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 NH_3
AND
white ppt **AND** insoluble in excess NH_3

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
$KMnO_4$ is not decolourised / remains purple (added after **M4** or directly to **FA 5** (aq))

3(a)(ii)

Zn^{2+}	X
SO_4^{2-}	✓
H_2O	✓

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

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	

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 + NH_3(aq)	red-brown / brown ppt **AND** insoluble in excess *	white ppt **AND** insoluble in excess *
3 + Na_2CO_3(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 + $BaCl_2$(aq) / $Ba(NO_3)_2$(aq)	white ppt **AND**	white ppt *
5 + H^+ / $KMnO_4$(aq)	stays purple / no change **AND**	stays purple / no change *

3(a)(ii)

ions	**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)

test	*observations*	
	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_2CO_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
$CH_3CH_2COOH + CH_3CH_2OH \rightarrow CH_3CH_2COOCH_2CH_3 + H_2O$
OR
$C_2H_5COOH + C_2H_5OH \rightarrow C_2H_5COOC_2H_5 + H_2O$

5(a)

species	number of **unpaired** electrons	
	3d	4s
Cu	0	1
Cu^{2+}	1	0

5(b)

- five 3d orbitals (lines, boxes) in the isolated Cu^{2+} 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

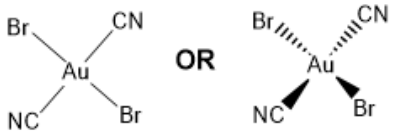
5(d)

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–

each row [1]

5(e)

M1:



M2: (shape) square planar **AND** (bond angle) 180°

5(f)(i)

M1: moles MnO_4^- = 0.075 × 0.0225 = 1.6875×10^{-3}

M2: moles V^{2+} = 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)

$2VO_3^- + 3Zn + 12H^+ \rightarrow 2V^{2+} + 3Zn^{2+} + 6H_2O$

M1: 2 : 3 ratio on both sides

M2: rest of the equation correct