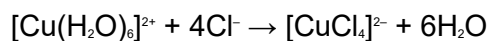


- M1.** (a) Brown ppt/solid 1
- Gas evolved/effervescence 1
- $$2[\text{Fe}(\text{H}_2\text{O})_6]^{3+} + 3\text{CO}_3^{2-} \rightarrow 2\text{Fe}(\text{H}_2\text{O})_3(\text{OH})_3 + 3\text{CO}_2 + 3\text{H}_2\text{O}$$
- Must be stated, Allow CO₂ evolved. Do not allow CO₂ alone
Correct iron product (1) allow Fe(OH)₃ and in equation
Balanced equation (1)* 2
- (b) White ppt/solid 1
- Colourless Solution
Only award M2 if M1 given or initial ppt mentioned 1
- $$[\text{Al}(\text{H}_2\text{O})_6]^{3+} + 3\text{OH}^- \rightarrow \text{Al}(\text{H}_2\text{O})_3(\text{OH})_3 + 3\text{H}_2\text{O}$$
- Allow $[\text{Al}(\text{H}_2\text{O})_6]^{3+} + 3\text{OH}^- \rightarrow \text{Al}(\text{OH})_3 + 6\text{H}_2\text{O}$* 1
- $$\text{Al}(\text{H}_2\text{O})_3(\text{OH})_3 + 3\text{OH}^- \rightarrow [\text{Al}(\text{OH})_6]^{3-} + 3\text{H}_2\text{O}$$
- Allow formation of $[\text{Al}(\text{H}_2\text{O})_{6-x}(\text{OH})_x]^{(x-3)-}$ where $x = 4, 5, 6$
Allow product without water ligands
Allow formation of correct product from $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$* 1
- (c) Blue ppt/solid 1
- (Dissolves to give a) deep blue solution
Only award M2 if M1 given or initial ppt mentioned 1
- $$[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{NH}_3 \rightarrow \text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2 + 2\text{NH}_4^+$$
- Allow $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{NH}_3 \rightarrow \text{Cu}(\text{OH})_2 + 2\text{NH}_4^+ + 4\text{H}_2\text{O}$
Allow two equations: $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$
then $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow \text{Cu}(\text{OH})_2 + 4\text{H}_2\text{O}$ etc* 1
- $$\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2 + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4]^{2+} + 2\text{OH}^- + 2\text{H}_2\text{O}$$
- Allow $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4]^{2+} + 4\text{H}_2\text{O}$* 1

(d) Green/yellow solution

1



1

[14]

M2.C

[1]

M3. (a) (i) Ammonia

If reagent is missing or incorrect cannot score M3

1

Starts as a pink (solution)

1

Changes to a yellow/straw (solution)

Allow pale brown

Do not allow reference to a precipitate

1

(ii) (dark) brown

Do not allow pale/straw/yellow-brown (i.e. these and other shades except for dark brown)

1

(b) (i) Ruby/red-blue/purple/violet/green

Do not allow red or blue

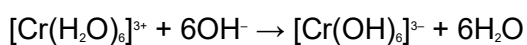
If ppt mentioned contradiction/CE =0

1

Green

If ppt mentioned contradiction/CE =0

1

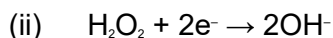


1

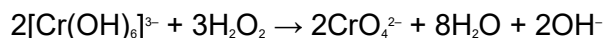
Formula of product

Can score this mark in (b) (ii)

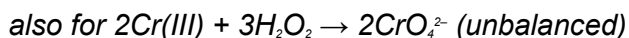
1



1



Allow 1 mark out of 2 for a balanced half-equation such as

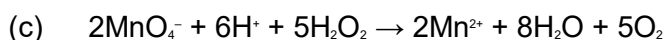


2

Yellow

Do not allow orange

1



if no equation and uses given ratio can score M2, M3, M4 & M5

1

$$\text{Moles MnO}_4^- = (24.35/1000) \times 0.0187 = \underline{4.55 \times 10^{-4}}$$

Note value must be quoted to at least 3 sig. figs.

M2 is for 4.55×10^{-4}

1

$$\text{Moles H}_2\text{O}_2 = (4.55 \times 10^{-4}) \times \underline{5/2} = 1.138 \times 10^{-3}$$

M3 is for $\times 5/2$ (or $7/3$)

Mark consequential on molar ratio from candidate's equation

1

Moles H_2O_2 in 5 cm^3 original

M4 is for $\times 10$

1

$$= (1.138 \times 10^{-3}) \times \underline{10} = 0.01138$$

$$\text{Original } [\text{H}_2\text{O}_2] = 0.01138 \times \underline{(1000/5)} = 2.28 \text{ mol dm}^{-3}$$

(allow 2.25-2.30)

M5 is for consequentially correct answer from (answer to mark 4) $\times (1000/5)$

Note an answer of between 2.25 and 2.30 is worth 4 marks)

If candidate uses given ratio 3/7 max 4 marks:

M1: Moles of $\text{MnO}_4^- = 4.55 \times 10^{-4}$

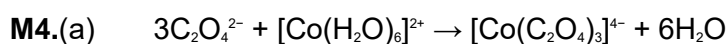
M2: Moles $\text{H}_2\text{O}_2 = (4.55 \times 10^{-4}) \times \frac{7}{3} = 1.0617 \times 10^{-3}$

M3: Moles H_2O_2 in 5 cm^3 original
 $= (1.0617 \times 10^{-3}) \times 10 = 0.01062$

M4: Original $[\text{H}_2\text{O}_2] = 0.01062 \times (1000/5) = 2.12 \text{ mol dm}^{-3}$
(allow 2.10 to 2.15)

1

[17]



Accept multiples.

Equation must have cobalt(II) hexaaqua ion.

1

- (b) Ethanedioate ion reduces iron(III) ion **or**
iron(III) ion oxidises ethanedioate ion

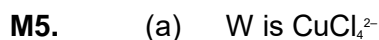
Allow answer using equations.

1

$E^\ominus(\text{CO}_2 / \text{C}_2\text{O}_4^{2-})$ more negative than $E^\ominus(\text{Fe}^{3+} / \text{Fe}^{2+})$ **or**
 $E^\ominus(\text{Fe}^{3+} / \text{Fe}^{2+}) > E^\ominus(\text{CO}_2 / \text{C}_2\text{O}_4^{2-})$
or e.m.f. positive **or** cell voltage = +1.26

1

[3]



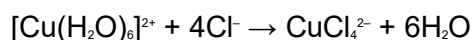
1

Yellow-green/yellow/green

Not necessary to indicate solution

Do not allow precipitate/solid

1



Allow $+ 4\text{HCl} \rightarrow 4\text{H}^+$

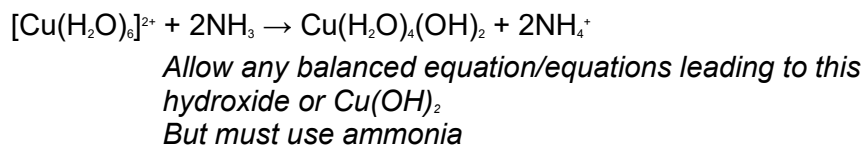
1

- (b) X is $\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2$
Allow $\text{Cu}(\text{OH})_2$ /copper hydroxide

1

Blue precipitate/solid
Ignore shades

1



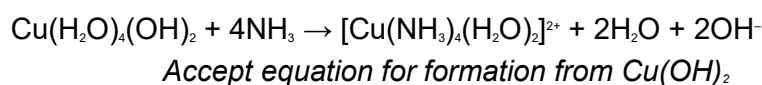
1

- (c) Y is $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$

1

Deep/dark/royal blue solution
QoL

1



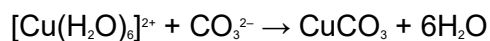
1

- (d) Z is CuCO_3
Allow copper carbonate

1

Green solid/precipitate
Allow blue-green precipitate

1



1

- (e) (i) $\text{Cu}^{2+}(\text{aq}) + \text{Fe}(\text{s}) \rightarrow \text{Cu}(\text{s}) + \text{Fe}^{2+}(\text{aq})$
*Allow hydrated ions
State symbols not essential but penalise if wrong*

1

Blue
Do not allow description of solids

1

Green

Allow yellow/(red-)brown/orange

1

- (ii) Any two correct points about copper extraction from two of these three categories:

Any relevant mention of lower energy consumption

Do not allow reference to electricity alone or to temperature alone.

Any relevant mention of benefits of less mining (of copper ore)

Allow avoids depletion of (copper ore) resources

Less release of CO₂ (or CO) into the atmosphere

Not just greenhouse gases. Must mention CO₂ or CO

Max 2

[17]