

# Mark scheme – Qualitative Analysis (MCQ)

Question			Answer/Indicative content	Marks	Guidance
1	a		$n(\text{H}_2\text{O}) = 27.55/18.0 = 1.5306 \text{ (mol)} \checkmark$ $n((\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2) = 72.45/284.0 = 0.2551 \text{ (mol)} \checkmark$ whole number ratio of $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$ : $\text{H}_2\text{O}$ $= 0.2551 : 1.5306 = 1 : 6$ <b>OR</b> $x = 6 \checkmark$	3	<p><b>If there is an alternative answer, check to see if there is any ECF credit possible</b></p> <p><b>ALLOW</b> calculator value or rounding to two significant figures or more but <b>IGNORE</b> 'trailing zeroes' if wrong <math>M</math> produces such numbers throughout.</p> <p><b>ALLOW ECF</b></p> <p>If no working, <b>ALLOW</b> 1 mark for <math>x = 6</math>.</p>
	b	i	To neutralise acidic soil $\checkmark$	1	
		ii	<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><b>Level 3 (5–6 marks)</b>            Describes practical details of tests and observations that allows all four ions to be identified  <b>AND</b>            Attempts associated equations, with most correct.</p> <p><i>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.</i></p> <p><b>Level 2 (3–4 marks)</b>            Describes most practical details of tests including the observations that allows most ions to be identified  <b>AND</b>            Attempts associated equations, with some correct.</p> <p><i>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.</i></p>	6	<p><b>Indicative scientific points may include</b></p> <p><b>Practical details:</b></p> <ul style="list-style-type: none"> <li>• Sample stirred with water and mixture filtered.</li> <li>• <math>\text{SO}_4^{2-}</math>, <math>\text{Fe}^{2+}</math>, <math>\text{NH}_4^+</math> tests on filtrate.</li> <li>• <math>\text{CO}_3^{2-}</math> test on residue or garden product</li> </ul> <p><b>Tests and associated equations:</b>  <math>\text{CO}_3^{2-}</math> test:            Test: Add nitric acid.            Observation: effervescence.            Equation: <math>\text{CaCO}_3 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + \text{CO}_2 + \text{H}_2\text{O}</math>  <b>ALLOW</b> <math>\text{CO}_3^{2-} + 2\text{H}^+ \rightarrow \text{CO}_2 + \text{H}_2\text{O}</math>  <b>OR</b> overall equation of <math>\text{CaCO}_3</math> and an acid.</p> <p><math>\text{SO}_4^{2-}</math> test:            Add <math>\text{BaCl}_2(\text{aq})/\text{Ba}(\text{NO}_3)_2(\text{aq})/\text{Ba}^{2+}(\text{aq})</math>.            Observation: white precipitate.            Equation: <math>\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4</math></p> <p><math>\text{Fe}^{2+}</math> test:            Test: Add <math>\text{NaOH}(\text{aq})</math>            Observation: green precipitate            Equation: <math>\text{Fe}^{2+} + 2\text{OH}^- \rightarrow \text{Fe}(\text{OH})_2</math></p> <p><math>\text{NH}_4^+</math> test:            Test: Add <math>\text{NaOH}(\text{aq})</math> and warm</p>

		<p><b>Level 1 (1–2 marks)</b> Describes some of the practical details of tests and observations would only allow some ions to be identified.</p> <p><b>OR</b> Attempts associated equations, with some correct.</p> <p><i>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.</i></p> <p><b>0 marks</b> No response or no response worthy of credit.</p>		<p><i>Observation:</i> gas turns red litmus indicator blue</p> <p><i>Equation:</i> <math>\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}</math></p>																				
		<b>Total</b>	<b>10</b>																					
2		<p><i>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</i></p> <p><b>Level 3 (5–6 marks)</b> A comprehensive conclusion using all data to obtain correct formulae for <b>A, B, C</b> and <b>D AND</b> optical isomers shown</p> <p><i>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.</i></p> <p><b>Level 2 (3–4 marks)</b> Reaches a sound conclusion for the formula of <b>B AND</b> obtains the correct formula of the hydrated complex <b>A OR</b> a 3D diagram of one optical isomer of cation <b>C</b></p> <p><i>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.</i></p>	6	<p><b>Indicative scientific points may include:</b></p> <p><b>1. Formula of anhydrous complex B</b> <math>\text{NiC}_6\text{N}_6\text{H}_{24}\text{Cl}_2</math></p> <p><i>Example of working</i></p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">Ni</td> <td style="text-align: center;">:</td> <td style="text-align: center;">C</td> <td style="text-align: center;">:</td> <td style="text-align: center;">N</td> <td style="text-align: center;">:</td> <td style="text-align: center;">H</td> <td style="text-align: center;">:</td> <td style="text-align: center;">Cl</td> </tr> <tr> <td style="text-align: center;">=</td> <td style="text-align: center;">:</td> <td style="text-align: center;"><math>\frac{18.95}{58.7}</math></td> <td style="text-align: center;">:</td> <td style="text-align: center;"><math>\frac{23.25}{12.0}</math></td> <td style="text-align: center;">:</td> <td style="text-align: center;"><math>\frac{27.12}{14.0}</math></td> <td style="text-align: center;">:</td> <td style="text-align: center;"><math>\frac{7.75}{1.00}</math></td> <td style="text-align: center;">:</td> <td style="text-align: center;"><math>\frac{22.93}{35.5}</math></td> </tr> </table> <p><b>There may be other methods</b></p> <p><b>2. Formula of hydrated complex A</b> <math>\text{NiC}_6\text{N}_6\text{H}_{24}\text{Cl}_2 \cdot 2\text{H}_2\text{O}</math> <b>OR</b> <math>\text{NiC}_6\text{N}_6\text{H}_{24}\text{Cl}_2(\text{H}_2\text{O})_2</math></p> <p><i>Example of working</i></p> $n(\text{anhydrous salt}) = \frac{7.433}{309.7} = 0.02400 \text{ (mol)}$ $n(\text{H}_2\text{O}) = \frac{0.864}{18.0} = 0.04800 \text{ (mol)} \checkmark$ <p><b>There may be other methods</b></p> <p><b>3. Formula of cation C</b> <math>[\text{NiC}_6\text{N}_6\text{H}_{24}]^{2+}</math> <b>OR</b> <math>[\text{Ni}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{2+}</math> <i>(could be in structures)</i> 2+ charge can be shown on cation <b>OR</b> optical isomers (i.e. seen somewhere)</p> <ul style="list-style-type: none"> <li>• <b>Bidentate ligand D</b></li> </ul> <p><math>\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2</math> or displayed so that structure is clearly unambiguous.</p>	Ni	:	C	:	N	:	H	:	Cl	=	:	$\frac{18.95}{58.7}$	:	$\frac{23.25}{12.0}$	:	$\frac{27.12}{14.0}$	:	$\frac{7.75}{1.00}$	:	$\frac{22.93}{35.5}$
Ni	:	C	:	N	:	H	:	Cl																
=	:	$\frac{18.95}{58.7}$	:	$\frac{23.25}{12.0}$	:	$\frac{27.12}{14.0}$	:	$\frac{7.75}{1.00}$	:	$\frac{22.93}{35.5}$														

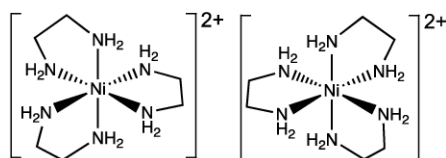
**Level 1 (1–2 marks)**

Reaches a simple conclusion to obtain the correct formula of anhydrous complex **B** OR shows that **A** contains  $2\text{H}_2\text{O}$

*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**

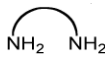


*Accuracy of structures*

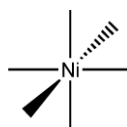
Bonding shown from Ni to N of  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$

**ALLOW**  $\text{CH}_3\text{CH}(\text{NH}_2)_2$  for ligand

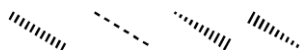
For  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$  in optical isomers,

**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  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$  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		<p><i>* Please refer to the marking instruction point 10 for guidance on how to mark this question.</i></p> <p><b>(Level 3)</b> Describes full details of all of the test procedures and observations that allows all four compounds identified.</p> <p><i>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.</i></p> <p>(5–6 marks)</p> <p><b>(Level 2)</b> Describes most of the tests in some detail including the observations that allows all four compounds to be identified.</p> <p><i>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.</i></p> <p>(3–4 marks)</p> <p><b>(Level 1)</b> Describes some of the tests but lacks details and observations to allow the identification of all four compounds.</p> <p><i>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.</i></p> <p>(1–2 marks)</p> <p><b>(0 marks)</b> No response or no response worthy of credit.</p>	6	<p><b>Indicative scientific points may include</b></p> <p><b>Details of tests</b> To identify sulfates:</p> <ul style="list-style-type: none"> <li>• Ammonium ion test: on the sulfates already identified; warm with NaOH(aq) <i>followed by</i></li> <li>• Universal indicator test: use of moist indicator paper on (ammonia) gas; correct observation (alkaline gas / high pH / blue or purple) for identification of <math>(\text{NH}_4)_2\text{SO}_4</math>, and by default of <math>\text{Na}_2\text{SO}_4</math>.</li> </ul> <p>To identify halides:</p> <ul style="list-style-type: none"> <li>• Halide ion test: addition of silver nitrate solution to remaining two solutions; correct observation (white precipitate / cream precipitate) <i>followed by</i></li> <li>• Solubility of precipitate: addition of dilute ammonia solution to halide precipitates; correct observation (silver chloride dissolves) enabling identification of NaCl and by default of KBr.</li> </ul>
		<b>Total</b>	<b>6</b>	