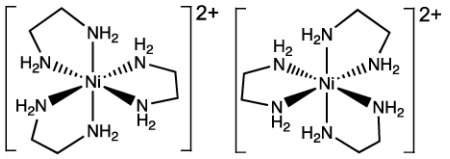
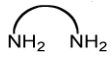
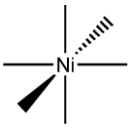
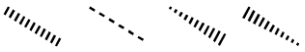
Mark scheme – Qualitative Analysis (MCQ)

Question			Answer/Indicative content	Marks	Guidance
1	a		$n(H_2O)$ = 27.55/18.0 = 1.5306 (mol) ✓ $n((NH_4)_2Fe(SO_4)_2)$ = 72.45/284.0 = 0.2551 (mol) ✓ whole number ratio of $(NH_4)_2Fe(SO_4)2$: H_2O = 0.2551 : 1.5306 = 1 : 6 **OR** x = 6 ✓	3	**If there is an alternative answer, check to see if there is any ECF credit possible** **ALLOW** calculator value or rounding to two significant figures or more but **IGNORE** 'trailing zeroes' if wrong *M* produces such numbers throughout. **ALLOW ECF** If no working, **ALLOW** 1 mark for *x* = 6.
	b	i	To neutralise acidic soil ✓	1	
		ii	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Describes practical details of tests and observations that allows all four ions to be identified **AND** Attempts associated equations, with most correct. *There is a well-developed line of reasoning and the method is clear and logically structured. The information presented is relevant and substantiated by observations from the tests described and practical details.* **Level 2 (3–4 marks)** Describes most practical details of tests including the observations that allows most ions to be identified **AND** Attempts associated equations, with some correct. *There is a line of reasoning presented and the method has some structure. The information presented is in the most-part relevant and supported by some evidence of observations from the tests described but practical details may be absent.*	6	**Indicative scientific points may include** **Practical details:** • Sample stirred with water and mixture filtered. • SO_4^{2-}, Fe^{2+}, NH_4^+ tests on filtrate. • CO_3^{2-} test on residue or garden product **Tests and associated equations:** CO_3^{2-} test: *Test:* Add nitric acid. *Observation:*effervescence. *Equation:* $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + CO_2 + H_2O$ ***ALLOW*** $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$ ***OR*** overall equation of $CaCO_3$ and an acid. SO_4^{2-}test: Add $BaCl_2(aq)/Ba(NO_3)_2(aq)/Ba^{2+}(aq)$. Observation: white precipitate. Equation: $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ Fe^{2+} test: Test: Add NaOH(aq) Observation: green precipitate Equation: $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ NH_4^+ test: *Test:* Add NaOH(aq) and warm

			Level 1 (1–2 marks) Describes some of the practical details of tests and observations would only allow some ions to be identified. **OR** Attempts associated equations, with some correct. *The information is basic and the method lacks structure. The information is supported by limited evidence of the observations, the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.		*Observation:* gas turns red litmus indicator blue *Equation:* $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$
			Total	**10**	
2			*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** A comprehensive conclusion using all data to obtain correct formulae for **A, B, C** and **D AND** optical isomers shown *There is a well-developed line of reasoning which is clear and logically structured with use of 3D structures for both optical isomers of **C,** use of wedges and bonding to N.* *The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Reaches a sound conclusion for the formula of **B** **AND** obtains the correct formula of the hydrated complex **A** **OR** a 3D diagram of one optical isomer of cation **C** *There is a line of reasoning and supported by some evidence. Calculations are clear and can be followed to obtain correct conclusions. 3D diagram, if present, should use wedges mostly correctly.* *Formula of **A** to show water separately or formula of **C** to show ligands separately, as appropriate.*	6	**Indicative scientific points may include:** **1. Formula of anhydrous complex B** $NiC_6N_6H_{24}Cl_2$ *Example of working* $\text{Ni : C : N : H : Cl} = \frac{18.95}{58.7} : \frac{23.25}{12.0} : \frac{27.12}{14.0} : \frac{7.75}{1.00} : \frac{22.93}{35.5}$ ***There may be other methods*** **2. Formula of hydrated complex A** $NiC_6N_6H_{24}Cl_2 \cdot 2H_2O$ **OR** $NiC_6N_6H_{24}Cl_2(H_2O)_2$ *Example of working* $n(\text{anhydrous salt}) = \frac{7.433}{309.7} = 0.02400 \text{ (mol)}$ $n(H_2O) = \frac{0.864}{18.0} = 0.04800 \text{ (mol)}$ ✓ ***There may be other methods*** **3. Formula of cation C** $[NiC_6N_6H_{24}]^{2+}$ **OR** $[Ni(H_2NCH_2CH_2NH_2)_3)]^{2+}$ *(could be in structures* 2+ charge can be shown on cation **OR** optical isomers (i.e. seen somewhere) • **Bidentate ligand D** $H_2NCH_2CH_2NH_2$ or displayed so that structure is clearly unambiguous.

			Level 1 (1–2 marks) Reaches a simple conclusion to obtain the correct formula of anhydrous complex **B OR** shows that **A** contains $2H_2O$ *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant. Attempts more than one part of the problem.* **0 marks** *No response or no response worthy of credit.*		• **Optical isomers**  *Accuracy of structures* Bonding shown from Ni to N of $H_2NCH_2CH_2NH_2$ **ALLOW** $CH_3CH(NH_2)_2$ for ligand For $H_2NCH_2CH_2NH_2$ in optical isomers, **ALLOW** C–C without Hs and  Each structure to contain 2 'out wedges', 2 'in wedges' and 2 lines in plane of paper **OR** 4 lines, 1 'out wedge' and 1 'in wedge':  Bond into paper can be shown as:  **Examiner's Comments** This was the second extended response question. Most candidates were able to make a start on this response and found the formula of **B.** A significant number of candidates assumed the bidentate ligand **D** to be $H_2NCH_2CH_2NH_2$ and worked backwards to identify **C.** Having identified **C,** the drawing of optical isomers proved relatively straightforward. Many strong candidates omitted to determine the formula of **A** or realised quite late on within their extended response that this was required.
			Total	**6**	

3			** Please refer to the marking instruction point 10 for guidance on how to mark this question.* **(Level 3)** Describes full details of all of the test procedures and observations that allows all four compounds identified. *There is a well-developed line of reasoning and the method is clear and logically structured. The information presented is relevant and substantiated by observations from the tests described.* (5–6 marks) **(Level 2)** Describes most of the tests in some detail including the observations that allows all four compounds to be identified. *There is a line of reasoning presented and the method has some structure. The information presented is in the most-part relevant and supported by some evidence of observations from the tests described.* (3–4 marks) **(Level 1)** Describes some of the tests but lacks details and observations to allow the identification of all four compounds. *The information is basic and the method lacks structure. The information is supported by limited evidence of the observations, the relationship to the evidence may not be clear.* (1–2 marks) **(0 marks)** No response or no response worthy of credit.	6	**Indicative scientific points may include** **Details of tests** To identify sulfates: • Ammonium ion test: on the sulfates already identified; warm with NaOH(aq) *followed by* • Universal indicator test: use of moist indicator paper on (ammonia) gas; correct observation (alkaline gas / high pH / blue or purple) for identification of $(NH_4)_2SO_4$, and by default of Na_2SO_4. To identify halides: • Halide ion test: addition of silver nitrate solution to remaining two solutions; correct observation (white precipitate / cream precipitate) *followed by* • Solubility of precipitate: addition of dilute ammonia solution to halide precipitates; correct observation (silver chloride dissolves) enabling identification of NaC*l* and by default of KBr.
			Total	**6**	