


Question	Answer	Marks
8(a)(i)	M1 potential difference between two half-cells/two electrodes in a cell M2 under conditions of 1 atm., 298 K, (all) solutions being 1 mol dm ⁻³	2
8(a)(ii)	both platinum	1
8(a)(iii)	$E^{\circ}_{\text{cell}} = 1.82 - 1.36 = (+)0.46 \text{ V}$	1
8(a)(iv)	$2\text{Co}^{3+} + 2\text{Cl}^{-} \rightarrow \text{Cl}_2 + 2\text{Co}^{2+}$	1
8(b)	M1 $Q = 2.5 \times 30 \times 60 \text{ C} = 4500 \text{ C}$ AND 96500 OR 579000 seen moles of $\text{CO}_2 = 4500/579000 = 7.8 \times 10^{-3}$ or 7.77×10^{-3} M2 volume of $\text{CO}_2 = 7.77 \times 10^{-3} \times 24000 = 187 \text{ cm}^3$	2

Question	Answer	Marks
3(a)(i)	hydrogen, delivery system, H^+ , platinum, [1]	1
3(a)(ii)	iron hydrogen iron [1]	1
3(b)(i)	(for specified V^{2+} , V^{3+} or VO^{2+}) E° is more positive than / above -0.44 AND more negative than / below 0.77 V [1]	1
3(b)(ii)	V and VO_2^{+} [1]	1
3(b)(iii)	$\text{V} + \text{Fe}^{2+} \rightarrow \text{V}^{2+} + \text{Fe}$ OR $\text{VO}_2^{+} + 2\text{H}^{+} + \text{Fe}^{2+} \rightarrow \text{VO}^{2+} + \text{H}_2\text{O} + \text{Fe}^{3+}$ [1]	1
3(c)(i)	Nernst: $E = 0.77 + (0.059/z)\log[\text{ox}]/[\text{red}]$ [1] 0.947 [1]	2
3(c)(ii)	$2\text{Fe}^{3+} + \text{Cl}^{-} + 2\text{OH}^{-} \rightarrow 2\text{Fe}^{2+} + \text{ClO}^{-} + \text{H}_2\text{O}$ [1]	1
3(d)	$E^{\circ}_{\text{cell}} = 1.33 \text{ V}$ [1] $\Delta G^{\circ} = -nE^{\circ}_{\text{cell}}F$ [1] -257 [1]	3

Question	Answer	Marks
3(e)	$0.64 \times 17 \times 60 = 653/652.8 \text{ Coulombs}$ [1] $652.8 \div 1.6 \times 10^{-19} = 4.08 \times 10^{21}$ (number of electrons) $4.08 \times 10^{21} \div 2 = 2.04 \times 10^{21}$ (number of atoms Fe) [1] $0.185 \div 55.8 = 3.31 \times 10^{-3}$ (number of moles Fe atoms) $2.04 \times 10^{21} \div 3.31 \times 10^{-3} = L = 6.153 \times 10^{23}$ [1]	3
3(f)(i)	$\Delta S = -179$ [1] $\Delta G = \Delta H - T\Delta S$ [1] -74.7 [1]	3
3(f)(ii)	less AND ΔG becomes more positive [1]	1

PUBLISHED

Question	Answer	Marks
1(a)(i)	oxidising agent [1] $\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{I}^- \rightarrow 2\text{H}_2\text{O} + \text{I}_2$ [1]	2
1(a)(ii)	M1: $K_{pc} (93.8) = [\text{I}_2(\text{cyclohexane})] + [\text{I}_2(\text{aq})]$ $93.8 = (0.390 / 15) + (x / 20)$ M2: mass of $\text{I}_2(\text{aq})$, $x = 5.54 \times 10^{-3}$ (g) ecf	2
1(a)(iii)	<ul style="list-style-type: none"> K_{pc} would be lower hexan-2-one is more polar (than cyclohexane) OR hexan-2-one is polar AND cyclohexane is non-polar I_2 is (therefore) less soluble in hexan-2-one <i>All three correct for two marks</i>	2
1(b)(i)	enthalpy change when one mole of a solute AND dissolves in water to form a solution of infinite dilution	1
1(b)(ii)	$-(-629) + (-322) + (-293) = (+)14$ (kJ mol ⁻¹)	1
1(b)(iii)	(cationic) charge density decreases Li^+ to K^+ [1] so lattice energies become less negative / less exothermic AND because less attraction between ions [1]	2
1(c)(i)	M1: moles of thiosulfate = $0.02230 \times 0.150 = 3.345 \times 10^{-3}$ M2: $[\text{Cu}^{2+}] = 2 \times \frac{1}{2} \times 3.345 \times 10^{-3} + 0.0250 = 0.134$ (mol dm ⁻³) ecf	2
1(c)(ii)	starch	
1(c)(iii)	 3d _{xy}	1
1(d)	Reduction of Fe^{3+} : $2\text{Fe}^{3+} + 2\text{I}^- \rightarrow 2\text{Fe}^{2+} + \text{I}_2$ [1] Regeneration of Fe^{3+} : $2\text{Fe}^{2+} + \text{S}_2\text{O}_8^{2-} \rightarrow 2\text{Fe}^{3+} + 2\text{SO}_4^{2-}$ [1]	2

PUBLISHED

Question	Answer	Marks
1(e)	M1: $([\text{Hg}^{2+}]) = 1.00 \times 10^{-7} + 454.4 = 2.20 \times 10^{-10}$ (mol dm ⁻³) M2: $K_{sp} = [\text{Hg}^{2+}][\text{I}^-]^2 = 4[\text{Hg}^{2+}]^3 = 4.26 \times 10^{-29}$ ecf M3: units = mol ³ dm ⁻⁹ ecf	3

Question	Answer	Marks
1(a)	Platinum and platinum	1
1(b)(i)	M1: Nernst quoted correctly $E = E^\ominus + 0.0590 / z \log [\text{ox}] / [\text{red}]$ or $E = 1.49 + 0.0590 \log 5$ M2: (+)1.53 V minimum 2 sig. fig. Correct answer scores 2 marks	2
1(b)(ii)	+/- 0.46 minimum 2 sig. fig.	
1(b)(iii)	M1: $\text{Mn}^{3+} + 2\text{Br}^- \rightarrow \text{Mn}^{2+} + \text{Br}_2$ M2: $2\text{Mn}^{3+} + 2\text{Br}^- \rightarrow \text{Mn}^{2+} + \text{Br}_2$	2
1(c)	M1: 16200 C M2: 1.0125×10^{23} electrons (use of 1.60×10^{-19}) M3: 0.0802 moles of copper (use of 5.09 and 63.5) M4: 0.1603 moles electrons M5: $L = 6.32 \times 10^{23}$ (correct answer [5]) other approaches acceptable including: M1: 16200 C M2: 1.0125×10^{23} electrons (use of 1.60×10^{-19}) M3: 5.0625×10^{22} copper atoms M4: 0.0802 moles of copper (use of 5.09 and 63.5) M5: $L = 6.32 \times 10^{23}$ (correct answer [5])	5
1(d)	M1: $\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$ $E^\ominus = -2.38$ and $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ $E^\ominus = 0.00$ M2: hydrogen produced instead / hydrogen easier to reduce / hydrogen preferentially reduced / hydrogen has more positive E^\ominus	2

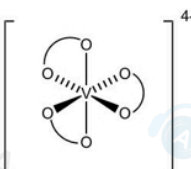
3/12

Question	Answer	Marks
3(a)	(a d-block element forms one or more) stable ions with incomplete filled d-subshell	1
3(b)(i)	<ul style="list-style-type: none"> they behave as catalysts they form complex ions / complexes they form coloured compounds / salts / ions any two	1
3(b)(ii)	the d and s sub-shells/orbitals are close/similar in energy	1
3(c)(i)	0.02500×0.0300 OR $7.50 \times 10^{-4} \text{ mol VO}_2^+$ $\text{OR } \frac{1}{2}(28.15 + 28.10)/1000 \times 0.0400$ OR $1.13 \times 10^{-3} \text{ mol C}_2\text{O}_4^{2-}$	1
	Use of their values to show ratio of $\text{VO}_2^+ : \text{C}_2\text{O}_4^{2-} = 1:1.5$ ALLOW any viable approach	1

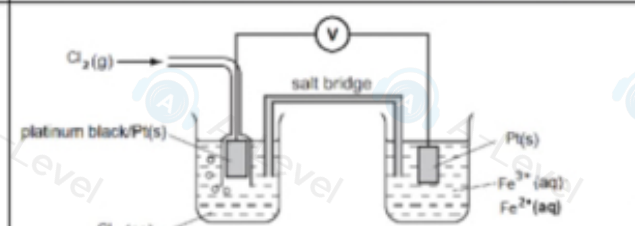
9701/42

Cambridge International AS & A Level – Mark Scheme
PUBLISHED

February/March 2023

Question	Answer	Marks
3(c)(ii)		1
3(d)(i)	VO_2^+ AND E^\ominus of H_2O_2 is largest / most positive value OR VO_2^+ AND E^\ominus is less positive than H_2O_2	1
3(d)(ii)	+5	1

PUBLISHED

Question	Answer	Marks
9(a)	potential difference / voltage between the two half-cells / two electrodes (in a cell) under standard conditions	1
9(b)	 <p> salt bridge voltmeter complete circuit [wires/salt bridge in/touching both solutions] Cl_2 Cl^- good delivery system (no arrow required) Pt Pt Fe^{2+} and Fe^{3+} </p> <p>Any three [1], any six [2], all nine [3]</p>	3
9(c)	M1 $(\Delta G^\ominus) = -nFE_{\text{cell}}^\ominus$ OR $-2 \times 96500 \times 0.59$ M2 $\Delta G^\ominus = -2 \times 96500 \times 0.59 = -113870 \text{ J mol}^{-1}$ $\Delta G^\ominus = -114 \text{ kJ mol}^{-1}$ min 3sf ecf	2
9(d)(i)	$E = 0.77 + (0.059 / 1) \log (1/0.15)$ use of $z = 1$ $E = 0.82 \text{ V}$	1
9(d)(ii)	$E_{\text{cell}} = 0.59 + 0.77 - (\text{answer to (d)(i)}) = 0.54 \text{ V ecf}$	1

Question	Answer	Marks
2(a)(i)	$2\text{LiNO}_3 \rightarrow \text{Li}_2\text{O} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$	1
2(a)(ii)	M1 radius / size of cation / M^+ increases OR charge density of ion decreases M2 less polarisation / distortion of anion / nitrate ion / NO_3^- / less weakening of NO bond	2
2(b)	M1 M2 any two for one mark or all four for two marks: <ul style="list-style-type: none"> mol total $\text{MnO}_4^- = 0.125 \times 0.0500 = 6.25 \times 10^{-3}$ mol $\text{Fe}^{2+} = 0.0400 \times 0.0225 = 9.00 \times 10^{-4}$ mol unreacted $\text{MnO}_4^- = 9.00 \times 10^{-4} + 5 = 1.80 \times 10^{-4}$ ecf mol reacted $\text{MnO}_4^- = 6.25 \times 10^{-3} - 1.80 \times 10^{-4} = 6.07 \times 10^{-3}$ ecf M3 mol $\text{NO}_2^- = 2.5 \times 6.07 \times 10^{-3} = 1.5175 \times 10^{-2}$ conc $\text{NaNO}_2 = 4 \times 1.5175 \times 10^{-2} = 6.07\text{-}6.08 \times 10^{-2}$ mol dm^{-3} ecf min 2sf	3
2(c)(i)	$3\text{MnO}_4^{2-} + 4\text{H}^+ \rightarrow 2\text{MnO}_4^- + \text{MnO}_2 + 2\text{H}_2\text{O}$ M1 MnO_4^{2-} as a reactant and $\text{MnO}_4^- + \text{MnO}_2$ products identified M2 correct equation	2
2(c)(ii)	(E_{cell}) decreases / becomes less positive AND as $[\text{H}^+]$ decreases AND equilibrium shifts to the left OR in alkali the $E_{\text{cell}} = 0.60 - 0.56 = 0.04$ V (working required)	1

PUBLISHED

Question	Answer	Marks								
1(a)(i)	$3s^2 3p^6 3d^9$ [1]	1								
1(a)(ii)	$[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (pale) blue CuCl_4^{2-} yellow both [1]	1								
1(a)(iii)	M1 energy gap / ΔE is different (for the ligands) [1] M2 different frequency / wavelength of light absorbed / transmitted / reflected [1]	2								
1(b)	M1 (Cu^+/Ag^+) d-shell is full / complete OR d-orbitals are full [1] M2 no electrons can be promoted [1]	2								
1(c)(i)	solubility = $\sqrt{5.0 \times 10^{-13}} = 7.1 \times 10^{-7}$ (mol dm^{-3}) [1] min 2sf	1								
1(c)(ii)	M1 (in conc. NH_3) $[\text{NH}_3]$ increases and equilibrium 2 shifts to the right [1] M2 $[\text{Ag}^+]$ decreases and equilibrium 1 shifts to the right [1]	2								
1(c)(iii)	$\text{AgBr} + 2\text{NH}_3 \rightleftharpoons [\text{Ag}(\text{NH}_3)_2]^+ + \text{Br}^-$ [1]	1								
1(c)(iv)	$K_{\text{eq3}} = K_{\text{sp}} \times K_{\text{stab}}$ [1] ALLOW $K_{\text{eq3}} = \frac{[\text{Ag}(\text{NH}_3)_2^+][\text{Br}^-]}{[\text{NH}_3]^2}$	1								
1(d)	The potential difference when a half-cell is connected to a (standard) hydrogen electrode under standard conditions [1] OR the potential difference / voltage / EMF between a hydrogen electrode and another half-cell under standard conditions [1]	1								
1(e)(i)	<table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">salt bridge</td> <td style="width: 50%;">• voltmeter / V •</td> </tr> <tr> <td>Ag</td> <td>• Ag^+ (or soluble silver salt) •</td> </tr> <tr> <td>Pt</td> <td>• H_2 (and delivery correct) + H^+ (or named strong acid) •</td> </tr> <tr> <td>1 atm. (pressure)</td> <td>• 1 mol dm^{-3} (and 298 K) •</td> </tr> </table> <p style="text-align: right;">mark as •••••••• [4]</p>	salt bridge	• voltmeter / V •	Ag	• Ag^+ (or soluble silver salt) •	Pt	• H_2 (and delivery correct) + H^+ (or named strong acid) •	1 atm. (pressure)	• 1 mol dm^{-3} (and 298 K) •	4
salt bridge	• voltmeter / V •									
Ag	• Ag^+ (or soluble silver salt) •									
Pt	• H_2 (and delivery correct) + H^+ (or named strong acid) •									
1 atm. (pressure)	• 1 mol dm^{-3} (and 298 K) •									
1(e)(ii)	Ag electrode labelled and arrow (in the external circuit moving towards this electrode) [1]	1								