

M1.(a) (i)  $\text{EDTA}^{4-} + [\text{Cu}(\text{H}_2\text{O})_6]^{2+} \rightarrow [\text{Cu}(\text{EDTA})]^{2-} + 6\text{H}_2\text{O}$  1

(ii) (Mol EDTA =  $(6.45/1000) \times 0.015 = 9.68 \times 10^{-5}$  mol Cu(II)) 1

Conc. Cu(II) =  $((9.68 \times 10^{-5}) / 0.025 = 0.00387 \text{ mol dm}^{-3}$   
*Correct answer without working gains M2 only.* 1

(b) Samples may not be consistent throughout the river  
OR  
Concentration may vary over time  
*Ignore comments on technique.* 1

(c)  $[\text{Ag}(\text{NH}_3)_2]^+$   
*Accept name eg diamminesilver(I) ion.* 1

aldehyde  
*Allow CHO.* 1

[6]

M2. (a) Partially filled/incomplete d sub-shell/orbital/shell  
*Ignore reference to f orbitals*  
*Do not allow d block*  
*Do not allow half-filled d orbitals* 1

(b) Has ligand(s)

- Allow molecules/ions with lone pairs* 1
- linked by co-ordinate bonds  
*Allow dative/donation of lone pair* 1
- (c) (Blue) light is absorbed (from incident white light) 1
- Due to electrons moving to higher levels/electrons excited  
*Allow  $d \rightarrow d$  transitions* 1
- Red light (that) remains (is transmitted)/light that remains  
(transmitted light) is the colour observed  
*Allow red light reflected* 1
- (d) (i) Circle round any O<sup>-</sup>  
*List principle* 1
- Circle round either N 1
- (ii)  $\text{EDTA}^{4-} + [\text{Co}(\text{H}_2\text{O})_6]^{2+} \rightarrow [\text{CoEDTA}]^{2-} + 6\text{H}_2\text{O}$   
*Allow missing square brackets*  
*Ignore state symbols* 1
- (iii) Increase in entropy/ $\Delta S$  positive  
*Or increase in disorder* 1
- Because 2 mol (of particles/molecules/species/entities) form 7 mol  
*Allow 'increase in number' as stated in words or as shown by any numbers deduced correctly from an incorrect equation*  
*Do not allow increase in ions/atoms* 1
- (e) (i) Co-ordinate/dative/dative covalent bond  
*Allow pair of electrons donated by nitrogen/ligand*

*Do not allow pair of electrons donated from Iron/Fe*

1

Covalent bond

*Shared electron pair*

1

(ii) Transport of oxygen/O<sub>2</sub>

*Allow any statement that implies oxygen carried (around the body)*

*Do not allow transport of carbon dioxide (CO<sub>2</sub>). This also contradicts the mark (list principle)*

1

(iii) Because it bonds to the iron/haemoglobin

*Allow blocks site*

*/CO has greater affinity for haemoglobin*

*/carboxyhaemoglobin more stable than oxyhaemoglobin*

1

Displaces oxygen

*Or prevents transport of oxygen*

*QoL*

1

[16]

**M3.** Linear complex e.g. [Ag(NH<sub>3</sub>)<sub>2</sub>]<sup>+</sup> (1)

Tetrahedral complex e.g. [CoCl<sub>4</sub>]<sup>2-</sup> (1)

Octahedral complex e.g. [Fe(H<sub>2</sub>NCH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>)<sub>3</sub>]<sup>3+</sup>

*Species (1)*

*Charge (1)*

[4]

|            |   |   |
|------------|---|---|
| <b>M4.</b> | (a) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$  | 1 |
|            | octahedral  |   |
|            | <i>Only allow if species has 6 ligands<br/>but allow if M1 not given because charge missing</i>                               | 1 |
|            | (b) $\text{CoCO}_3$   |   |
|            | <i>Mark independently</i>   | 1 |
|            | Purple solid (allow pink)   |   |
|            | <i>Allow pink precipitate</i>   | 1 |
|            | (c) $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 6\text{NH}_3 \rightarrow [\text{Co}(\text{NH}_3)_6]^{2+} + 6\text{H}_2\text{O}$ |   |
|            | <i>Allow <math>[\text{Co}(\text{NH}_3)_5\text{H}_2\text{O}]^{3+}</math></i>   |   |
|            | Formula of product  | 1 |
|            | Balanced equation   | 1 |
|            | (d) $[\text{Co}(\text{NH}_3)_6]^{3+}$   |   |
|            | <i>Allow <math>[\text{Co}(\text{NH}_3)_5\text{H}_2\text{O}]^{3+}</math></i>   | 1 |
|            | Oxidising agent   | 1 |
|            | (e) $[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{2+}$  |   |
|            | <i>Allow use of en <math>[\text{Coen}_3]^{2+}</math></i>  | 1 |
|            | Entropy change for reaction is positive   |   |
|            | <i>Mark independently</i>   | 1 |
|            | Because 4 mol reactants form 7 mol products<br>(or increase in number of particles)   |   |
|            | <i>Or bidentate replaces unidentate</i>   | 1 |

(f)  $[\text{CoCl}_4]^{2-}$

1

$\text{Cl}^-$  ligand too big to fit more than 4 round  $\text{Co}^{2+}$

*Allow  $\text{Cl}^-$  is bigger*

*Allow chlorine and Cl but NOT chlorine molecules.*

1

**[13]**