrow AgX$ ✓ ***IGNORE*** *state symbols (ppt already assessed)* **Identification of B and C** **B**: NaBr **OR** sodium bromide ✓ **C**: $CaCl_2$ **OR** calcium chloride ✓	5 (AO3.3×3 AO3.2×2)	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **IGNORE** addition of HNO_3 but HCl **CONs** $AgNO_3$ **IGNORE** references to solubility in NH_3 (dil or conc), even if incorrect **ALLOW** chlorine for chloride, etc **ALLOW** equation with Br^- **OR** I^- e.g. $Ag^+ + Br^- \rightarrow AgBr$ **ALLOW** full/partial equations, e.g. $AgNO_3 + Cl^- \rightarrow AgCl + NO_3^-$ **ALLOW** explanation for identification: i.e. **B (Group 1):** Subtract molar/atomic mass of halide/Br from number in range 100–115/molar mass of B ✓ **C (Group 2):** Subtract **2** × molar/atomic mass of halide/Cl from number in range 100–115/molar mass of **C** ✓ **ALLOW** displacement by addition of halogen ✓ 2 correct colours in water or organic solvent ✓ Equation, e.g. $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓ **<u>Examiner's Comments</u>** Candidates generally answered the first part of this question well. Most candidates were able to identify silver nitrate (or a halogen displacement method), to describe the expected observations, supported with mainly correct ionic equations. Candidates found it much harder to identify B and C as NaBr and $CaCl_2$. They could do this in various ways by matching possible formula with the provided molar mass ranges. The mark scheme did allow marks to be given when candidates described the identification process, although this

					was often very muddled, so, only the most able few candidates fully identified the unknown B and C.
			Total	**5**	
8		i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.53(g) award 5 marks** **--** **[H^+]** = $10^{-13.12}$ **OR** 7.58..... × 10^{-14} (mol dm^{-3}) ✓ $[OH^-] = \frac{1 \times 10^{-14}}{7.58........ \times 10^{-14}}$ **OR** 0.1318 .... (mol dm^{-3}) ✓ $n(OH^-)$ in 250 cm^3 = $\frac{0.1318.....}{4}$ **OR** 0.0329...... (mol) ✓ $n(Ba(OH)_2)$ or $n(BaO)$ = $\frac{0.0329.......}{2}$ **OR** 0.0164….. (mol) ✓ **Mass of BaO** = 0.0164..... × 153.3 = 2.53 (g) **3SF** ✓	5 (AO2.4×5)	**ALLOW ECF and 3SF throughout.** **ALLOW** calculation process in any order. **IGNORE** rounding errors past **3SF** **---** Calculator: 7.58577575 × 10^{-14} Calculator: 0.1318256739 **ALLOW** alternative approach using pOH for first 2 marks. p[OH^-] = 14 − 13.12 = 0.88 [OH^-] = $10^{-0.88}$ = 0.1318….. Calculator: 0.03295641846 0.033(0) comes from [OH^-] = 0.132 Calculator: 0.01647820923 Calculator: 2.526109475 **Common errors 4 marks** 5.05g Not dividing by 2 2.82g Use of M_r for $Ba(OH)_2$ 5.06g rounds to 0.132 in M2 then not dividing by 2 **3 marks** 5.65g not dividing by 2 and using Mr for $Ba(OH)_2$ **<u>Examiner's Comments</u>** Although few candidates got the correct final answer, however almost all achieved some marks from this calculation through error carried forward, with marks spread across the available range. Almost all candidates were able to find the concentrations of

					hydrogen and hence hydroxide ions. A few candidates successfully used p[OH⁻] method. Most were able to calculate the moles of hydroxide ions in 250cm^3. Many then did not realise the need to half this number to find the moles of barium, and/or used the Mr for barium hydroxide instead of barium oxide.
		ii	$Ba^{2+}(aq) + 2H^+(aq) + SO_4^{2-}(aq) + 2OH^-(aq)$ $\rightarrow BaSO_4(s) + 2H_2O(l)$✓	1 (AO3.2)	**ALLOW** multiples **ALLOW** $H^+(aq) + OH^-(aq) \rightarrow H2O(l)$ **OR** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **<u>Examiner's Comments</u>** This question was answered well, with many candidates giving one of the equations in the 'ALLOW' part of the mark scheme. Those candidates who did not gain this mark gave full equations or missed out state symbols.
			Total	**6**	
9			**D**	1(AO2.7)	**<u>Examiner's Comments</u>** This question proved to be difficult, with only the most able candidates selecting the correct answer of D. A was often given as an incorrect answer as candidates recognised that AgCl would be the only halide precipitate to show a change with dilute ammonia but did not realise that as it would redissolve, it would be the only one not in the filtrate.
			Total	**1**	
10		i	Any value in range: 8–14 ✓	1 (AO1.1)	**<u>Examiner's Comments</u>** Most candidates gained this mark. The most common incorrect response was pH 7 with a few giving a pH value of less than 7.
		ii	White precipitate/white solid ✓ $BaSO_4$ ✓	2 (AO 3.1) (AO 3.2)	**<u>Examiner's Comments</u>**

					Most candidates were able to give the formula of the barium compound as $BaSO_4$. However, they did not recognise that this would cause a white ppt to be seen, presumably as not in the context of qualitative ions testing. Many candidates said they would see bubbling/fizzing. Some gave a colour change as they were possibly considering what would be seen if an indicator is present. Others mentioned a precipitate but with no colour given. Some candidates gave the incorrect formula, such as Ba_2SO_4 or $Ba(SO_4)_2$, again showing the importance of practising writing formulae. In addition, some candidates wrote out the whole equation for the reaction. **OCR support** We have produced a topic support pack to assist with learning about the reaction of group 2 elements and their compounds: http:/www.ocr.org.uk/Images/364103-chemistry-of-group2.docx
			Total	**3**	