Question Number	Acceptable Answers	Reject	Mark
1(a)	**First mark** Electronic configurations: Cu^{2+} is [Ar] $3d^9$ **and** Zn^{2+} is [Ar] $3d^{10}$ IGNORE $4s^0$ / full electronic configuration of Ar **(1)** **Second mark** If both EC are correct: EITHER Copper (is a transition element because it) forms a (stable) **ion** with an incompletely / partially filled **d**-subshell / orbital(s) ALLOW forms an **ion** with unpaired **d** electron(s) OR Zinc only forms an **ion** with a full **d**-subshell / all **d** orbital**s** full **(1)** If one or both EC are incorrect: Copper (is a transition element because it) forms a (stable) **ion** with an incompletely filled **d**-subshell / orbital(s) **and** zinc only forms an **ion** with a full **d**-subshell / all **d** orbital**s** full **(1)**	d shell sub-shell / orbital other than 3d	**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(b)	$CuCl + AgCl \rightleftharpoons CuCl_2 + Ag$ OR $Cu^+ + Ag^+ \rightleftharpoons Cu^{2+} + Ag$ OR $CuCl + Ag^+ \rightleftharpoons Cu^{2+} + Ag + Cl^-$ ALLOW $\rightarrow$ **(1)** IGNORE state symbols / half-equations **Stand alone mark** (Equilibrium moves to the right in sunlight) producing silver **(1)** IGNORE copper(II) compounds	Copper (metal)/ copper(I) compounds	**(2)**

Question Number	Acceptable Answers	Reject	Mark
2(i)	Ni: $(1s^2\ 2s^2 2p^6)\ 3s^2 3p^6\ 3d^8\ 4s^2$ (1) Cu: $(1s^2\ 2s^2 2p^6)\ 3s^2 3p^6\ 3d^{10} 4s^1$ (1) ALLOW capital letters, subscripts for superscripts ALLOW 4s before 3d Penalise omission of $3s^2 3p^6$ once only if rest is correct		2

Question Number	Acceptable Answers	Reject	Mark
2*(ii)	First electron removed is from **4s** (in both atoms) (1) Second electron in Cu (is harder to remove so it is) EITHER closer to nucleus/in inner shell OR less shielded (1) IGNORE Comments about second electron being in full shell/ in a 3d shell/in a 3d orbital Reference to $3d^{10}$ stability		2

Question Number	Acceptable Answers	Reject	Mark
2a(iii)	(attraction on (3d) electrons increases due to) number of protons increasing / nuclear charge increasing IGNORE The charge density of the 2^+ ions increases Effective nuclear charge		1

Question Number	Acceptable Answers	Reject	Mark
2b(i)	$2Cu^{+}(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$ IGNORE Eqm sign for $\rightarrow$	Reverse equation Any equation involving electrons	1

Question Number	Acceptable Answers	Reject	Mark
2b(ii)	Both white ALLOW (both) Colourless (1) COMMENT Ignore states eg solution/precipitate As have $3d^{10}$ / have a full 3d sub-shell /**ALL** 3d orbitals are full (1) IGNORE Does not have partially filled d orbitals They do not absorb light No d-d transitions occur		2

Question Number	Acceptable Answers	Reject	Mark
2c	(Zinc) does not form a (stable) **ion** with incompletely/partially filled d orbitals ALLOW d sub-shell for d orbitals The only (stable) **ion** formed by zinc has full d sub-shell It does not form a (stable) oxidation state with incompletely/partially filled d orbitals	Element has full d shells.	1

Question Number	Acceptable Answers	Reject	Mark
3 (a)	(A transition metal) forms **ions / oxidation states** with partially filled / incomplete d orbital(s) / d sub-shell		1

Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	**W** = chromate(VI) (ion) / CrO_4^{2-} **(1)** **X** = chromium(III) hydroxide / $Cr(OH)_3$ / $Cr(OH)_3(H_2O)_3$ **(1)** **Y** = hexahydroxochromate(III) (ions) / $[Cr(OH)_6]^{3-}$ /tetrahydroxochromate(III) (ions) / $[Cr(OH)_4]^-$ / $[Cr(H_2O)_2(OH)_4]^-$ **(1)** **Z** = chromium(II) (ions) / chromium(II) sulfate / Cr^{2+} / $Cr^{2+}(aq)$ / $[Cr(H_2O)_6]^{2+}$ **(1)** ALLOW Name or formula of the compounds IGNORE Omission of square brackets around complexes	Names without oxidation numbers.	4

Question Number	Acceptable Answers	Reject	Mark
3 (b)(ii)	**A** = ethanol / C_2H_5OH / ethanal / CH_3CHO OR any primary or secondary alcohol or any aldehyde **(1)** **B** = zinc / Zn ALLOW magnesium / Mg **(1)** **C** = any acid (name or formula) **(1)** IGNORE Omission of (aq) with acid formula Concentration of acid	CH_3COH Alkali metals Tin / Sn H^+ or H_3O^+ or acid	3

Question Number	Acceptable Answers	Reject	Mark
3 (b)(iii)	$Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$ OR Multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
3 (b)(iv)	$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4H_2O$ Allow multiples **(1)** Chromium is reduced from (+)6 to (+)3 **(1)** Nitrogen is oxidized from −3 to 0 **(1)** Penalise use of 'changes' / 'increases' / 'decreases' for 'oxidises' or 'reduces' once only		3

Question Number	Acceptable Answers	Reject	Mark
3 (b)(v)	(chromium(II) ions) oxidized by (oxygen in the) air ALLOW Just 'oxygen'		1

Question Number	Acceptable Answers	Reject	Mark
3 (c)(i)	(A ligand is a) molecule or (negative) ion with a (lone) pair (of electrons) ALLOW Species / Compound / group **(1)** Which forms a dative covalent bond with a (central) metal ion or atom (to form a complex) **(1)** ALLOW (if no other marked scored) Electron pair donor	Positive ion	2

Question Number	Acceptable Answers	Reject	Mark
3 (c)(ii)	$Cr(H_2O)_6^{3+} + 6NH_3 \rightarrow Cr(NH_3)_6^{3+} + 6H_2O$ ALLOW $Cr(H_2O)_6^{3+} + 4NH_3 \rightarrow Cr(NH_3)_4(H_2O)_2^{3+} + 4H_2O$ Correct formula for ammine **(1)** Rest of the equation correct **(1)**	Cr^{3+} and $Cr^{3+}(aq)$	2

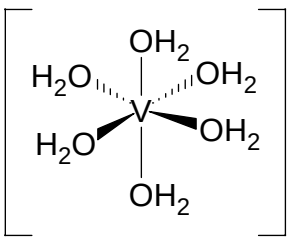
Question Number	Acceptable Answers	Reject	Mark
4 (a)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 (4s^0)$ **(1)** Accept $[Ar]3d^5(4s^0)$ (Ion) has an incompletely filled (3)d-orbital / sub-shell / unpaired d electron **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
***4 (b)**	Gases adsorb onto / bind to catalyst (surface) **(1)** Allow gases are absorbed onto surface Then react **and** desorb / leave **(1)** Reaction could be faster because Any two • These processes lower the activation energy (by providing an alternative route so a greater proportion of molecules react) • Bonds in reactant(s) are weakened • Reactants may be positioned in more favourable orientations • Reactants can migrate towards each other on surface • Increases likelihood of molecules coming into contact / colliding • Adsorption onto surface means more reactant molecules in a given space	Just 'bonds in reactants are broken'	**4**

Question Number	Acceptable Answers	Reject	Mark
4 (c)	E_{cell} for reaction is (+) 0.84 (V) (so will work) / E_{cell} for item 44 is more positive than for item 19 / illustrate using anti-clockwise rule **(1)** $2Fe + O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4OH^-$ or $2Fe + O_2 + 2H_2O \rightarrow 2Fe(OH)_2$ **(1)** E_{cell} for reaction is (+)0.96 (V) (so will work) / E_{cell} for item 44 is more positive than for item 17 / illustrate using anti-clockwise rule **(1)** $4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3$ **(1)**	Just 'because of the anti-clockwise rule'	**4**

Question Number	Acceptable Answers	Reject	Mark
4 (d)	Lone pair(s) (from nitrogen(s)) **(1)** Forms dative / dative covalent / coordinate bond (with Fe^{2+}) **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
5(a)(i)	Any TWO of: complex ions / complexes **(1)** coloured ions / compounds / solutions **(1)** catalytic properties **(1)** paramagnetic **(1)** Allow coloured complexes **(2)** coloured complex compound **(1)** If a list appears with 1 or 2 correct properties followed by properties related to the element, then (1) mark only Ignore 'partially filled *d*-orbitals'	complex compounds	**2**

Question Number	Acceptable Answers	Reject	Mark
5(a)(ii)	 ignore absence of charge **clearly** octahedral (ignore bonds to the H in H_2O) **(1)** but allow some latitude in the symbols used to show the 3D structure. Wedges do not have to be exact – if used they are enough to show 3D if the axial bonds are lines The word 'octahedral' does not salvage a poor drawing dative (covalent) / coordinate (bond) **(1)** not just shown by an arrow lone pair (of electrons on the oxygen) **(1)** can be shown on the diagram		**3**

Question Number	Acceptable Answers	Reject	Mark
5(b)(i)	(+) 0.34 (V) OR (+) 0,34 V sign not needed		**1**

Question Number	Acceptable Answers	Reject	Mark
5(b)(ii) QWC	(simultaneous) oxidation and reduction **(1)** Allow redox of a species / substance / reactant / compound / chemical / element **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
5(b)(iii)	− 0.66(V) **(1)** Allow TE from (b)(i) reaction not feasible **since the potential is negative** (2^{nd} mark is for an answer consistent with sign of E^{o}) **(1)**		**2**