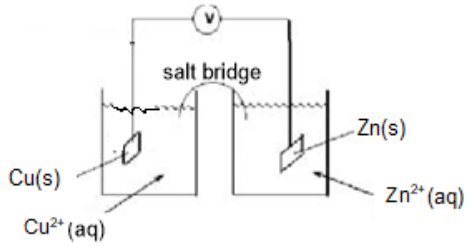
2(a)	the (3)d and (4)s sub-shells / orbitals / electrons are close / similar in energy
2(b)	species or ion formed by a central metal atom/ion **AND** surrounded by/bonded to (one or more) ligands
2(c)(i)	NaOH / OH^-(aq) **AND** precipitation / ligand exchange / deprotonation / acid–base
2(c)(ii)	**M1**: $Fe(H_2O)_4(OH)_2$ is oxidised (from + 2 to + 3 on standing) **M2**: $E^\ominus$ of $Fe(H_2O)_3(OH)_3$ is more negative than $E^\ominus$ of O_2 **OR** $E^\ominus_{cell}$ = 0.40 – (–0.56) = (+)0.96 V **M3**: $4Fe(H_2O)_4(OH)_2 + O_2 \rightarrow 4Fe(H_2O)_3(OH)_3 + 2H_2O$
2(d)	$\Delta G^\ominus = -2 \times 1.67 \times 96\,500 = -322\,310$ J mol^{-1} **M1:** $\Delta G^\ominus = -nE^\ominus_{cell}F$ **AND** n = 2 **OR** $-2 \times 1.67 \times 96\,500$ **M2:** $\Delta G^\ominus$ = –322.3 kJ mol^{-1}

4(a)	**M1:** potential difference / voltage / EMF **AND** between two half-cells / two electrodes (in a cell) **M2:** (at concentration of) 1 mol dm^{-3} **AND** (pressure of) 1 atm / 101 kPa **AND** (temperature of) 298 K / 25 °C
4(b)(i)	 **M1**: salt bridge labelled **AND** voltmeter / V **AND** wire to electrode and liquid level shown [complete circuit] **M2**: Cu(s) **AND** Cu^{2+}(aq) **M3**: Zn(s) **AND** Zn^{2+}(aq)
4(b)(ii)	ions **AND** electrons
4(b)(iii)	**M1**: Nernst equation $E = E^\ominus + (0.059/z) \log(Zn^{2+}/Zn)$ **M2**: E = –0.76 + (0.059 / 2) log(0.25) = –0.778 V **OR** $E = -0.76 + (8.31 \times 298) / (96\,500 \times 2) \ln(0.25)$ = –0.778 V min 2sf
4(c)(i)	(from) +4 (to) +3
4(c)(ii)	$Zn + 2MnO_2 \rightarrow ZnO + Mn_2O_3$
4(c)(iii)	$E^\ominus (MnO_2 / Mn_2O_3)$ = 1.47 – 1.28 = (+)0.19 V

5(a)(i)	Co^{2+} = [Ar] $3d^7$ **AND** Co^{3+} = [Ar] $3d^6$
5(a)(ii)	has vacant d orbitals that are energetically accessible
5(a)(iii)	• pink • blue • aqueous Any two [1], all three [2]
5(a)(iv)	$[Co(H_2O)_6]^{2+} + 4HCl \rightarrow [CoCl_4]^{2-} + 6H_2O + 4H^+$ **OR** $[Co(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CoCl_4]^{2-} + 6H_2O$

5(a)(v)	ligand exchange
5(a)(vi)	$[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(OH)_2(H_2O)_4 + 2H_2O$ **OR** $[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(OH)_2 + 6H_2O$
5(b)(i)	**M1:** Nernst equation $E = E^{\ominus} + (0.059 / z) \times \log(\frac{[\text{oxidised}]}{[\text{reduced}]})$ **M2:** $E = -0.28 + (0.059 / 2) \times \log(0.02)$
5(b)(ii)	1.66 V
5(b)(iii)	$3Co + Cr_2O_7^{2-} + 14H^+ \rightarrow 3Co^{2+} + 2Cr^{3+} + 7H_2O$
5(b)(iv)	Co^{2+} / Co, Co^{2+} / Co, $Cr_2O_7^{2-}$ / Cr^{3+}
5(c)	**M1:** moles of cobalt = 0.547 / 58.9 = 0.00929 **M2:** coulombs required = $0.00929 \times 96500 \times 2 = 1792$ **M3:** time required = 1792 / 0.50 = 3584.8 s = 59.7 minutes 3sf