Redox Equilibria - Mark Scheme

Q1.

Question number	Answer		Additional guidance	Marks
(a)	• copper is **oxidised** from 0 to +2 • nitrogen is **reduced** from (+)5 to (+)4	(1) (1)	Look at the equation in the question for the correct oxidation number changes if not given on the answer lines Award maximum of one mark if the terms oxidised and reduced are not used or used the wrong way round	2

Question number	Answer		Additional guidance	Mark
(b)	An answer which makes reference to the following points: • (precaution) carry out in a fume cupboard • (hazard) toxic nitrogen dioxide/NO_2 gas.	 (1) (1)	Accept the points in either order Do not award 'well-ventilated laboratory/ face masks' Allow poisonous	2

Question number	Answer		Additional guidance	Marks
(c)	• calculation of the number of moles of thiosulfate • evaluation of the number of moles of iodine • evaluation of the number of moles of copper ions in the 10.0 cm^3 aliquot • evaluation of the number of moles of copper ions in 250 cm^3 • evaluation of mass of copper ions in sample • evaluation of percentage of copper in sample to 2/3 SF	(1) (1) (1) (1) (1) (1)	Example of calculation: $n(S_2O_3^{2-}) = (22.65 \times 0.100 \div 10000=)$ $= 2.265 \times 10^{-3}$ /0.002265 (mol) $n(I_2) = (2.265 \times 10^{-3} \div 2=)$ $= 1.1325 \times 10^{-3}$ / 0.0011325 (mol) $n(Cu^{2+}) = (1.1325 \times 10^{-3} \times 2=)$ $= 2.265 \times 10^{-3}$ / 0.002265 (mol) $n(Cu^{2+}) = (2.265 \times 10^{-3} \times 25)$ $= 5.6625 \times 10^{-2}$ / 0.056625 (mol) $m(Cu^{2+}) = (5.6625 \times 10^{-2} \times 63.5=)$ $= 3.5956875$ (g) % = (3.5956875 ÷ 5.0000 × 100= 71.91375=) = 72/71.9 % Penalise inappropriate rounding once only Correct answer with no working scores 6 marks	6

Question number	Answer	Additional guidance	Marks
(d)	An answer that makes reference to the following points: • colours of the precipitates formed (1) • addition of excess sodium hydroxide has no effect on copper precipitate (1) • but the zinc precipitate dissolves to form colourless solution (1) • equation for the formation of a precipitat for either copper(II) or zinc ions (1) • equation for the dissolving of the zinc precipitate (1) • all state symbols correct. (1)	Blue precipitate with copper(II) ions **and** white precipitate with zinc ions Do not award 'clear' Example of equations: $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(H_2O)_4OH)_2(s) + 2H_2O(l)$ or $[Zn(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s) + 6H_2O(l)$ or $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ or $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$ $Zn(OH)_2(s)+2OH^-(aq) \rightarrow [Zn(OH)_4]^{2-}(aq)$	6

Question number	Answer	Additional guidance	Marks
(e)	An explanation that makes reference to: • copper forms an ion with an incomplete d subshell (1) • but the only ion that zinc forms has a completely filled d subshell. (1)		2

Question number	Answer	Additional guidance	Marks
(f)	A explanation that makes reference to: • the atoms/cations are of different size (in brass) (1) • therefore the layers do not slide over one another so easily. (1)	Ignore movement of the electrons Accept a labelled diagram	2

Q2.

Question number	Answer	Mark
	A $\frac{1}{2}O_2(g) + H_2O(l) + 2e^- \rightarrow 2OH^-(aq)$	1

Q3.

Question number	Answer	Mark
(a)	D the colour change of the reduction of the manganate(VII) ions is sufficient	1

Question number	Answer	Mark
(b)	B uncertainty 0.06%	1

Question number	Answer	Mark
(c)	D 0.014	1

Q4.

Question number	Answer	Additional guidance	Marks
(a)	• 298 K and 100 kPa (of gases)	Accept 25 °C Accept 1 atm	1

Question number	Answer	Additional guidance	Marks
(b)(i)	• $E^{\ominus}_{cell}$ = (+0.34 – −0.76=) (+)1.10 (V)		1

Question number	Answer	Additional guidance	Marks
(b)(ii)	An answer to include observations such as: • blue colour of copper(II) sulfate becomes paler • (pink/brown) copper metal deposited (on the electrode surface) • zinc electrode decreases in size.	Observations can be in any order Three observations scores 2 Two observations scores 1	2

Question number	Answer	Additional guidance	Marks
(c)	A justification that makes reference to the following points: • Iron $E^{\ominus}_{cell}$ = (−0.44 – +0.77 =) −1.21 (V) **and** Copper $E^{\ominus}_{cell}$ = (+0.52 – +0.15 =) +0.37 (V) (1) • $2Cu^{+} \rightarrow Cu^{2+} + Cu$ (1) • comment on copper electrode potential is positive so disproportionation is feasible and iron electrode potential is negative so disproportionation is not feasible. (1)	Ignore: $3Fe^{2+} \rightarrow Fe + 2Fe^{3+}$ Ignore state symbols	3

Question number	Answer	Additional guidance	Marks
(d)	• High activation energy/physical barrier prevents reaction Reaction is (very) slow Reaction conditions may not be standard		1