Question number	Answer	Additional guidance	Mark
1(a)(i)	• (cation) $Fe^{2+}/[Fe(H_2O)_6]^{2+}$	Ignore names and any state symbols even if incorrect	1

Question number	Answer	Additional guidance	Mark
1(a)(ii)	• (green precipitate) $Fe(OH)_2/Fe(H_2O)_4(OH)_2$	Ignore names and any state symbols even if incorrect	1

Question number	Answer	Additional guidance	Mark
1(a)(iii)	• iron(III) hydroxide or • $Fe(OH)_3/Fe(H_2O)_3(OH)_3$	Ignore any state symbols even if incorrect Do not award Fe_2O_3	1

Question number	Answer	Additional guidance	Mark
1(a)(iv)	• Oxidation	Allow redox	1

Question number	Answer	Additional guidance	Mark
1(a)(v)	An answer that makes reference to: • if a precipitate is formed then it may dissolve in excess or • the precipitate may be amphoteric and dissolve in excess.	Allow The formation of the precipitate might be overlooked (if the hydroxide is amphoteric / dissolves)	1

Question number	Answer	Additional guidance	Marks
1(b)(i)	A description that makes reference to: • use of (damp) red litmus paper (1) • change from red to blue (shows alkalinity). (1)	Allow universal indicator paper (Yellow) to blue Do not award testing with HCl(g) or result	2

Question number	Answer	Additional guidance	Marks
1(b)(ii)	A description that makes reference to: • use of (conc.) HCl(aq) on a glass rod held in the gas or • use of (conc.) HCl(aq) on a glass stopper held in the gas (1) • formation of white smoke (shows presence of ammonia). (1)	Do not award adding dilute hydrochloric acid Allow white fumes / white solid Ignore reference to indicator and/or smell Do not award steamy fumes	2

Question number	Answer	Additional guidance	Mark
1(c)(i)	• (acid) removes carbonate ions that also give a white precipitate or • prevents other anions forming a white precipitate	Allow sulfite ions for carbonate ions	1

Question number	Answer	Additional guidance	Mark
1(c)(ii)	Route 1: • use of mask/fume cupboard **and** prevent breathing in dust. or Route 2: • use of gloves **and** poison could be irritating to the skin.	 Allow poison could be absorbed by the skin	1

Question number	Answer	Additional guidance	Mark
1(d)	• Any ratio of Fe^{2+}, NH_4^+ and SO_4^{2-} ions that gives a neutral species	Example formula: $Fe(NH_4)_2(SO_4)_2$ Allow separate formulae:$(NH_4)_2SO_4$ **and** $FeSO_4$	1

Question number	Answer		Additional guidance	Marks
2(a)	A description that makes reference to:			2
	• addition of Brady's reagent/2,4-dintrophenylhydrazine	(1)	Allow 2,4-DNPH/2,4-DNP	
	• formation of orange precipitate.	(1)	Colour and state required Allow red/yellow	

Question number	Answer	Additional guidance	Marks
2(b)	A description of any two of the following tests: Test 1: • (warm with) Tollens' reagent/ammoniacal silver nitrate (1) • formation of silver 'mirror'/solid silver/black solid. (1) or Test 2: • (heat with) addition of Fehling's/Benedict's solution (1) • change (from blue solution) to (brick) red precipitate. (1) or Test 3: • (heat with) addition of acidified potassium dichromate(VI) (1) • colour change (of orange) to green. (1)	Ignore references to spectroscopy Accept description of formation of Tollens' reagent Do not award Fehling's and Benedict's as separate tests Allow acidified dichromate((VI)) ions Accept orange to blue	**4**

Question number	Answer	Additional guidance	Mark
2(c)	• (pale) yellow precipitate	Allow antiseptic smell Ignore name of precipitate	**1**

Question number	Answer	Additional guidance	Marks
2(d)(i)	A deduction that makes reference to: • area ratio of three means three equivalent hydrogens/three hydrogens in the same (chemical) environment (1) • (splitting pattern of a singlet) as there are no hydrogens on the adjacent carbon (1) • hence **X** is butanone. (1)	Accept 'proton' for 'hydrogen' Ignore reference to chemical shift Do not award identification unless an attempt at justification is given	**3**

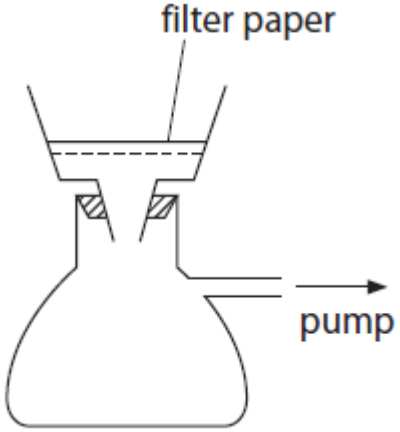
Question number	Answer	Additional guidance	Marks
2(d)(ii)	An explanation that makes reference to: • peak is due to TMS/tetramethylsilane (1) • added to calibrate the NMR machine (1) or • added to provide a reference point/a zero point		**2**

Question number	Answer	Additional guidance	Mark
3(a)(i)	• $2Co^{2+} + H_2O_2 + 2H^+ \rightarrow 2Co^{3+} + 2H_2O$	Allow multiples Ignore state symbols even if incorrect	**1**

Question number	Answer		Additional guidance	Marks
3(a)(ii)	• calculation of number of moles of hydrogen peroxide	(1)	Example of calculation: $n(H_2O_2)$ = (0.75 ÷ 34=) 0.022. (mol)	**4**
	• calculation of M_r of $Co(NO_3)_2.6H_2O$	(1)	M_r = 290.9	
	• calculation of number of moles of $Co(NO_3)_2.6H_2O$	(1)	0.012375 (mol)	
	• use of mol ratio	(1)	Minimum H_2O_2 needed = 0.012375 ÷ 2 = 0.006188 (mol)	

Question number	Answer		Additional guidance	Marks
3(a)(iii)	• oxygen (gas)	(1)		**2**
	• $H_2O_2 \rightarrow ½O_2 + H_2O$	(1)	Allow multiples Ignore state symbols even if incorrect	

Question number	Answer		Additional guidance	Marks
3(b)	An answer that makes reference to:			**2**
	• the salt is less soluble in ethanol (than water)	(1)		
	• solubility decreases with temperature.	(1)		

Question number	Answer	Additional guidance	Marks
3(c)	A labelled diagram that includes: • Buchner/side-armed flask (1) • side-arm connected to pump/water aspirator (1) • funnel with flat filter paper. (1)	Exemplar diagram:  Do not award fluted filter paper	3

Question number	Answer	Additional guidance	Mark
3(d)(i)	An answer that makes reference to: • the smallest amount of product remains in solution (after crystallisation).	Accept: to form a saturated solution. Ignore: to maximise yield.	1

Question number	Answer	Additional guidance	Mark
3(d)(ii)	• insoluble impurities		1

Question number	Answer	Additional guidance	Mark
3(d)(iii)	• soluble impurities		1

Question number	Answer	Additional guidance	Marks
3(d)(iv)	A description including: • the crystals need to be dried (1) • method of drying. (1)	Examples of acceptable methods: between filter papers or in a desiccator or in a warm oven	2

Question number	Answer	Additional guidance	Mark
3(e)(i)	An answer that makes reference to: • the crystals are not dry/the mass of the crystals includes ethanol.		1

Question number	Answer	Additional guidance	Mark
3(e)(ii)	An answer that makes reference to: • the crystals lose ammonia.	Allow loss of water loss of ethanol	1

Question Number	Answer	Additional guidance	Mark
4(a)	• deionised water may be left in the pipette which will dilute the propanoic acid dispensed from it		1

Question Number	Answer	Additional guidance	Mark
4(b)	A statement that makes reference to: • no effect (on K_a) and because the colour change to pale pink is important and not the accurate volume added from the burette.		1

Question Number	Answer	Additional guidance	Mark
4(c)	• too much/excess sodium hydroxide added from the burette	Do not award reference to too much phenolphthalein/indicator added	1

Question Number	Answer	Additional guidance	Mark
4(d)	• calculation of percentage uncertainty	Example of calculation: % = ((0.06 ÷ 25.00) × 100 =) 0.24%	1

Question Number	Answer	Additional guidance	Mark
4(e)	A description that makes reference to: • use of a buffer of known pH.		1

Question Number	Answer	Additional guidance	Marks
4(f)	• evaluation (1) • units and SF (1)	Example of calculation: $K_a = 10^{-pH}$ $= 1.2589 \times 10^{-5}$ $= 1/1.3/1.26 \times 10^{-5}$ mol dm^{-3}	2