5(a)

species	number of **unpaired** electrons	
	3d	4s
Cu	0	1
Cu^{2+}	1	0

5(b)

- five 3d orbitals (lines, boxes) in the isolated Cu^{2+} ion of the same energy
- splitting: three higher and two lower d orbitals
- energy of all five d orbitals in complex higher than all d orbitals in isolated ion

any two [1], all three [2]

5(c)

M1: more than one (stable) oxidation state / exist in variable oxidation states

M2: vacant / empty (d) orbitals are energetically accessible
OR vacant / empty (d) orbitals can form dative bonds with ligands

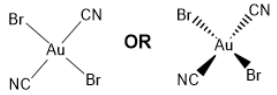
5(d)

metal ion	coordination number	formula of complex ion	charge of complex ion
Ag^+	2	$Ag(CN)_2$	1–
Fe^{2+}	6	$Fe(CN)_6$	4–

each row [1]

5(e)

M1:



M2: (shape) square planar **AND** (bond angle) 180°

5(f)(i)

M1: moles MnO_4^- = 0.075 × 0.0225 = 1.6875 × 10^{-3}

M2: moles V^{2+} = 5 / 3 × 1.6875 × 10^{-3} = 2.8125 × 10^{-3}

M3: mass V = 50.9 × 2.8125 × 10^{-3} = 0.143 g
% of V = 0.143 / 0.250 × 100 = 57.3 min 2sf

5(f)(ii)

$2VO_3^- + 3Zn + 12H^+ \rightarrow 2V^{2+} + 3Zn^{2+} + 6H_2O$

M1: 2 : 3 ratio on both sides

M2: rest of the equation correct

6(a)(i) $Ni(CO)_4$

6(a)(ii)

- ethanedioate given as C_2O_4
- formula shows one Ni and three ligands
- charge = 4^-

any two [1], all three [2]

$Ni(C_2O_4)_3^{4-}$ scores [2]

6(a)(iii) **F AND** optical

6(b)(i) N atom can donate one lone pair of electrons

6(b)(ii) $[Cd(en)_2]^{2+}$ **AND** has a larger K_{stab} / is more stable

6(b)(iii) $\frac{[[Cd(CH_3NH_2)_4]^{2+}]}{[Cd^{2+}][CH_3NH_2]^4}$

1(a) forms (one or more) stable ions / compounds / oxidation states
with incomplete / partially filled (3)d orbital(s) / d shell / d sub-shell

1(b)(i) (orbitals) are at the same energy

1(b)(ii) ($1s^2$) $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^9$

1(c)(i) $[Cu(NH_3)_4(H_2O)_2]^{2+}(aq)$ deep / dark / royal blue

AND

$[CuCl_4]^{2-}(aq)$ yellow

1(c)(ii)

M1: d orbital(s) of different energy / d-d splitting occurs / d sub-shell splits

M2: electron(s) promoted / excited

M3: light / wavelength / frequency / photon absorbed **AND** complementary colour seen

1(d)(i)

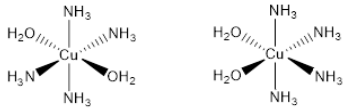
M1: ligand exchange / replacement / substitution / displacement

M2: $[CuCl_4]^{2-} + 4NH_3 + 2H_2O \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4Cl^-$

1(d)(ii)

M1: one correct 3D structure of $[Cu(H_2O)_2(NH_3)_4]^{2+}$

M2: correct 3D stereoisomer structure of isomer 1



1(d)(iii) cis isomer **AND** dipoles do not cancel

1(e)(i) (two) oxygen and (one) nitrogen (can donate) three lone pair(s) of electrons (to the metal ion)

1(e)(ii) $[Co(C_4H_5NO_4)_2]^-$

1(f)(i) equilibrium constant for the formation of the complex (ion)

in a solvent / water / solution **OR** from its constituent ions or molecules

1(f)(ii) $[Ag(CN)_2]^-(aq)$ **AND** largest (value of) K_{stab}

1(g) **M1 M2:** any two [1], all four [2]

- moles MnO_4^- = 0.015 ×18.70/1000 = 2.805 × 10^{-4}
- moles SO_3^{2-} = 2.805 × 10^{-4} × 5/2 = 7.0125 × 10^{-4} (in 10 cm^3)
- moles SO_3^{2-} = 1.753 × 10^{-2} (in 250 cm^3)
- mass Na_2SO_3 = 1.753 × 10^{-2} × 126.1 = 2.21 g

M3: % purity = 100 × 2.21 / 3.75 = **58.9 – 59.0 %** min 2sf