

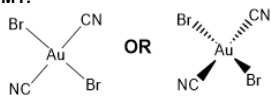
3(a)(i)	M1 Heat (solid FA 5) AND observe condensation, droplets, steam, water vapour M2 Make an aqueous solution of FA 5 / dissolve in water to use for tests M3 (To portion of the solution) add aqueous NH₃ AND white ppt AND insoluble in excess NH₃ M4 (To portion of the solution) add aqueous barium chloride or barium nitrate AND white precipitate M5 to distinguish sulfate / sulfite (white precipitate from M4) insoluble in hydrochloric OR nitric acid OR KMnO₄ is not decolourised / remains purple (added after M4 or directly to FA 5 (aq))																									
3(a)(ii)	<table><tr><td>Zn²⁺</td><td>X</td></tr><tr><td>SO₄²⁻</td><td>✓</td></tr><tr><td>H₂O</td><td>✓</td></tr></table>			Zn ²⁺	X	SO ₄ ²⁻	✓	H ₂ O	✓																	
Zn ²⁺	X																									
SO ₄ ²⁻	✓																									
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3(b)(i)	• (FA 6) starting colour purple • solid jumps / moves around • black residue • test with glowing splint • splint relights / glows more brightly																									
3(b)(ii)	(dark) Green																									
3(c)(i)	'No change' 2 correct = *, 3 correct = ** 2* = 1 mark Max mark = 4 <table><tr><th rowspan="2">test</th><th colspan="3">observations</th></tr><tr><th>FA 7</th><th>FA 8</th><th>FA 9</th></tr><tr><td>Test 1 Add hydrogen peroxide</td><td>Bubbles/ effervescence * Purple / FA 7 (solution) to colourless (solution) * (Gas / oxygen) relights glowing splint *</td><td>No change</td><td>Bubbles / effervescence * (Gas/ oxygen) relights glowing splint *</td></tr><tr><td>Test 2 Add sodium hydroxide, then</td><td></td><td>Off-white ppt*</td><td>No change</td></tr><tr><td>leave to stand</td><td></td><td>brown ppt on standing*</td><td></td></tr><tr><td>Test 3 Add aqueous iron(II) sulfate</td><td>Turns colourless / yellow OR colourless / yellow solution formed*</td><td>No change</td><td></td></tr></table>			test	observations			FA 7	FA 8	FA 9	Test 1 Add hydrogen peroxide	Bubbles/ effervescence * Purple / FA 7 (solution) to colourless (solution) * (Gas / oxygen) relights glowing splint *	No change	Bubbles / effervescence * (Gas/ oxygen) relights glowing splint *	Test 2 Add sodium hydroxide, then		Off-white ppt*	No change	leave to stand		brown ppt on standing*		Test 3 Add aqueous iron(II) sulfate	Turns colourless / yellow OR colourless / yellow solution formed*	No change	
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3(c)(ii)	manganese / Mn																									

3(c)(iii)		FA 6 / FA 7	FA 8
	oxidation state	(+7)	(+2)

3(a)(i)	2 * = 1 mark (round down). Max 5 marks.		
	test	observations	
		FA 4	FA 5
	1 + NaOH(aq)	red-brown / brown ppt AND insoluble in excess *	white ppt * soluble in excess *
	2 + $\text{NH}_3(\text{aq})$	red-brown / brown ppt AND insoluble in excess *	white ppt AND insoluble in excess *
	3 + $\text{Na}_2\text{CO}_3(\text{aq})$	fizzing * gas gives white ppt with limewater * red-brown ppt *	white ppt * fizzing * gas gives white ppt with limewater (award if not awarded for FA 4)
	4 + $\text{BaCl}_2(\text{aq})$ / $\text{Ba}(\text{NO}_3)_2(\text{aq})$	white ppt AND	white ppt *
	5 + $\text{H}^+ / \text{KMnO}_4(\text{aq})$	stays purple / no change AND	stays purple / no change *

3(a)(ii)	<i>ions</i>	FA 4	FA 5
	cations	Fe ³⁺ ; H ⁺	Al ³⁺
	anions	SO ₄ ²⁻	SO ₄ ²⁻
5 ions correct = 3 marks 3 or 4 ions correct = 2 marks 2 ions correct = 1 mark			
3(b)(i)	2 * = 1 mark (round down)		
	<i>test</i>	<i>observations</i>	
		FA 6	FA 7
	1 + H ⁺ / KMnO ₄ (aq)	(turns paler pink)	(purple fades slightly)
	and warm	decolourises / turns colourless / turns (pale) yellow *	decolourises / turns colourless / turns (pale) yellow *
	2 + I ₂ (aq) + NaOH (and warm)	no change *	ppt * that is (pale) yellow *
	3 + Na ₂ CO ₃ (aq)	fizzing *	no change *

3(b)(ii)	M1 (FA 6 is) methanoic acid because it produces CO ₂ / reacts with sodium carbonate AND it can be oxidised / it reacts with KMnO ₄ M2 (FA 7 is) propan-2-ol as it gives a ppt in test 2 OR gives a positive tri-iodomethane/iodoform test OR has the –CH(OH)CH ₃ group
3(c)	Correct equation $\text{CH}_3\text{CH}_2\text{COOH} + \text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3 + \text{H}_2\text{O}$ OR $\text{C}_2\text{H}_5\text{COOH} + \text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_5\text{COOC}_2\text{H}_5 + \text{H}_2\text{O}$

5(a)	<table><tr><th rowspan="2">species</th><th colspan="2">number of unpaired electrons</th></tr><tr><th>3d</th><th>4s</th></tr><tr><td>Cu</td><td>0</td><td>1</td></tr><tr><td>Cu²⁺</td><td>1</td><td>0</td></tr></table>	species	number of unpaired electrons		3d	4s	Cu	0	1	Cu ²⁺	1	0	
species	number of unpaired electrons												
	3d	4s											
Cu	0	1											
Cu ²⁺	1	0											
5(b)	• five 3d orbitals (lines, boxes) in the isolated Cu²⁺ ion of the same energy • splitting: three higher and two lower d orbitals • energy of all five d orbitals in complex higher than all d orbitals in isolated ion any two [1], all three [2]												
5(c)	M1: more than one (stable) oxidation state / exist in variable oxidation states M2: vacant / empty (d) orbitals are energetically accessible OR vacant / empty (d) orbitals can form dative bonds with ligands												
5(d)	<table><tr><th>metal ion</th><th>coordination number</th><th>formula of complex ion</th><th>charge of complex ion</th></tr><tr><td>Ag⁺</td><td>2</td><td>Ag(CN)₂</td><td>1-</td></tr><tr><td>Fe²⁺</td><td>6</td><td>Fe(CN)₆</td><td>4-</td></tr></table> each row [1]	metal ion	coordination number	formula of complex ion	charge of complex ion	Ag ⁺	2	Ag(CN)₂	1-	Fe ²⁺	6	Fe(CN)₆	4-
metal ion	coordination number	formula of complex ion	charge of complex ion										
Ag ⁺	2	Ag(CN)₂	1-										
Fe ²⁺	6	Fe(CN)₆	4-										
5(e)	M1:  M2: (shape) square planar AND (bond angle) 180°												
5(f)(i)	M1: moles MnO₄⁻ = 0.075 × 0.0225 = 1.6875 × 10⁻³ M2: moles V²⁺ = 5 / 3 × 1.6875 × 10⁻³ = 2.8125 × 10⁻³ M3: mass V = 50.9 × 2.8125 × 10⁻³ = 0.143 g % of V = 0.143 / 0.250 × 100 = 57.3 min 2sf												
5(f)(ii)	2VO₃⁻ + 3Zn + 12H⁺ → 2V²⁺ + 3Zn²⁺ + 6H₂O M1: 2 : 3 ratio on both sides M2: rest of the equation correct												