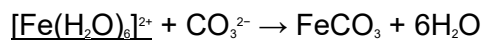


M1.(a) Iron(II): green (solution) gives a green precipitate

Apply list principle throughout if extra colours and / or extra observations given. Ignore state symbols in equations.

Not blue-green ppt.

1



Must start from $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$

Allow equations with Na_2CO_3

1

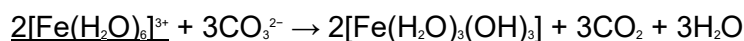
Iron(III): yellow / purple / brown / lilac / violet (solution) gives a brown / rusty precipitate

1

Effervescence / gas / bubbles

Allow CO_2 evolved but not just CO_2

1

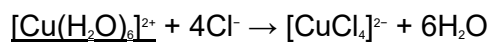


1

(b) Copper(II): blue (solution) gives a green / yellow solution **OR** blue solution (turns) to green / yellow / olive green

Apply list principle throughout if extra colours and / or extra observations given. Ignore state symbols in equations.

1

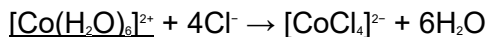


Allow equations with HCl

1

Cobalt(II): pink (solution) gives a blue solution **OR** pink solution turns blue

1

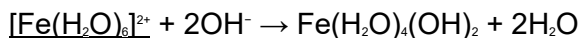


1

- (c) Iron(II): green (solution) gives a green precipitate

Apply list principle throughout if extra colours and / or extra observations given. Ignore state symbols in equations.

1



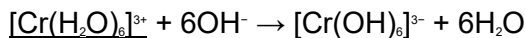
Allow equations with NaOH

1

Chromium(III): green / ruby / purple / violet / red-violet (solution) gives a green solution **OR** green / ruby / purple / violet / red-violet solution turns green

Ignore green ppt.

1



Allow also with 4 or 5 OH balanced with 2 or 1 waters.

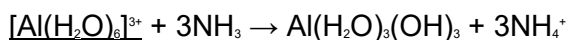
Also allow two correct equations showing $\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3$ as intermediate.

1

- (d) Al: colourless (solution) gives a white ppt

Apply list principle throughout if extra colours and / or extra observations given. Ignore state symbols in equations.

1



Allow $+ 3\text{OH}^- \rightarrow 3\text{H}_2\text{O}$ if

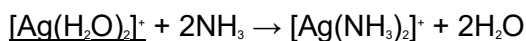
$\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$ also

1

Ag: colourless (solution) remains a colourless solution / no visible change

Ignore brown ppt.

1



Allow 2 / 3 equations involving Ag_2O or $\text{Ag}(\text{OH})_2$

1

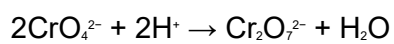
[17]

M2.(a) Yellow (solution)

1

Orange solution

1



Allow equation with H₂SO₄

1

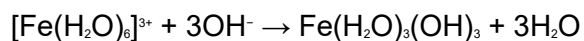
(b) Yellow / purple (solution)

Allow orange / brown (solution)

1

Brown precipitate / solid

1



1

(c) Blue (solution)

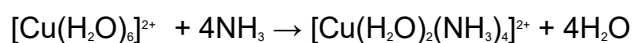
Allow pale blue

1

Dark / deep blue solution

Ignore any reference to blue ppt

1



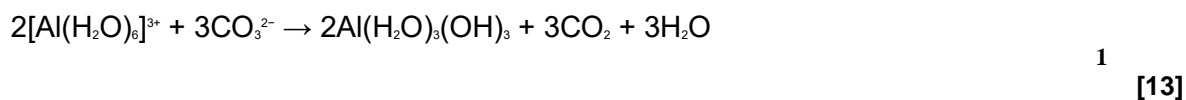
Can be in two equations

1

(d) Colourless (solution) 1

White precipitate / solid
Do not allow grey 1

Bubbles / effervescence / gas evolved / given off
Do not allow just CO₂ 1



M3.(a) Idea that over time / after storage meter does not give accurate readings
Do not accept 'to get an accurate reading' without further qualification.
Allow 'temperature variations affect reading'. 1

(b)
$$\frac{[[\text{Fe}(\text{H}_2\text{O})_5\text{OH}]^{2+}(\text{aq})][\text{H}^+(\text{aq})]}{[[\text{Fe}(\text{H}_2\text{O})_6]^{3+}(\text{aq})]}$$

Allow without (aq) symbols.
Need at least one set of square brackets around complex ions 1

(c) $\text{pH} = -\log [\text{H}^+]$ 1

$[\text{H}^+] = 0.0240$
Do not penalise precision of [H⁺]

Correct answer scores M1 and M2.

1

$$K_a = (0.0240)^2 / 0.1 = 5.75 \times 10^{-3} \text{ or } 5.76 \times 10^{-3}$$

Correct answer without working loses M1 and M2.

Allow 7.58×10^{-3}

1

Answer, even if incorrect, given to 3 sig figs

1

(d) Oxygen (in the air) / O₂

Ignore 'air' or 'the atmosphere' or 'chemicals in soil'.

List principle.

1

(e) 4.0 – 6.9

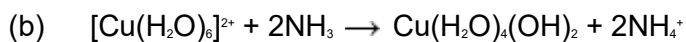
Do not penalise precision.

[7]

M4.(a) Electron pair donor

Allow lone pair donor

1

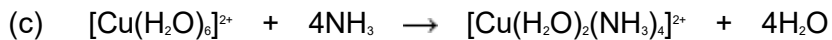


1

(Blue solution) gives a (pale) blue precipitate/solid

M2 only awarded if M1 shows Bronsted–Lowry reaction

1



Allow formation in two equations via hydroxide

1

(Blue solution) gives a dark/deep blue solution

If (b) and (c) are the wrong way around allow one mark only for each correct equation with a correct observation (max 2/4)

M2 only awarded if M1 shows Lewis base reaction

1

(d) (Start with) green (solution)

1

Green precipitate of $\text{Fe}(\text{H}_2\text{O})_4(\text{OH})_2$ / $\text{Fe}(\text{OH})_2$ / iron(II) hydroxide

Do not allow observation if compound incorrect or not given

1

Slowly changes to brown solid

Allow red-brown ppt

Allow turns brown or if precipitate implied

Can only score M3 if M2 scored

1

(Iron(II) hydroxide) oxidised by air (to iron(III) hydroxide)

Allow $\text{Fe}(\text{OH})_2$ oxidised to $\text{Fe}(\text{OH})_3$ by air / O_2

Ignore equations even if incorrect

1

(e) (i) $2[\text{Al}(\text{H}_2\text{O})_6]^{3+} + 3\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \rightarrow 2\text{Al}(\text{H}_2\text{O})_3(\text{OH})_3 + 3[\text{H}_3\text{NCH}_2\text{CH}_2\text{NH}_3]^{2+}$

For correct Al species

1

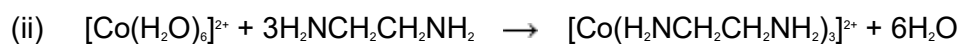
For correct balanced equation

Allow equation with formation of $3[\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_3] +$ from 1 mol $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$

1

White precipitate

1



1

Complex with 3 en showing 6 correct bonds from N to Co

Ignore charge

Accept N – N for ligand

Ignore incorrect H

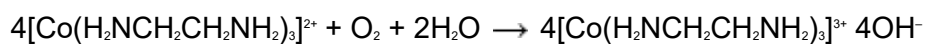
If C shown, must be 2 per ligand

1

Co–ordinate bonds (arrows) shown from N to Co

Can only score M3 if M2 correct

1



For Co(III) species

1

For balanced equation (others are possible)

Allow $+\text{O}_2 + 4\text{H}^+ \rightarrow 2\text{H}_2\text{O}$

If en used can score M4 and M5 only

If Cu not Co, can only score M2 and M3

Allow $\text{N}_2\text{C}_2\text{H}_8$ in equations

1

[17]