

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

Ignore any unnecessary preliminary preparation of Cr(OH)_3

1

Green / grey-green solid

Mark colours independently from equations

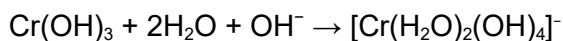
Allow green ppt.

1

Forms green / purple / ruby / violet solution

ignore shades of colours

1



Allow with 5 or 6 OH^- provided complex has co-ordination number of 6

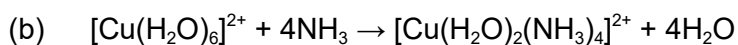
Penalise complex ions with incorrect charges overall or if shown on ligand.

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 OH^- instead of NH_3

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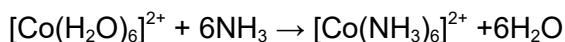
Blue (solution)

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

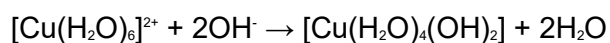
M2.B

[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 (NH_3) (solution) / NaOH

1

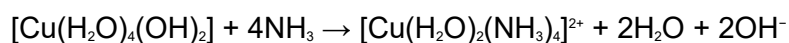
*Do not allow OH⁻ for reagent**Product 1, balanced equation 1**Allow either equation for ammonia*

2

(b) Reaction 2

Ammonia (conc / xs)

1

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

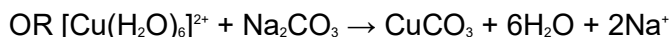
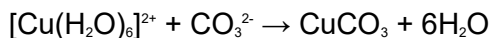
2

(c) **Reaction 3**

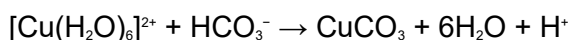
Na₂CO₃ / any identified soluble carbonate / NaHCO₃

Do not allow NaCO₃ or any insoluble carbonate but mark on

1



OR with NaHCO₃



Product 1, balanced equation 1

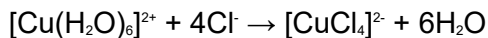
2

(d) **Reaction 4**

HCl (conc / xs) / NaCl

Allow any identified soluble chloride

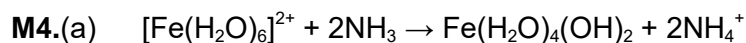
1



Product 1, balanced equation 1

2

[12]

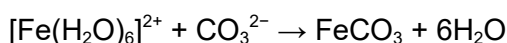


Allow equation with OH⁻ provided equation showing formation of OH⁻ from NH₃ given

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Green precipitate

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1

Green precipitate

effervescence incorrect so loses M4

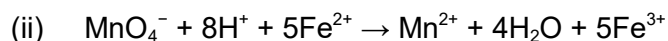
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- (b) (i) Colourless / (pale) green changes to pink / purple (solution)
Do not allow pale pink to purple

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Just after the end-point MnO_4^- is in excess / present

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

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

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Is donated from the ligand to the central metal ion

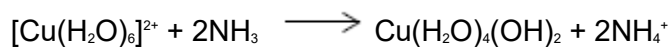
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(b) Blue precipitate

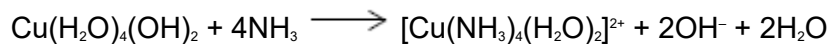
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Dissolves to give a dark blue solution

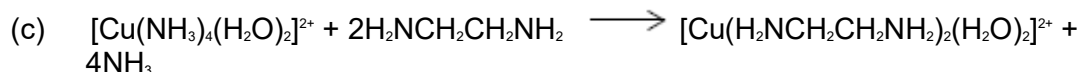
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(d) Cu–N bonds formed have similar enthalpy / energy to Cu–N bonds broken

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

¹
[11]