

*Can start with  $\text{Cr(H}_2\text{O)}_3(\text{OH})_3$  for each equation*

*Ignore any unnecessary preliminary preparation of  $\text{Cr(OH)}_3$*

1

Green / grey-green solid

*Mark colours independently from equations*

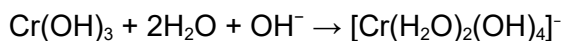
*Allow green ppt.*

1

Forms green / purple / ruby / violet solution

*ignore shades of colours*

1



*Allow with 5 or 6  $\text{OH}^-$  provided complex has co-ordination number of 6*

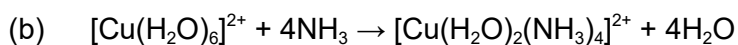
*Penalise complex ions with incorrect charges overall or if shown on ligand.*

1

Forms green solution

*Note that for each equation final complex must be 6 co-ordinate*

1



*Allow two correct equations via intermediate hydroxide in both cases even if first equation uses  $\text{OH}^-$  instead of  $\text{NH}_3$*

1

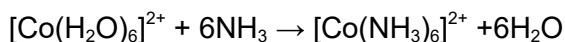
Blue (solution)

*Mark colours independently from equations*

1

Dark / deep / royal blue solution

1



1

pink / red (solution)

1

Brown / straw / yellow solution

*ignore darkens in air / with time*

1

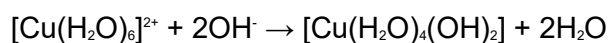
M2.B

[1]

## M3.(a) Reaction 1

**General principles in marking this question***Square brackets are not essential**Penalise charges on individual ligands rather than on the whole complex**Reagent and species can be extracted from the equation**Ignore conditions such as dilute, concentrated, excess**Reagent must be a compound NOT just an ion**Equations must start from  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  except in part (b)**Mark reagent, species and equation independently*ammonia ( $\text{NH}_3$ ) (solution) / NaOH

1

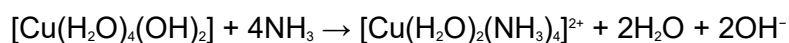
*Do not allow OH<sup>-</sup> for reagent**Product 1, balanced equation 1**Allow either equation for ammonia*

2

## (b) Reaction 2

Ammonia (conc / xs)

1

*Product 1, balanced equation 1**Note that the equation must start from the hydroxide* *$[\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2]$* 

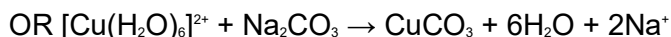
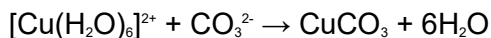
2

(c) **Reaction 3**

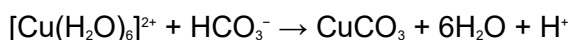
Na<sub>2</sub>CO<sub>3</sub> / any identified soluble carbonate / NaHCO<sub>3</sub>

*Do not allow NaCO<sub>3</sub> or any insoluble carbonate but mark on*

1



OR with NaHCO<sub>3</sub>



*Product 1, balanced equation 1*

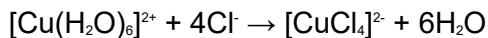
2

(d) **Reaction 4**

HCl (conc / xs) / NaCl

*Allow any identified soluble chloride*

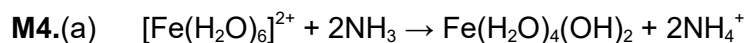
1



*Product 1, balanced equation 1*

2

[12]

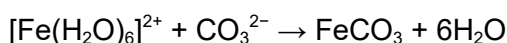


*Allow equation with OH<sup>-</sup> provided equation showing formation of OH<sup>-</sup> from NH<sub>3</sub> given*

1

Green precipitate

1



1

Green precipitate

*effervescence incorrect so loses M4*

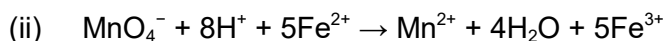
1

- (b) (i) Colourless / (pale) green changes to pink / purple (solution)  
*Do not allow pale pink to purple*

1

Just after the end-point  $\text{MnO}_4^-$  is in excess / present

1



1

$$\text{Moles KMnO}_4 = 18.7 \times 0.0205 / 1000 = (3.8335 \times 10^{-4})$$

*Process mark*

1

$$\text{Moles Fe}^{2+} = 5 \times 3.8335 \times 10^{-4} = 1.91675 \times 10^{-3}$$

*Mark for M2 × 5*

1

$$\text{Moles Fe}^{2+} \text{ in } 250 \text{ cm}^3 = 10 \times 1.91675 \times 10^{-3} = 0.0191675 \text{ moles in } 50 \text{ cm}^3$$

*Process mark for moles of iron in titration (M3) × 10*

1

$$\text{Original conc Fe}^{2+} = 0.0191675 \times 1000 / 50 = 0.383 \text{ mol dm}^{-3}$$

*Answer for moles of iron (M4) × 1000 / 50*

*Answer must be to at least 2 sig. figs. (0.38)*

1

[11]

**M5.B**

[1]

**M6.D**

[1]

**M7.(a)** An electron pair on the ligand

1

Is donated from the ligand to the central metal ion

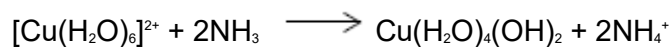
1

(b) Blue precipitate

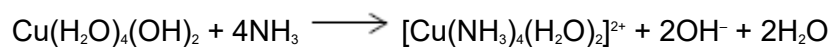
1

Dissolves to give a dark blue solution

1



1



1

(c)  $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 2\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \longrightarrow [\text{Cu}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2(\text{H}_2\text{O})_2]^{2+} + 4\text{NH}_3$

1

(d) Cu–N bonds formed have similar enthalpy / energy to Cu–N bonds broken

1

And the same number of bonds broken and made

1

(e) 3 particles form 5 particles / disorder increases because more particles are formed / entropy change is positive

1

Therefore, the free-energy change is negative

*M2 can only be awarded if M1 is correct*

<sup>1</sup>  
[11]