

Question	Answer	Marks	Guidance
1	C	1	ALLOW +6 in the box

Question	Answer	Marks	Guidance
2	C	1	

Question			Answer	Marks	Guidance
3	(a)	(i)	<i>Disproportionation:</i> oxidation and reduction of the same element ✓ <i>Redox:</i> Cl is oxidised from +5 (in KClO_3) to +7 (in KClO_4) ✓ Cl is reduced from +5 (in KClO_3) to -1 (in KCl) ✓	3	ALLOW 'chlorine' OR 'Cl' for same element IGNORE 'species' for 'element' ALLOW after number, e.g. 5+ IGNORE ionic charges, e.g. Cl^{5+} IGNORE '5' (signs required) IGNORE any reference to electron loss/gain (even if wrong) ALLOW one redox mark if oxidation numbers are correct but reduction/oxidation is incorrectly assigned

Question			Answer	Marks	Guidance
4	(a)	(i)	<i>Circuit:</i> complete circuit AND voltmeter AND labelled salt bridge linking two half-cells ✓ <i>Half cells:</i> Pt AND Fe²⁺ AND Fe³⁺ ✓ Zn AND Zn²⁺ ✓ <i>Standard conditions:</i> 1 mol dm⁻³ (solution(s)) AND 298 K / 25°C ✓	4	Electrodes / salt bridge must at least touch the surface ALLOW small gaps in circuit wires ALLOW half cells drawn either way around ALLOW 1 mol/dm³ OR 1 M ALLOW 1 mol dm⁻³/1M if omitted here but shown for just one solution in diagram IGNORE pressure DO NOT ALLOW 1 mol(e) for concentration
		(ii)	1.53 (V) ✓	1	IGNORE sign
	(b)		<i>strongest reducing agent:</i> Zn ✓ <i>strongest oxidising agent:</i> MnO₄⁻ ✓	2	NOTE: H ⁺ has been ignored
	(c)		AWARD 2 marks for correct balancing AND all species cancelled on both sides of equation: 2MnO₄⁻ + 6H⁺ + 5SO₃²⁻ → 2Mn²⁺ + 3H₂O + 5SO₄²⁻ ✓ ✓ AWARD 1 mark for correct balancing but not all species (H₂O, H⁺) cancelled on both sides of equation ✓ e.g. 2MnO₄⁻ + 16H⁺ + 5SO₃²⁻ + 5H₂O → 2Mn²⁺ + 8H₂O + 5SO₄²⁻ + 10H⁺	2	ALLOW correct multiples e.g. MnO₄⁻ + 3H⁺ + 2½SO₃²⁻ → Mn²⁺ + 1½H₂O + 2½SO₄²⁻ IGNORE state symbols e.g. MnO₄⁻ + 8H⁺ + 2½SO₃²⁻ + 2½H₂O → Mn²⁺ + 4H₂O + 2½SO₄²⁻ + 5H⁺
			Total	9	

Question	Answer	Marks	AO element	Guidance
5	C	1	AO2.2	

Question	Answer	Marks	AO element	Guidance
6	D	1	AO2.5	

Question			Answer	Marks	Guidance
7	(a)	(i)	Titres correct and ALL recorded to 2 decimal places Titre: 24.00 23.40 23.75 23.85 ✓ mean titre = 23.80 (cm ³) ✓	2	ALLOW 23.8 cm ³
	(d)	(ii)	Percentage uncertainty = $\frac{0.05 \times 2}{23.40} \times 100 = 0.43 \text{ (\%)} \checkmark$	1	ALLOW ECF from incorrect subtraction in (i) or incorrect mean ALLOW 0.42% from titre values 2, 3 or 4 or mean titre or trial titre. 2 DP required
	(d)	(iii)	Add starch (near the end point) ✓ Blue to colourless ✓	2	ALLOW blue/black OR black OR purple for colour of mixture

Question		Answer	Marks	Guidance
	(d) (iv)	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF B = RbIO₃ AND relative formula mass = 260.5 award 5 marks IF relative formula mass = 260.5 award 4 marks ----- $n(\text{S}_2\text{O}_3^{2-})$ in titration $= \frac{0.150 \times 23.80}{1000} = 3.57 \times 10^{-3} \text{ (mol) } \checkmark$ $n(\text{IO}_3^-)$ in titration $= \frac{3.57 \times 10^{-3}}{6} = 5.95 \times 10^{-4} \text{ (mol) } \checkmark$ $n(\text{IO}_3^-)$ in original 250 cm³ $= 10 \times 5.95 \times 10^{-4} = 5.95 \times 10^{-3} \text{ (mol) } \checkmark$ Relative formula mass of B $= \frac{1.55}{5.95 \times 10^{-3}} = 260.5 \text{ (g mol}^{-1}\text{) } \checkmark$ Formula of B (must be derived from relative formula mass) Iodate of Group 1 metal that most closely matches calculated molar mass of B Formula from 260.5 = RbIO₃ $\checkmark$	5	ALLOW ECF from incorrect mean titre in (a)(i) ECF from $n(\text{S}_2\text{O}_3^{2-})$ in titration ALLOW a two-step calculation $n(\text{I}_2) = n(\text{S}_2\text{O}_3^{2-}) \div 2$ and $n(\text{IO}_3^-) = n(\text{I}_2) \div 3$ ECF from $n(\text{IO}_3^-)$ in titration ECF from $n(\text{IO}_3^-)$ in original 250 cm³ IF scaling $\times 10$ is omitted, ALLOW ECF from $n(\text{IO}_3^-)$ in titration ALLOW ECF from incorrect RFM of B provided metal is from Group 1 ALLOW RbIO₃⁻ DO NOT ALLOW RbIO₃ without relative formula mass value. DO NOT ALLOW 260.4 (without working) and RbIO₃ IF B = RbIO₃ AND relative formula mass = 261 award 5 marks
		Total	20	

8	(a)	(i)	<i>Circuit:</i> complete circuit AND voltmeter AND salt bridge linking two half-cells ✓ <i>Half cells:</i> Pt AND I⁻ AND I₂ ✓ Ni AND Ni²⁺ ✓ <i>Standard conditions:</i> 1 mol dm⁻³ solutions AND 298 K / 25°C ✓	4	Voltmeter must be shown AND salt bridge must be labelled ALLOW small gaps in circuit ALLOW half cells drawn either way around IGNORE 2 before I⁻(aq) DO NOT ALLOW I₂(g) OR I₂(s) OR I₂(l) ALL conditions required BUT ALLOW 1 mol dm⁻³/1M if omitted here but shown for just one solution in diagram Look on diagram in addition to answer lines IGNORE pressure <i>Not relevant for this cell</i> DO NOT ALLOW 1 mol for concentration
	(a)	(ii)	$E = 0.79 \text{ (V)}$ ✓	1	IGNORE sign
	(b)	(i)	$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{Fe}^{2+}(\text{aq}) \rightarrow 2\text{Fe}^{3+}(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$ ✓	1	ALLOW multiples IGNORE state symbols, even if wrong

Question			Answer	Marks	Guidance
	(b)	(ii)	Equations $3\text{Zn(s)} + \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) \rightarrow 3\text{Zn}^{2+}(\text{aq}) + 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O(l)}$ ✓ $\text{Zn(s)} + 2\text{Cr}^{3+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{Cr}^{2+}(\text{aq}) \quad \checkmark$ Comparison of E values (seen once) E of Zn is more negative/less positive than E of $\text{Cr}_2\text{O}_7^{2-}$ OR E of Zn is more negative/less positive than E of Cr^{3+} ✓ Equilibrium shift related to E values More negative/less positive OR Zn system shifts left OR Less negative/more positive $\text{Cr}_2\text{O}_7^{2-}$ system shifts right OR Less negative/more positive Cr^{3+} system shifts right ✓	4	ALLOW multiples IGNORE state symbols, even if wrong ALLOW E_{cell} is (+) 2.09V for Zn/$\text{Cr}_2\text{O}_7^{2-}$ cell OR ALLOW E_{cell} is (+) 0.34V for Zn/Cr^{3+} cell IGNORE 'lower/higher' For 'shifts left': ALLOW '(Zn) is oxidised' OR 'electrons are lost (from Zn)' For 'shifts right', ALLOW '(Cr) is reduced' OR 'electrons are gained'

Question	Answer	Marks	AO	Guidance
9	B	1	AO1.2	

Question	Answer	Marks	AO	Guidance
10	D	1	AO1.2	

Question	Answer	Marks	AO	Guidance
11	C	1	AO2.1	

12	(a)	(i)	<i>Explanation of colours</i> VO^{2+} goes to V^{3+} (green) AND then V^{3+} goes to V^{2+}	3	3.1 x2	
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Question			Answer	Marks	AO element	Guidance
			(violet) ✓ <i>Explanation using $E^\ominus$ values</i> $(E^\ominus \text{ of system 4 (VO}^{2+}/\text{V}^{3+}) \text{ is more positive / less negative than system 2 (Fe}^{2+}/\text{Fe) OR}$ $(E^\ominus \text{ of system 3 (V}^{3+}/\text{V}^{2+}) \text{ is more positive / less negative than system 2 (Fe}^{2+}/\text{Fe) ✓}$ <i>Equilibrium shift related to $E^\ominus$ values</i> More positive/less negative system 4 $(\text{VO}^{2+}/\text{V}^{3+})$ shifts right AND More positive/less negative system 3 $(\text{V}^{3+}/\text{V}^{2+})$ shifts right		3.2 × 1	IGNORE 'lower/higher' ALLOW reverse argument System 2 more negative than system 4 etc $E = (+)0.78 \text{ V}$ for system 4 + system 2 reaction OR $E = (+)0.18 \text{ V}$ for system 3 + system 2 reaction For shifts right' ALLOW (VO^{2+}) is reduced OR gains electrons (maybe seen as an equation) AND 'For shifts right' ALLOW (V^{3+}) is reduced OR gains electrons (maybe seen as an equation) IGNORE Fe oxidised
		(ii)	$\text{Fe} + 4\text{H}^+ + 2\text{VO}^{2+} \rightarrow \text{Fe}^{2+} + 2\text{H}_2\text{O} + 2\text{V}^{3+}$	1	2.8	IGNORE state symbols ALLOW multiples

Question	Answer	Marks	AO	Guidance
13	C	1	2.6	

Question			Answer	Marks	AO element	Guidance
14	(a)		Equation: $\text{Mg} + 2\text{CH}_3\text{COOH} \rightarrow (\text{CH}_3\text{COO})_2\text{Mg} + \text{H}_2$ ✓	3	2.6	ALLOW $\text{Mg}(\text{CH}_3\text{COO})_2$ ALLOW multiples IGNORE Oxidation numbers in formulae IGNORE state symbols
			Oxidation: Mg from 0 to +2 ✓		1.2	Mark independently from equation
			Reduction: H from +1 to 0 ✓		1.2	ALLOW 1 mark for correct oxidation numbers but

				element	
15	(a)	Circuit Complete circuit AND voltmeter AND salt bridge linking two half-cells ✓ Half cells Ag AND Ag⁺ AND 1 mol dm⁻³ solution ✓ Pt AND H⁺ AND MnO₄⁻ AND Mn²⁺ AND 1 mol dm⁻³ /equimolar solution ✓	3	3.4 × 1 1.2 × 1 1.2 × 1	Voltmeter must be shown AND salt bridge must be labelled ALLOW small gaps in circuit If species in BOTH half cells are correct but concentration of 1 mol dm⁻³ omitted, ALLOW 1 mark for BOTH half cells. ALLOW acidified as an alternative for H⁺ IGNORE stated pressure <i>Not relevant here as no gas</i>
	(b)	Comparison of E values <i>E</i> of redox system 4 (MnO₄⁻/Mn²⁺) is more positive/less negative than <i>E</i> of redox systems 2 (HCOOH/HCHO) OR 1 (CO₂/HCOOH) ✓ Equilibrium shift related to E values More negative/less positive/system 2 (HCOOH/HCHO) OR system 1 (CO₂/HCOOH) shifts left OR Less negative/more positive/system 4 (MnO₄⁻/Mn²⁺) shifts right ✓ • 2 and 4 2MnO₄⁻ + 5HCHO + 6H⁺ → 2Mn²⁺ + 5HCOOH + 3H₂O ✓ • 1 and 4 2MnO₄⁻ + 5HCOOH + 6H⁺ → 2Mn²⁺ + 5CO₂ + 8H₂O ✓	4	3.1 × 2 3.2 × 2	IGNORE higher/lower ALLOW Overall E_{reaction} = (+)1.54V OR (+)1.62V For 'shifts left', ALLOW 'is oxidised' OR 'electrons are lost' OR 'reducing agent' For 'shifts right', ALLOW 'is reduced' OR 'electrons are gained' OR 'oxidising agent' IGNORE state symbols ALLOW multiples DO NOT ALLOW un-cancelled species, e.g. H⁺, on both sides ALLOW for 1 mark two balanced equations with uncancelled species. ALLOW combined equation for 2 marks: 4MnO₄⁻ + 5HCHO + 12H⁺ → 4Mn²⁺ + 5CO₂ + 11H₂O

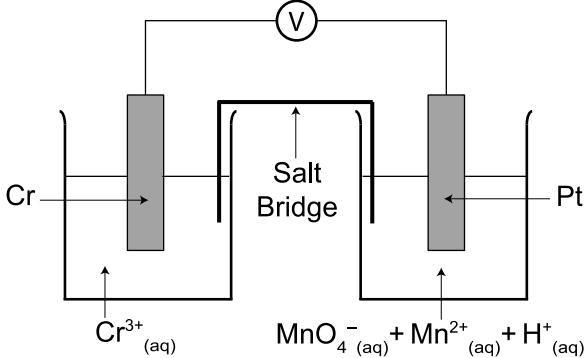
Question			Answer	Marks	element	Guidance
	(c)		$2\text{H}^+ + \frac{1}{2}\text{O}_2 + 2\text{e}^- \rightarrow \text{H}_2\text{O} \checkmark$ $1.34 + (-0.11) = (+) \underline{1.23} \text{ (V)} \checkmark$	2	2.6 2.2×1	IGNORE state symbols ALLOW multiples
			Total	9		

Question		Answer	Marks	AO element	Guidance
	(ii)	+2 ✓	1	2.1	+ required ALLOW 2+
	16(a)	$n(\text{MnO}_4^-)$ in titration $= 0.01 \times \frac{12.6}{1000} = 1.26 \times 10^{-4} \checkmark$ $n(\text{SO}_3^{2-})$ in 25.0 cm ³ $= 1.26 \times 10^{-4} \times 2.5 = 3.15 \times 10^{-4} \text{ (mol)} \checkmark$ $n(\text{SO}_3^{2-})$ in 250 cm ³ $= 10 \times 3.15 \times 10^{-4} = 3.15 \times 10^{-3} \text{ (mol)} \checkmark$ mass Na ₂ SO ₃ in 525 g meat $= 3.15 \times 10^{-3} \times 126.1 = 0.397 \text{ (g)} \checkmark$ mass Na ₂ SO ₃ in 1 kg of meat $= 0.397215 \times \frac{1000}{525} = 0.7566 \text{ g OR } 756.6 \text{ mg}$ AND less than the maximum permitted level OR AW ✓	5	1.2×1 2.8×3 3.2×1	ALLOW 3 SF or more throughout ALLOW ECF throughout Calculator = 0.397215 g ALLOW within range: 756 to 757 mg ALLOW 0.397 g < 0.446 g per 525 g meat.
		Total	15		

Question	Answer	Marks	AO element	Guidance
17	C	1	AO1.2	

Question			Answer	Marks	AO element	Guidance
18	(a)		Formula: CuCO_3 ✓ $\text{CuCO}_3 + 2\text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{CO}_2 + \text{H}_2\text{O}$ ✓	2	AO1.2 AO2.6	IGNORE state symbols ALLOW formula within equation. ALLOW other copper(II) compounds which can react with nitric acid to form a gas e.g. CuS , CuSO_3 for mark 1, with correct equation for mark 2. e.g. $\text{CuSO}_3 + 2\text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{SO}_2 + \text{H}_2\text{O}$
	(b)		$2\text{Cu}^{2+}(\text{aq}) + 4\text{I}^{-}(\text{aq}) \rightarrow 2\text{CuI}(\text{s}) + \text{I}_2(\text{aq})$ ✓	1	AO2.6	ALLOW multiples State symbols are required
	(c)		starch (solution) AND blue-black to colourless ✓	1	AO1.2	ALLOW blue OR black OR purple for colour of mixture ALLOW blue colour disappears (to colourless) IGNORE 'clear' IGNORE 'colorimetry'
	(d)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.35 award 4 marks ----- $n(\text{S}_2\text{O}_3^{2-}) = 0.0200 \times \frac{26.55}{1000}$ $= 5.31 \times 10^{-4} \text{ (mol) } \checkmark$ $n(\text{I}_2) = 2.655 \times 10^{-4}$ OR $n(\text{Cu}^{2+}) = 5.31 \times 10^{-4} \text{ (mol) } \checkmark$ $m(\text{Cu}/\text{Cu}^{2+}) \text{ in ore} = 63.5 \times 5.31 \times 10^{-4}$ $= 0.0337\text{..... (g) } \checkmark$ $\text{percentage} = \frac{0.0337\text{....}}{2.50} \times 100$ $= 1.35 \text{ (\%) } \checkmark$ (3SF required)	4	AO2.8 ×5	FULL ANNOTATIONS MUST BE USED ----- ALLOW ECF throughout If 1:2 ratio for $\text{I}_2:\text{Cu}^{2+}$ not used check ratio in b) and allow ECF IGNORE rounding errors after 3 SF Calculator: 0.0337185 ALLOW 3 SF (0.0337) up to calculator value ECF dependent on the use of a calculated mass of Cu/Cu^{2+}

Question			Answer	Marks	AO element	Guidance
	(e)	(i)	Lower AND smaller titre ✓	1	AO3.4	ALLOW less I ₂ produced / less Cu ²⁺ reacts
		(ii)	The same AND burette measures by difference ✓	1	AO3.4	ALLOW AW
	(f)		Any two of the following: Make up a (standard solution) from Step 2 to a stated volume (e.g. 250 cm³) OR Repeat titrations AND Take mean of concordant/closest titres/ identify anomalies OR lower [S₂O₃]²⁻ to increase titre volume (to reduce the percentage error). OR higher [S₂O₃]²⁻ so not to refill the burette. OR Use a 3 dec place balance (to reduce the percentage error).	2	AO3.4 x 2	
			Total	12		

Question	Answer	Marks	AO element	Guidance
19 (a) (i)	Complete circuit with voltmeter AND labelled salt bridge linking two half-cells ✓  Cr electrode in Cr^{3+} ✓ Pt electrode in MnO_4^- AND H^+ AND Mn^{2+} ✓	3	AO1.2 ×3	Half cells can be drawn in either order Half cells must show electrodes dipping into solutions ALLOW small gaps in circuit IGNORE any stated concentrations IGNORE state symbols In salt bridge, ALLOW any stated ion that may be present, e.g. Cr^{3+}, MnO_4^-, Mn^{2+}, H^+
(a) (ii)	$5\text{Cr} + 3\text{MnO}_4^- + 24\text{H}^+ \rightarrow 5\text{Cr}^{3+} + 3\text{Mn}^{2+} + 12\text{H}_2\text{O}$ ✓	1	AO2.6	IGNORE state symbols ALLOW multiples
(b) (i)	Mn is oxidised from +6 (in MnO_4^{2-}) to +7 (in MnO_4^-) ✓ Mn is reduced from +6 (in MnO_4^{2-}) to +4 (in MnO_2) ✓	2	AO2.1 ×2	IGNORE '6' (signs required) ALLOW after number, e.g. 5+ ALLOW 1 mark for correct oxidation numbers but not linked to oxidation/reduction. IGNORE any reference to electron loss/gain (even if wrong)

Question			Answer	Marks	AO element	Guidance
	(b)	(ii)	<i>Explanation using E° values</i> $(E^\circ \text{ of system 3 (MnO}_4^-/\text{MnO}_4^{2-}) \text{ is less positive / more negative than system 5 (MnO}_4^{2-}/\text{MnO}_2) \checkmark$ <i>Equilibrium shift related to E° values</i> system 3 (MnO₄⁻/MnO₄²⁻) shifts left AND system 5 (MnO₄²⁻/MnO₂) shifts right ✓	2	AO3.1 ×2	IGNORE 'lower/higher' ALLOW reverse argument: System 5 more positive than system 3, etc Must be comparative ALLOW response in terms of E_{cell} $E = (+)1.14 \text{ V for system 5 – system 3}$ Shift dependent on systems 3 and 5 correctly identified
	(c)	(i)	$\text{H}_2 + 2\text{OH}^- \rightarrow 2\text{H}_2\text{O} + 2\text{e}^- \checkmark$	1	AO2.6	ALLOW multiples ALLOW $\text{H}_2 + 2\text{OH}^- - 2\text{e}^- \rightarrow 2\text{H}_2\text{O}$ ALLOW equation with equilibrium sign
	(c)	(ii)	$(0.40 - 1.23 =) -0.83 \text{ (V)} \checkmark$	1	AO1.2	
	(c)	(iii)	Fuel reacts with oxygen/oxidant to give electrical energy/voltage ✓	1	AO1.1	ALLOW named fuel. e.g. hydrogen/H₂; ethanol; methanol, etc ALLOW fuel cell requires <u>continuous</u> supply of

Question	Answer	Marks	AO	Guidance
20	Award the mark regardless of response.	1	2.2	

Question			Answer	Marks	AO element	Guidance
21		(a)	Oxidation $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ ✓ Reduction $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ OR $\text{H}^+ + \text{e}^- \rightarrow \frac{1}{2}\text{H}_2$ ✓	2	AO2.6 ×2	IGNORE exothermic In half equations, ALLOW the use of e for e⁻ ALLOW $\text{Mg} - 2\text{e}^- \rightarrow \text{Mg}^{2+}$ IGNORE state symbols even is wrong BUT half equations MUST only have species that change. For charges on half equations, ALLOW Mg^{+2} for Mg^{2+} OR H^{+1} for H^+ If BOTH half equations are correct but shown with oxidation and reduction the wrong way around, award 1 mark from the 2 marks for half equations

Question	Answer	Marks	AO element	Guidance
22	(a) Explanation of the brown precipitate The brown ppt is $\text{Fe}(\text{OH})_3$ OR $\text{Fe}(\text{OH})_2$ loses electrons/ $\text{Fe}(\text{OH})_2$ oxidised ✓ Comparison of E values (E of) Fe/Redox system 1 is more negative/less positive (than E of O_2/redox system 2) OR (E of) O_2/Redox system 2 is more positive/less negative (than E of Fe/redox system 1) ✓ Equilibrium shift More negative/less positive OR Fe system OR Redox system 1 shifts left OR More Positive/less negative OR O_2 system OR Redox system 2 shifts right ✓ Equation $4\text{Fe}(\text{OH})_2(\text{s}) + \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow 4\text{Fe}(\text{OH})_3(\text{s})$ ✓	4	AO3.1 ×4	ORA ALLOW Fe^{2+} is oxidised to Fe^{3+} ALLOW Fe ALLOW E_{cell} is (+) 0.96V IGNORE 'lower/higher' For equilibrium shift ALLOW E_{cell} is +ve therefore the reaction is feasible. OR Direction of half equation correctly written. ALLOW multiples ALLOW equilibrium IGNORE state symbols, even if wrong

Question	Answer	Marks	AO element	Guidance
23	C	1	AO2.6	

Question	Answer	Marks	AO element	Guidance
24	B	1	AO2.1	
	Total	15		

Question			Answer	Marks	AO element	Guidance			
25	(a)	(i)	Colourless to (pale) pink	1	AO1.1	ALLOW <u>Pale</u> purple DO NOT ALLOW purple			
		(ii)	<table border="1"><tr><td>12.65</td><td>12.95</td><td>12.75</td></tr></table> ✓ $\frac{12.65+12.75}{2} = 12.7(0) \text{ cm}^3 \checkmark$	12.65	12.95	12.75	2	AO2.8 x2	
12.65	12.95	12.75							
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE if answer = 6.35×10^{-3} award 3 marks ----- $n(\text{MnO}_4^-)$ in titration $= (0.00250 \times \frac{12.7}{1000})$ $= 3.175 \times 10^{-5} \checkmark$ $n(\text{Fe}^{2+})$ in 25.0 cm³ $= (3.175 \times 10^{-5} \times 5)$ $= 1.5875 \times 10^{-4} \text{ (mol)} \checkmark$ $[\text{Fe}^{2+}] = (1.5875 \times 10^{-4} \div 0.025)$ OR $(1.5875 \times 10^{-4} \times 40)$ $= 6.35 \times 10^{-3} \text{ (mol dm}^{-3}\text{)} \checkmark$	3	AO2.8 x3	ALLOW ECF from incorrect titre in 21 a ii) for 3 marks e.g. Titre of 12.78 cm³ gives 6.39×10^{-3} ----- ALLOW 3 SF or more throughout ALLOW ECF throughout ALLOW $n(\text{Fe}^{2+})$ in 250 cm³ = $1.5875 \times 10^{-3} \text{ (mol)}$ so $[\text{Fe}^{2+}]$ in 25 cm³ $= 1.5875 \times 10^{-3} \div 0.025 = 6.35 \times 10^{-3}$ Common errors for 2 marks 2.46×10^{-2} (volumes transposed) 1.25×10^{-2} (same volume used twice) 1.27×10^{-3} (no x 5) 2.54×10^{-4} ($\div 5$)			

	(b)		4	AO3.1 ×1 AO3.4 ×1 AO3.1 ×1 AO3.4 ×1	ALLOW ORA throughout IGNORE larger/smaller/greater/less throughout ALLOW E° = (+)1.53(V) ALLOW comparison if Fe system is identified ALLOW E° = (+) 2.27(V) ALLOW comparison if MnO_4^- is identified
		System 1/$E^\ominus(\text{Zn})$ is more negative/less positive than system 2/ $E^\ominus(\text{Fe}^{3+})$ ✓ Eqm 2 shifts to right AND Eqm 1 shifts to left OR Zinc reduces iron(III) ions (to iron(II)) OR $\text{Zn} + 2\text{Fe}^{3+} \rightarrow \text{Zn}^{2+} + 2\text{Fe}^{2+}$ ✓ System 1/$E^\ominus(\text{Zn})$ is more negative than system 3/ $E^\ominus(\text{MnO}_4^-)$ ✓ Eqm 3 shifts to right AND Eqm 1 shifts to left OR (If unfiltered), MnO_4^- oxidise zinc OR $2\text{MnO}_4^- + 5\text{Zn} + 16\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 5\text{Zn}^{2+} + 8\text{H}_2\text{O}$ ✓			

Question			Answer	Marks	AO element	Guidance
26	(a)		$3\text{V}^{3+} + \text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+ \rightarrow 3\text{VO}_2^+ + 2\text{Cr}^{3+} + \text{H}_2\text{O}$ ALL reactant and product species correct ✓ Correct balancing (of correct equation) AND cancelling of species ✓	2	AO2.5 AO2.6	IGNORE Balancing and electrons for first mark DO NOT ALLOW electrons in final answer

Question	Answer	Marks	Guidance
27	D	1	

Question	Answer	Marks	Guidance
28	D	1	

29	(a)	FIRST CHECK ANSWER ON ANSWER LINE If answer = 84 award 4 marks ----- $n(\text{I}^-) = \frac{26.2 \times 0.150}{1000} = 3.93 \times 10^{-3} \checkmark$ $n(\text{IO}_3^-) = \frac{3.93 \times 10^{-3}}{5} = 7.86 \times 10^{-4} \checkmark$ mass KIO_3 in 2 tablets = $7.86 \times 10^{-4} \times 214 = 0.168204 \text{ g}$ $\checkmark$ mass KIO_3 in 1 tablet = $0.084102 \text{ g} = 84 \text{ mg}$ (nearest whole number)$\checkmark$	4	ALLOW 3 SF or more throughout ALLOW ECF throughout Care – other sequence of calculations can be valid. <u>Alternative route</u> M3 mol (IO_3^-) in one tablet = $\frac{7.86 \times 10^{-4}}{2} = 3.93 \times 10^{-4}$ M4 Mass (KIO_3) in one tablet = $3.93 \times 10^{-4} \times 214 = 84$ Final answer must be a whole number Common Errors 3 marks: 69 mg (using M_r of IO_3^-) 421mg (not divided by 5)
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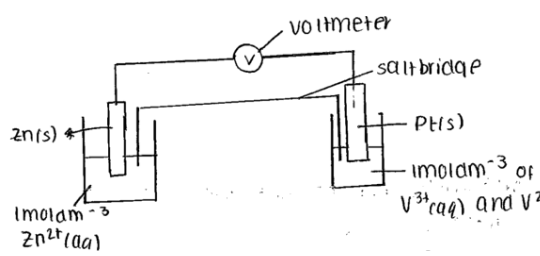
Question		Answer	Marks	Guidance
	(b)	Complete circuit AND voltmeter AND labelled salt bridge linking two half-cells ✓ Pt AND Fe²⁺ AND Fe³⁺ ✓ Pt AND H₂ AND H⁺ AND delivery system for H₂ gas ✓ Standard conditions 1 mol dm⁻³ AND Temperature: 298 K / 25 °C AND Pressure: 1 atm / 100 kPa/101 kPa ✓	4	Electrodes / salt bridge must at least touch the surface of solutions ALLOW small gaps in circuit wires ALLOW half-cells drawn on either side ALLOW a formula of a strong acid for H⁺ For standard conditions: Can be awarded if all quoted on standard condition line or in labelled diagram. ALLOW 1M ALLOW equimolar solutions for Fe²⁺ AND Fe³⁺ only. i.e. need 1 mol dm⁻³ for [H⁺] IGNORE H₂SO₄ in diagram unless concentration is stated with a value other than 0.5 moldm⁻³ DO NOT ALLOW if any concentration is incorrect
	(c)	(i) Li + CoO ₂ → LiCoO ₂ ✓	1	ALLOW ⇌ DO NOT ALLOW uncanceled species

Question	Answer	Marks	Guidance
	(ii) Cell potentials: $(E^\ominus) = 1.23 - 0.00$ OR 1.23 (V) OR (redox system 6 – redox system 3) = 1.23 (V) AND $(E^\ominus) = 0.40 - (-0.83) = 1.23$ (V) OR (redox system 4 – redox system 2) = 1.23 (V) ✓ Acidic <i>Cell equation</i> $(2\times) \text{H}_2 \rightleftharpoons 2\text{H}^+ + 2\text{e}^-$ AND $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$ AND $2 \text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ ✓ Alkaline <i>Cell equation</i> $(2\times) \text{H}_2 + 2\text{OH}^- \rightleftharpoons 2\text{H}_2\text{O} + 2\text{e}^-$ AND $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightleftharpoons 4\text{OH}^-$ AND $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$ ✓	3	IGNORE state symbols throughout ALLOW multiples ALLOW $\rightleftharpoons$ Overall equation AND with evidence of working: e.g. half-equations written out / combined but not cancelled / with crossings out OR <u>System 6</u> goes forward / reduced OR <u>system 3</u> goes backwards / oxidised ALLOW multiples Overall equation AND with evidence of working: e.g. half-equations written out / combined but not cancelled / with crossings out OR <u>System 4</u> goes forward / reduced OR <u>system 2</u> goes backwards oxidised

Question	Answer	Marks	Guidance
30	C	1	

Question	Answer	Marks	Guidance
31	B	1	

Question			Answer	Mark	Guidance
32	(a)		(Simultaneous) oxidation and reduction of (the same) <u>element</u> ✓ N from +3 (in HNO_2) to +5 (in HNO_3) AND N from +3 (in HNO_2) to +2 (in NO) ✓ N is oxidised to HNO_3 AND N is reduced to NO ✓	3	ALLOW N / nitrogen for element IGNORE species for element + required ALLOW 3+, 5+, and 2+ DO NOT ALLOW N^{3+} , N^{5+} and N^{2+} ALLOW clearly assigned oxidation numbers above the equation if not quoted on the answer line

33	(a)	(i)	<i>Circuit:</i> complete circuit AND voltmeter AND labelled salt bridge linking two half-cells ✓ <i>Half cells</i> Pt AND V^{2+} AND V^{3+} ✓ Zn AND Zn^{2+} ✓ <i>Standard conditions:</i> 1 mol dm⁻³ seen anywhere in response AND 298 K / 25°C ✓	4	FULL ANNOTATIONS MUST BE USED Electrodes / salt bridge must at least touch the surface ALLOW small gaps in circuit wires ALLOW half cells drawn either way around  ALLOW 1 M IGNORE Equimolar for half cell 4 IGNORE 1 mol / dm³ IGNORE pressure DO NOT ALLOW 1 mol(e) for concentration
		(ii)	(+)0.5(0) V ✓	1	$E^\ominus_{\text{cell}} = -0.26 - (-0.76) = +0.5$ DO NOT ALLOW -0.5V

Question			Answer	Mark	Guidance
	(b)		Equations $\text{Co} + 2\text{VO}^{2+} + 4\text{H}^+ \rightarrow \text{Co}^{2+} + 2\text{V}^{3+} + 2\text{H}_2\text{O}$ ✓ $\text{Co} + 2\text{V}^{3+} \rightarrow \text{Co}^{2+} + 2\text{V}^{2+}$ ✓ Comparison of E values (E of) Co / system 3 is more negative/less positive than (E of) VO^{2+} / system 5 AND (E of) Co / system 3 is more negative/less positive than (E of) V^{3+} / system 4 ✓ Equilibrium shift related to E values (3/5 OR 3/4) More negative/less positive (Co) / system 3 shifts left AND Less negative/more positive VO^{2+} / system 5 shifts right OR Less negative/more positive V^{3+} / system 4 shifts right ✓	4	ALLOW multiples ALLOW $\rightleftharpoons$ ALLOW CO as Co IGNORE state symbols even if wrong IGNORE higher / lower electrode potential IGNORE use of $< / >$ for E comparison ALLOW E_{cell} is (+)0.62V for Co / VO^{2+} cell AND E_{cell} is (+)0.02V for Co / V^{3+} cell ALLOW both half equations with <u>one</u> headed arrow ($\rightarrow$) for each half equation in correct direction for systems 3/5 OR systems 3/4 e.g. $2\text{H}^+ + \text{VO}^{2+} + \text{e}^- \rightarrow \text{V}^{3+} + \text{H}_2\text{O}$ AND $\text{Co} \rightarrow \text{Co}^{2+} + 2\text{e}^-$ IGNORE working on the table, treat as rough working

Question			Answer	Mark	Guidance
34	(a)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 65.4% award 5 marks $n(\text{S}_2\text{O}_3^{2-}) = \frac{31.15 \times 0.0800}{1000} = 2.492 \times 10^{-3} \checkmark$ $n(\text{Cu}^{2+}) \text{ in } 25 \text{ cm}^3 = 2.492 \times 10^{-3}$ OR $n(\text{I}_2) = 1.246 \times 10^{-3} \checkmark$ $n(\text{Cu}^{2+}) \text{ in } 250 \text{ cm}^3 = 2.492 \times 10^{-2} \checkmark$ Mass $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ in mixture A = $2.492 \times 10^{-2} \times 249.6$ $= 6.22(0032) \text{ g} \checkmark$ $\% = \frac{6.22 \times 100}{9.51} = 65.4 \%$ (3 SF required) $\checkmark$	5	ALLOW ECF throughout ALLOW 3 SF up to calculated value IGNORE rounding errors after 3 SF Common Errors 4 marks 65.2% (use of 249 rather than 249.6) 41.8% (use of 159.6 (CuSO_4)) 32.7% (no use of second ratio) 6.54% (no x 10)
		(ii)	Iron(III) / Fe^{3+} reacts with iodide ions (I^-) to form <u>iodine</u> (I_2) OR Iron(III) / Fe^{3+} oxidises $\text{I}^- \checkmark$	1	ALLOW ORA ALLOW (because) Iron(III) is reduced by /reacts with thiosulfate