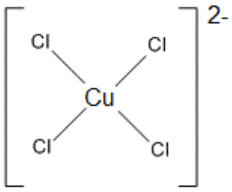
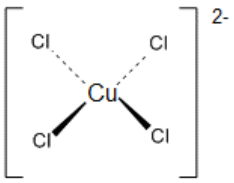
Question Number	Acceptable Answers	Reject	Mark
1(a)	**First mark** Electronic configurations: Cu^{2+} is [Ar] $3d^9$ **and** Zn^{2+} is [Ar] $3d^{10}$ IGNORE $4s^0$ / full electronic configuration of Ar **(1)** **Second mark** If both EC are correct: EITHER Copper (is a transition element because it) 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 → **(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
1(c)	Shape – square planar  or  ALLOW bonds with or without arrows ALLOW Cls joined by lines in a square ALLOW tetrahedral shape **(1)** IGNORE brackets and/or charges Bonding - dative (covalent) /co-ordinate ALLOW shown on diagram as arrows from Cl to Cu **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(d)(i)	$Cu + CuCl_2 + 2HCl \rightarrow 2[CuCl_2]^- + 2H^+$ OR $Cu + Cu^{2+} + 4Cl^- \rightarrow 2[CuCl_2]^-$ OR $Cu + [Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow 2[CuCl_2]^- + 6H_2O$ OR $Cu + [Cu(H_2O)_6]^{2+} + 4HCl \rightarrow 2[CuCl_2]^- + 6H_2O + 4H^+$ OR $Cu + CuCl_2 + 2Cl^- \rightarrow 2[CuCl_2]^-$ IGNORE state symbols, even if incorrect / missing brackets		**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(d)(ii)	Disproportionation is the simultaneous oxidation and reduction of a (single) species / atom / element / ion (to form 2 different oxidation states) **(1)** IGNORE reactant / substance / molecule / compound Not disproportionation because two different species (of copper) are oxidised and reduced OR Not disproportionation as (start with 2 different oxidation states of copper and) only produces 1 oxidation state ALLOW Disproportionation is the other way around / this is reverse disproportionation / comproportionation **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(d)(iii)	The d-subshell is full / d^{10} OR **all** d orbital**s** are full ALLOW d shell is full **(1)** d-d transitions cannot take place OR Electrons cannot move between **d** orbitals OR Electrons cannot be promoted / excited to higher **d** orbital(s) **(1)** IGNORE just 'movement to different energy level'	d orbital any number other than 3(d) d-subshell / d orbitals do not split	**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(e)(i)	State symbols **are** required IGNORE missing square brackets $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ OR $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s) + 6H_2O(l)$ OR $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(H_2O)_4(s) + 2H_2O(l)$ OR $Cu^{2+}(aq) + 2OH^-(aq) + 4H_2O(l) \rightarrow Cu(OH)_2(H_2O)_4(s)$ ALLOW equations with $[Cu(H_2O)_4]^{2+}(aq)$	Equations with NaOH / Na^+/ SO_4^{2-} ions	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(e)(ii)	Ligand exchange / ligand substitution / ligand replacement	Acid/base reaction Deprotonation	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(f)(i)	Ligand has 2 atoms that can form (co-ordinate / dative covalent) bonds (to the metal ion) ALLOW Has 2 lone pairs that form (co-ordinate / dative covalent) bonds ALLOW Has 2 lone pairs that it donates (to the metal ion) ALLOW Forms 2 (co-ordinate / dative covalent) bonds (to the metal ion)	2 ligands attached to the ion Ionic bond Just 'has 2 lone pairs'	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(f)(ii)	**First mark** (there are) more particles / moles / species on the right (of the equation) OR (there is an increase from) 4 particles / moles / species on the left of the equation to 7 on the right **(1)** **Second mark** (so) ΔS_{system} increases / is positive (and the reaction is thermodynamically feasible) ALLOW ΔS_{total} is positive / increasing (and the reaction is thermodynamically feasible) ALLOW (there is) an increase in entropy (and the reaction is thermodynamically feasible) **(1)** IGNORE Just 'disorder increases'	Molecules / atoms Incorrect numbers of particles / moles	**(2)**

Total for Question 22 = 16 marks

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

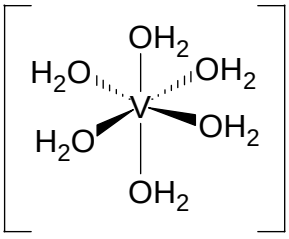
Question Number	Acceptable Answers	Reject	Mark
4 (a)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 (4s^0)$ **(1)** Accept $[Ar]3d^5(4s^0)$ (Ion) has an incompletely filled (3)d-orbital / sub-shell / unpaired d electron **(1)**		**2**

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**