

- M1.** (a) oxidation state of N in $\text{Cu}(\text{NO}_3)_2$: +5; 1
- oxidation state of N in NO_2 : +4; 1
- oxidation product: oxygen; 1
- (b) copper-containing species: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$; 1
- shape: octahedral; 1
- (c) (i) precipitate B: $\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2$ or $\text{Cu}(\text{OH})_2$ or name; 1
- equation: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{NH}_3 \rightarrow \text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2 + 2\text{NH}_4^+$
- OR
- $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$
- and
- $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow \text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2 + 2\text{H}_2\text{O}$; 1
- (ii) NH_3 accepts a proton; 1
- (d) (i) identity: $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$; 1
- colour: deep blue; 1
- equation:
- $\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2 + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 2\text{H}_2\text{O} + 2\text{OH}^-$; 1

- (ii) NH_3 is an electron pair donor; 1
- (e) identity: $[\text{CuCl}_4]^{2-}$; 1
- colour: yellow-green; 1
- shape: tetrahedral; 1
- (f) (i) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$; 1
- (ii) role of Cu: a reducing agent; 1

[17]

- M2.** (a) Ligand: -
atom, ion or molecules which can donate a pair of electrons to a metal ion. 1
- co-ordinate bond:- a covalent bond 1
- in which both electrons are donate by one atom 1
- (b) (i) Two correct complex ions 1
- Balanced equation 1
- Two correct colours 2
- (ii) Complex with a bidentate ligand 1
- Balanced equation

NB en not allowed as a ligand unless structure also given

1

More molecules/ions formed

1

Increase in entropy

1

more stable complex formed

1

Max 2

(c) ΔE ; energy absorbed by electron, ground to excited state (QoL)

1

h ; Planck's constant or a constant

1

Change in

Oxidation state

1

Ligand

1

Co-ordination number

Apply list principle to incorrect additional answers

1

[16]

M3. (a) (i) An atom, ion or molecule which can donate a lone electron pair

1

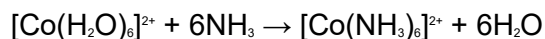
(ii) A central metal ion/species surrounded by co-ordinately bonded ligands or ion in which co-ordination number exceeds oxidation state

1

(iii) The number of co-ordinate bonds formed to a central metal ion or number of electron pairs donated or donor atoms

1

(b) (i) *Allow the reverse of each substitution*



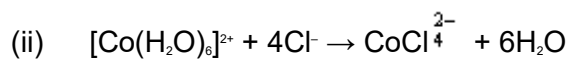
Complex ions

1

Balanced

1

Allow partial substitution



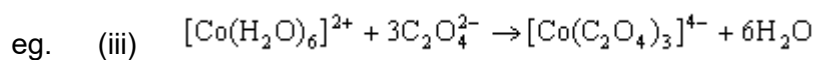
Complex ions

1

Balanced

or H₂O or NH₃ or C₂O₄²⁻ by Cl⁻

1



Complex ions

1

Balanced

1

Allow all substitution except

(i) NH₃ by H₂O

(ii) more than 2Cl⁻ substituted for NH₃ or H₂O



Complex ions

1

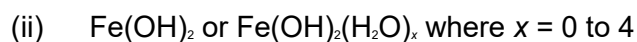
Balanced

or H₂O or NH₃ by C₂O₄²⁻ and NH₃ or Cl⁻ by EDTA⁴⁻

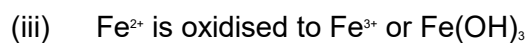
1



1



1



1

By oxygen in the air

1

[15]

M4. (a) $\text{C}_2\text{O}_4^{2-}$ or $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ (1)

1

(b) $[\text{AgCl}_2]^-$ or $[\text{Ag}(\text{CN})_2]^-$ or $[\text{Ag}(\text{NH}_3)_2]^+$ (1)

1

(c) e.g. $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightarrow [\text{CoCl}_4]^{2-} + 6\text{H}_2\text{O}$
Correct complex species (1), Balanced (1), Only allow if species correct

2

(d) e.g. $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 6\text{NH}_3 \rightarrow [\text{Co}(\text{NH}_3)_6]^{2+} + 6\text{H}_2\text{O}$
Correct complex species (1), Balanced (1), Only allow if species correct

2

(e) *Equation:* $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + \text{EDTA}^{4-} \rightarrow [\text{Co}(\text{EDTA})]^{2-} + 6\text{H}_2\text{O}$ (1)
Explanation: More molecules on right hand side (1)
Entropy increases (1)

3

[9]