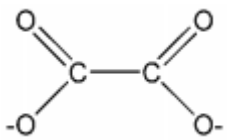
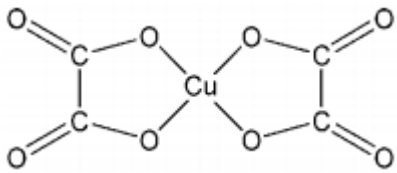
Question number	Answer	Marks	Guidance
1 (a)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$	1	allow [He] $2s^2$, or [Ne] $3s^2$, or [Ar] $3d^{10}$
	d-sub-shell / shell / orbitals / sub-level full (or not partially full)	1	can only score M2 if d^{10} in M1 correct allow 'full d-orbital' if d^{10} in M1 do not allow d-block
1 (b)	atom or ion or transition metal bonded to / surrounded by one or more ligands	1	Allow Lewis base instead of ligand
	by co–ordinate / dative (covalent) bonds / donation of an electron pair	1	can only score M2 if M1 correct
1 (c)	H_2 / hydrogen	1	do not allow H
	no lone / spare / non-bonded pair of electrons	1	only score M2 if M1 correct or give 'H' in M1
1 (d) (i)	+2 **OR** 2+ **OR** Pd^{2+} **OR** II **OR** +II **OR** II+ **OR** two **OR** two plus	1	
1 (d) (ii)	Tetrahedral	1	these shapes can be in any order allow phonetic spelling, e.g., tetrahydral
	square planar	1	
2 (a) (i)	absorbs (certain frequencies of) (white) light / photons	1	not absorbs white / u.v. light
	d-electrons excited / promoted	1	or d-electrons move between levels / orbitals d-electrons can be implied elsewhere in answer
	the colour observed is the light not absorbed / light reflected / light transmitted	1	allow blue light transmitted penalise emission of light in M3

2 (a) (ii)	*E* is the energy gained by the (excited) electrons (of Cu^{2+})	1	allow: • energy difference between orbitals / subshells • energy of photon / light absorbed • change in energy of the electrons • energy lost by excited electrons • energy of photon / light emitted
	h (Planck's) constant	1	do not allow wavelength
	v frequency of light (absorbed by $Cu^{2+}(aq)$)	1	If energy lost / photon lost / light emitted in M1 do not penalised light emitted
2 (a) (iii)	$[Cu(H2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6H_2O$	1	note that $[CuCl_4^-]^{2-}$ is incorrect penalise charges shown separately on the ligand and overall penalise HCl
	Tetrahedral	1	
	Cl^- / Cl / chlorine too big (to fit more than 4 round Cu)	1	allow water smaller than Cl^- explanation that change in shape is due to change in co-ordination number
2 (b)		1	allow: • ion drawn with any bond angles • ion in square brackets with overall / 2− charge shown outside the brackets • ion with delocalised O=C—O bonds in carboxylate group(s)
	lone pair(s) on O^-/ O	1	allow position of lone pair(s) shown on O in the diagram even if the diagram is incorrect.

2 (c) (i)	$[Cu(H_2O)_6]^{2+} + 2C_2O_4^{2-} \rightarrow [Cu(C_2O_4)_2(H_2O)_2]^{2-} + 4H_2O$ product correct equation balanced 6 octahedral	 1 1 1 1	 note can only score M3 and M4 if M1 awarded or if complex in equation has 2 waters and 2 ethanedioates If this condition is satisfied the complex can have the wrong charge(s) to allow access to M3 and M4 but not M1
2 (c) (ii)	 90°	1 1	ignore charges diagram must show both ethanedioates with correct bonding ignore water allow 180° mark bond angle independently but penalise if angle incorrectly labelled / indicated on diagram
3 (a)	A ligand is a species which can donate a pair of electrons to a metal ion. A co-ordinate bond is a covalent bond in which both electrons are donated by one atom.	3	
3 (b) (i)	e.g.$[Co(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CoCl_4]^{2-} + 6H_2O$ pink blue	8	one mark is for the two correct complex ions and the other for a balanced equation one mark is given for each of the colours of the complex ions
3 (b) (ii)	e.g., $[Co(NH_3)_6]^{2+} + 3NH_2CH_2CH_2NH_2 \rightarrow [Co(NH_2CH_2CH_2NH_2)_3]^{2+} + 6NH_3$ More molecules and/or ions formed. Increase in entropy because the reaction involves an increase in the number of molecules and ions.		one mark is for the two correct complex ions and the other for a balanced equation