

Exercise walk-through

5.2.4

Metal redox evidence, complete tests and complex preparation

Pearson Edexcel · International A-Level · Chemistry

Choose a cell voltage

Your turn

Reduction potentials are $+0.80\text{ V}$ and $+0.34\text{ V}$. What is spontaneous E°_{cell} ?

- A. $+1.14\text{ V}$
- B. $+0.46\text{ V}$
- C. -0.46 V

Find oxidation state and coordination

Your turn

$[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$ has which chromium state and coordination number?

- A. +1 and 4
- B. +3 and 6
- C. +3 and 2

Aspirin transfer calculation

Your turn

2.76 g salicylic acid, $M=138$, gives aspirin $M=180$ in 1:1 ratio. Dry mass is 2.52 g. What is yield?

- A. 50.0%
- B. 70.0%
- C. 91.3%

Exercises 2.1·2.3

2.1 Complete the observations for initial hydroxide precipitates of Cr^{3+} , Mn^{2+} , Fe^{2+} , Fe^{3+} , Co^{2+} , Ni^{2+} , Cu^{2+} and Zn^{2+} , using fresh room-temperature samples. [8]

2.2 Write precipitation equations with OH^- for Mn^{2+} and Ni^{2+} , and a net equation with

2.3 Write the equation for $\text{Cr}(\text{OH})_3$ dissolving in OH^- to $[\text{Cr}(\text{OH})_6]^{3-}$. Explain what amphoteric means. [2]

3 Exam-style questions

Exercises 2.1·2.3

2.1 Complete the observations for initial hydroxide precipitates of Cr^{3+} , Mn^{2+} , Fe^{2+} , Fe^{3+} , Co^{2+} , Ni^{2+} , Cu^{2+} and Zn^{2+} , using fresh room-temperature samples. [8]

2.1 Cr^{3+} green/grey-green; Mn^{2+} off-white/very pale precipitate, darkens in air; Fe^{2+} green; Fe^{3+} red-brown; Co^{2+} blue initially; Ni^{2+} green; Cu^{2+} pale blue; Zn^{2+} white. Observations on standing can differ because of oxidation/slow changes.

2.2 Write precipitation equations with OH^- for Mn^{2+} and Ni^{2+} , and a net equation with

2.2 $\text{Mn}^{2+} + 2\text{OH}^- \rightarrow \text{Mn}(\text{OH})_2(\text{s})$; $\text{Ni}^{2+} + 2\text{OH}^- \rightarrow \text{Ni}(\text{OH})_2(\text{s})$; $\text{Fe}^{3+} + 3\text{NH}_3 + 3\text{H}_2\text{O}$

2.3 Write the equation for $\text{Cr}(\text{OH})_3$ dissolving in OH^- to $[\text{Cr}(\text{OH})_6]^{3-}$. Explain what amphoteric means. [2]

3 Exam-style questions

2.3 $\text{Cr}(\text{OH})_3(\text{s}) + 3\text{OH}^- \rightarrow [\text{Cr}(\text{OH})_6]^{3-}$. The hydroxide reacts with both acids and bases.

Exercises 3.1·3.3

3.1 Given $\text{VO}^{2+}/\text{V}^{3+}$ $E^\circ = +0.34$ V and Zn^{2+}/Zn $E^\circ = -0.76$ V, write the full zinc/vanadium

3.2 Chromium(III) hydroxide is oxidised by H_2O_2 in alkaline solution. Balance $2\text{Cr}(\text{OH})_3 + 3\text{H}_2\text{O}_2 + \text{OH}^- \rightarrow 2\text{CrO}_4^{2-} + \text{H}_2\text{O}$. State what acidifying the chromate then changes. Explain two stages of catalytic-converter action. [5]

3.3 A complex synthesis has limiting metal amount 0.0100 mol, product ratio 1:1 and product $M = 250$ g mol⁻¹. Dry crystals weigh 1.75 g. Find percentage yield. Explain one low-yield cause and one cause of misleadingly high mass. [4]

Exercises 3.1·3.3

3.1 Given $\text{VO}^{2+}/\text{V}^{3+}$ $E^\circ = +0.34$ V and Zn^{2+}/Zn $E^\circ = -0.76$ V, write the full zinc/vanadium

3.1 $\text{VO}^{2+} + 2\text{H}^+ + \text{e}^- \rightarrow \text{V}^{3+} + \text{H}_2\text{O}$. Double it and combine $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$ to give

3.2 Chromium(III) hydroxide is oxidised by H_2O_2 in alkaline solution. Balance $2\text{Cr}(\text{OH})_3 + 3\text{H}_2\text{O}_2 + \text{OH}^- \rightarrow 2\text{CrO}_4^{2-} + \text{H}_2\text{O}$. State what acidifying the chromate then changes. Explain two stages of catalytic-converter action. [5]

3.2 $2\text{Cr}(\text{OH})_3 + 3\text{H}_2\text{O}_2 + 4\text{OH}^- \rightarrow 2\text{CrO}_4^{2-} + 8\text{H}_2\text{O}$. Acidification favours dichromate without changing Cr(VI) oxidation state. CO/NO adsorb and react on the surface through weakened bonds/lower barrier; CO_2/N_2 desorb.

3.3 A complex synthesis has limiting metal amount 0.0100 mol, product ratio 1:1 and product $M = 250$ g mol⁻¹. Dry crystals weigh 1.75 g. Find percentage yield. Explain one low-yield cause and one cause of misleadingly high mass. [4]

3.3 Theoretical mass = $0.0100 \times 250 = 2.50$ g; yield = $1.75/2.50 \times 100 = 70.0\%$. Solubility/transfer loss or incomplete reaction lowers recovery; retained solvent/water or impurity raises apparent mass.

Exercises 3.4·3.6

3.4 A supplied reduction potential for $\text{Cr}^{3+}/\text{Cr}^{2+}$ is -0.41 V ; Zn^{2+}/Zn is -0.76 V . Test

3.5 Write the excess-ammonia dissolution equations for $\text{Ni}(\text{OH})_2$ to $[\text{Ni}(\text{NH}_3)_6]^{2+}$ and

3.6 Supplied reduction potentials at the same specified alkaline conditions are $\text{H}_2\text{O}_2/2\text{OH}^- = +0.88\text{ V}$ and $\text{CrO}_4^{2-}/\text{Cr}(\text{OH})_3 = -0.13\text{ V}$. Predict whether peroxide oxidation of $\text{Cr}(\text{III})$ to $\text{Cr}(\text{VI})$ is thermodynamically favoured. Explain which half-reaction reverses and one limitation of the prediction. [3]

Exercises 3.4·3.6

3.4 A supplied reduction potential for $\text{Cr}^{3+}/\text{Cr}^{2+}$ is -0.41 V ; Zn^{2+}/Zn is -0.76 V . Test

3.4 $E^\circ = -0.41 - (-0.76) = +0.35\text{ V}$. $\text{Zn} + 2\text{Cr}^{3+} \rightarrow \text{Zn}^{2+} + 2\text{Cr}^{2+}$. Cr^{2+} is blue;

3.5 Write the excess-ammonia dissolution equations for $\text{Ni}(\text{OH})_2$ to $[\text{Ni}(\text{NH}_3)_6]^{2+}$ and

3.5 $\text{Ni}(\text{OH})_2 + 6\text{NH}_3 \rightleftharpoons [\text{Ni}(\text{NH}_3)_6]^{2+} + 2\text{OH}^-$. $\text{Zn}(\text{OH})_2 + 4\text{NH}_3 \rightleftharpoons [\text{Zn}(\text{NH}_3)_4]^{2+} + 2\text{OH}^-$. Coordination counts differ, so changing both to the same ligand coefficient changes the specified complex and fails species/atom balance.

3.6 Supplied reduction potentials at the same specified alkaline conditions are $\text{H}_2\text{O}_2/2\text{OH}^- = +0.88\text{ V}$ and $\text{CrO}_4^{2-}/\text{Cr}(\text{OH})_3 = -0.13\text{ V}$. Predict whether peroxide oxidation of $\text{Cr}(\text{III})$ to $\text{Cr}(\text{VI})$ is thermodynamically favoured. Explain which half-reaction reverses and one limitation of the prediction. [3]

3.6 Peroxide is reduced while the chromium reduction half-reaction reverses to oxidation. $E_{\text{cell}} = 0.88 - (-0.13) = +1.01\text{ V}$, so that direction is favoured under the stated conditions. Actual rate may be slow, or changing conditions changes the potentials.