Question Number	Acceptable Answers	Reject	Mark
1 (a)	Either Anode $H_2 - 2e^{(-)} \rightarrow 2H^+$ **(1)** Cathode $O_2 + 4H^+ + 4e^{(-)} \rightarrow 2H_2O$ **(1)** Or Anode $H_2 + 2OH^- - 2e^{(-)} \rightarrow 2H_2O$ **(1)** Cathode $O_2 + 2H_2O + 4e^{(-)} \rightarrow 4OH^-$ **(1)** Electrons can be on either side of the equation Allow multiples Allow equilibria signs Ignore state symbols		**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)	One advantage e.g. quieter, more efficient (energy transfer), no NO_x formed Ignore references to carbon dioxide and / or water as only product	Just easier to control	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c)	Ethanol can be obtained from biomass / plants / fermentation / ethanol is a bio fuel **(1)** hydrogen from (electrolysis of) water using a non-fossil source of energy **(1)** these are renewable / fossil fuels are a finite resource **(1)** Allow for third mark so less burning/use of fossil fuels hence lower carbon emissions / less impact on greenhouse effect		**3**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(i)	**Copper:** 0 to +2/2+/2^+/II/2 **(1)** **Nitrogen:** +5/5+/5^+/V/5 to +4/4+/4^+/IV/4 **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	$Cu \rightarrow Cu^{2+} + 2e^{(-)}$ OR $Cu - 2e^{(-)} \rightarrow Cu^{2+}$ **(1)** $Cu[(H_2O)_6]^{2+}$ OK if 6 waters shown on l.h.s. $NO_3^- + 2H^+ + e^{(-)} \rightarrow NO_2 + H_2O$ OR $2NO_3^- + 4H^+ + 2e^{(-)} \rightarrow 2NO_2 + 2H_2O$ **(1)** OR $2NO_3^- + 4H^+ + 2e^{(-)} \rightarrow N_2O_4 + 2H_2O$ **(1)** Ignore the full equation if it is given as well Allow equations written as reverse of above Ignore state symbols even if wrong Allow $\rightleftharpoons$ for $\rightarrow$		**2**

Question Number	Acceptable Answers	Reject	Mark
2(a)(iii)	(electrode potential) values are for standard conditions **(1)** **nitric acid** is concentrated / not 1 mol dm^{-3} / not 1 M **(1)** Allow temperature not stated for second mark	NO_3^- are not 1 mol dm^{-3} Any reference to loss of NO_2	**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	initially a (pale/light) **blue precipitate (1)** Allow blue solid Ignore white precipitate (re-dissolves in excess to form) a (deep) blue **solution (1)** Stand alone mark Accept any shade of blue except greenish-blue	Any colour (other than blue) precipitate in blue solution	**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ **(1)** $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$ **(1)** $Zn(OH)_2(s) + 2OH^-(aq) \rightarrow Zn(OH)_4^{2-}(aq)$ **(1)** If two previous equations combined correctly then **(1)** only : $Zn^{2+} + 4OH^- \rightarrow Zn(OH)_4^{2-}$ **Allow** $Zn(OH)_2(s) + 2OH^-(aq) \rightarrow ZnO_2^{2-}(aq) + 2H_2O(l)$ OR $Zn(OH)_2(s) + 4OH^-(aq) \rightarrow Zn(OH)_6^{4-}(aq)$ OR equivalent non-ionic equations, including those with $Zn^{2+} + 2NaOH$ etc OR Correct balanced equations starting with hexaqua or tetraqua cations ALLOW the hydroxides to be shown as e.g. $Zn(OH)_2(H_2O)_4(s)$ provided that the whole equation balances. Penalise missing /incorrect state symbols on product once only. Ignore other state symbols		**3**

Question Number	Acceptable Answers	Reject	Mark
2(b)(iii) **QWC**	**First 2 marks:** zinc **hydroxide/oxide** amphoteric because it reacts with alkali (to give a solution of a zincate) **(1)** and reacts with acid (to give a salt) **(1)** zinc hydroxide **is / acts as** both an acid and an alkali – scores **(1)** only **Third mark:** hexaquazinc or hydrated zinc ions exchanged water for ammonia or other named ligand **(1)** OR $Zn(H_2O)_6^{2+} + 4NH_3 \rightarrow$ etc **(1)** Allow any number of ammonias from 1 to 6 Allow balanced equations, ionic or full. Ligand exchange reaction must start with a complex ion **Note:** If zinc mentioned initially but equation refers to a correct compound then credit should be given If equations wrong but words are correct then ignore equations	Reference to zinc ions or zinc metal Do not allow deprotonation	**3**

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ Ignore state symbols even if wrong.	Non-ionic equation.	**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii) **QWC**	Amount thiosulphate = 0.0331 dm^3 x 0.1 mol dm^{-3} = 0.00331 mol **(1)** = amount of copper(II) ions in 25 cm^3 portion **(1)** ∴ amount Cu = 10 x 0.00331= 0.0331 mol in total **(1)** ∴ mass Cu = 0.0331 mol x 63.5 g mol^{-1} **(1)** = 2.102 g ∴ % copper = (2.102 x 100)÷ 3.00 **(1)** = 70.1% **(1)** to **3 s.f. only** Mark consequentially but if % > 100 then (-1) If equation in (i) is incorrect but used correctly in part (ii) then all marks can be scored unless answer > 100% Correct answer can score 6 marks irrespective of the stoichiometry of the equation in (c)(i) If candidates uses 64 for molar mass of Cu final answer will be 70.6; scores max of 5	70.06 or 70.0	**6**

Question Number	Acceptable Answers	Reject	Mark
2(c)(iii)	some reagent used to fill the jet (which does not react with the iodine solution) **and so** the titre is too high **(1)** and hence the percentage value would be too high **(1)** Allow only if the titre is said to be high If the titre is thought to be too low then allow percentage value too low for 2nd mark **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3(a)	$3d^3 4s^2$ OR $4s^2 3d^3$ $3d^5 4s^1$ OR $4s^1 3d^5$ both must be correct. ALLOW Electron numbers could be on the line or as subscripts IGNORE case of letters		**1**

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	Variable/varying/different/several/ more than one **oxidation state** /**number** **(1)** Complex (ion formation) **(1)** Treat Physical properties (if correct) including catalytic activity as neutral	Each metal has a different oxidation number Ligand exchange	**2**

Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	The following metals scores (2) marks with correct E value: Mg 1.96, Ce 1.92, U 1.39, Al 1.25, Mn 0.78, V 0.77, Zn 0.35 **NOTE:** Positive sign/unit not needed, but penalise negative value The following metals score (1) mark with correct E value: Li 2.62, Rb 2.52, K 2.51, Ca 2.46, Na 2.30, Cr 0.33, Fe 0.03 **NOTE:** Positive sign/unit not needed, but penalise negative value	All other metals 0/2	**2**

Question Number	Acceptable Answers	Reject	Mark
3(b)(iii)	Not a redox process Chromate and dichromate **both** the same/no change in oxidation number **(1)** contain Cr(VI) 6/6+ **(1)** Mark independently OR Not redox and **both** contain Cr(VI) 6/6+ **(2)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3(b)(iv)	Forms two (dative/covalent) bonds/has two lone pairs (to the Transition Metal/ion) OR donates two pairs of electrons (to the Transition Metal/ion) **Check answer to (v) if mark not awarded here**	'…to the molecule'	**1**

Question Number	Acceptable Answers	Reject	Mark
3(b)(v)	**Any two from** Both have two nitrogen atoms with lone pairs or implied **(1)** or Far enough apart/longer chain in between in en (but not in hydrazine)/too close in hydrazine/hydrazine is too short/not as long **(1)** or Dative bonds/lone pairs too close/repel in hydrazine **(1)** OR for two marks Forms 5-membered ring (with en with no angle strain/stable) **(2)** or Bond angles too acute/too much ring strain in hydrazine **(2)** **Mark for iv can be awarded here.**	N=N, or triple bond in hydrazine max 1 or if implies **only** en has lone pairs max 1	**2**

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	- 0.41 (V) +1.33 (V) **Both** answers needed, with number and sign, for 1 mark IGNORE additional words		**1**

Question Number	Acceptable Answers	Reject	Mark
***3(c)(ii) QWC**	Combines the equations to obtain $8Cr^{3+} + 7H_2O \rightarrow 6Cr^{2+} + Cr_2O_7^{2-} + 14H^+$ ALLOW $6Cr^{3+} + 2Cr^{3+}$ instead of $8Cr^{3+}$ IGNORE state symbols even if wrong species **(1)**, balance **(1)** $E^{\ominus}_{reaction}$ = — 1.74V **(1)** So not feasible on condition of negative value **(1)** OR $6Cr^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 8Cr^{3+} + 7H_2O$ If fully correct **(1)** $E^{\ominus}_{reaction}$ = + 1.74V **(1)** **Disproportionation** not feasible on condition of positive value but reject 'reaction is spontaneous' **(1)** **Other wrong equations** **IF** $Cr_2O_7^{2-}$ or Cr^{2+} on left Then + 1.74 V **(1)** **If** Cr^{3+} alone on the left Then -1.74 V **(1)** and reaction not feasible **(1)**	1 max for the equation if electrons are shown balanced or unbalanced	**4**