

Practice Questions

- 5 (a) $\overset{+5}{2}\text{KNO}_3(\text{s}) \rightarrow \overset{+3}{2}\text{KNO}_2(\text{s}) + \overset{0}{\text{O}_2}(\text{g})$
This is a redox reaction where the oxidation number of N decreases from +5 in KNO_3 to +3 in KNO_2 , and the oxidation number of O increases from -2 in KNO_3 to 0 in O_2 .
- (b) $\overset{+6}{2}\text{CrO}_4^{2-}(\text{aq}) + \overset{+6}{2}\text{H}^+(\text{aq}) \rightarrow \overset{+6}{\text{Cr}_2\text{O}_7^{2-}}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
This is not a redox reaction since there is no change in initial and final oxidation states for all elements.
- (c) $\overset{+1}{\text{Cu}_2}\text{O}(\text{s}) + \overset{0}{\text{H}_2}\text{SO}_4(\text{aq}) \rightarrow \overset{0}{\text{Cu}}(\text{s}) + \overset{+2}{\text{CuSO}_4}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
This is a redox reaction where Cu is both reduced and oxidised.
- A disproportionation reaction is a redox reaction in which the same element in a substance is simultaneously oxidised and reduced. If the question asks to state the type of reaction, a better answer would be disproportionation rather than redox.
- (d) $\overset{-4}{2}\text{CH}_4(\text{g}) + \overset{0}{2}\text{NH}_3(\text{g}) + \overset{+2}{3}\text{O}_2(\text{g}) \rightarrow \overset{-2}{2}\text{HCN}(\text{g}) + \overset{-2}{6}\text{H}_2\text{O}(\text{g})$
This is a redox reaction where the oxidation number of O decreases from 0 in O_2 to -2 in H_2O , and the oxidation number of C increases from -4 in CH_4 to +2 in HCN .
- 6 (a) **Oxidation:** $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$
Reduction: $\text{H}_2\text{SO}_4 + 8\text{H}^+ + 8\text{e}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$
Overall: $8\text{I}^-(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) + 8\text{H}^+(\text{aq}) \rightarrow 4\text{I}_2(\text{g}) + \text{H}_2\text{S}(\text{g}) + 4\text{H}_2\text{O}(\text{l})$
- (b) **Oxidation:** $\text{MnO}_4^{2-} \rightarrow \text{MnO}_4^- + \text{e}^-$
Reduction: $\text{MnO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$
Overall: $3\text{MnO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) \rightarrow \text{MnO}_2(\text{s}) + 2\text{MnO}_4^-(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
This is another example of a disproportionation reaction.
- (c) *Note: Both the cation and the anion in FeC_2O_4 undergo oxidation.*
 $\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}^{3+}(\text{aq}) + \text{e}^-$
 $\text{C}_2\text{O}_4^{2-}(\text{aq}) \rightarrow 2\text{CO}_2(\text{g}) + 2\text{e}^-$
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- Oxidation:** $\text{FeC}_2\text{O}_4 \rightarrow \text{Fe}^{3+} + 2\text{CO}_2 + 3\text{e}^-$
Reduction: $\text{Ce}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Ce}^{2+}(\text{aq})$
Overall: $\text{FeC}_2\text{O}_4(\text{aq}) + 3\text{Ce}^{3+}(\text{aq}) \rightarrow \text{Fe}^{3+}(\text{aq}) + 2\text{CO}_2(\text{g}) + 3\text{Ce}^{2+}(\text{aq})$

- 7 (a) **Oxidation:** $\text{Mn}(\text{OH})_2 + 2\text{OH}^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O} + 2\text{e}^-$
Reduction: $\text{ClO}^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Cl}^- + 2\text{OH}^-$
Overall: $\text{ClO}^-(\text{aq}) + \text{Mn}(\text{OH})_2(\text{s}) \rightarrow \text{Cl}^-(\text{aq}) + \text{MnO}_2(\text{s}) + \text{H}_2\text{O}(\text{l})$
- (b) **Oxidation:** $\text{C}_2\text{O}_4^{2-} + 4\text{OH}^- \rightarrow 2\text{CO}_3^{2-} + 2\text{H}_2\text{O} + 2\text{e}^-$
Reduction: $\text{MnO}_4^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$
Overall: $2\text{MnO}_4^-(\text{aq}) + 3\text{C}_2\text{O}_4^{2-}(\text{aq}) + 4\text{OH}^-(\text{aq}) \rightarrow 2\text{MnO}_2(\text{s}) + 6\text{CO}_3^{2-}(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- (c) **Oxidation:** $\text{ClO}^- + 4\text{OH}^- \rightarrow \text{ClO}_3^- + 2\text{H}_2\text{O} + 4\text{e}^-$
Reduction: $\text{ClO}^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Cl}^- + 2\text{OH}^-$
Overall: $3\text{ClO}^-(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{ClO}_3^-(\text{aq})$
This is another example of a disproportionation reaction.

- 8 (a) $3\text{SO}_2 + \text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 3\text{SO}_4^{2-} + \text{H}_2\text{O}$
[Oxidation: $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$
& Reduction: $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$]
- (b) $3\text{SO}_2 + \text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+ \rightarrow 3\text{SO}_4^{2-} + 2\text{Cr}^{3+} + \text{H}_2\text{O}$
Amount of $\text{Cr}_2\text{O}_7^{2-}$ reacted = $14.20 \times 10^{-3} \times 0.0100 = 1.420 \times 10^{-4}$ mol
Amount of SO_2 produced = $3 \times 1.420 \times 10^{-4} = 4.260 \times 10^{-4}$ mol



$$\text{Amount of Na}_2\text{S}_2\text{O}_5 \text{ present} = 4.260 \times 10^{-4} \div 2 = 2.130 \times 10^{-4} \text{ mol}$$

$$\text{Mass of Na}_2\text{S}_2\text{O}_5 \text{ present} = 2.130 \times 10^{-4} \times (2 \times 23.0 + 2 \times 32.1 + 5 \times 16.0) = 0.04051 \text{ g}$$

$$\text{Concentration of Na}_2\text{S}_2\text{O}_5 \text{ in ppm} = \frac{0.04051}{100} \times 10^6 = 405 \text{ ppm}$$

Mass of $\text{Na}_2\text{S}_2\text{O}_5$ / g	:	Mass of preserved meat / g
0.04051	:	100
$\frac{0.04051}{100}$	:	1
$\frac{0.04051}{100} \times 10^6 = 405$	:	10^6

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Oxidation: $\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + 2\text{H}^+ + 2\text{e}^-$
or $4\text{H}_2\text{O}_2 \rightarrow 4\text{O}_2 + 8\text{H}^+ + 8\text{e}^-$

$n_{\text{Cl}_2\text{O}_7}$	:	n_{e^-}	:	$n_{\text{H}_2\text{O}_2}$
1	:	:	:	4
1	:	8	:	4

+7

Reduction (unbalanced): $\text{Cl}_2\text{O}_7 + 8\text{e}^- \rightarrow ?$

⇒ Each Cl atom **accepted 4 e⁻**.

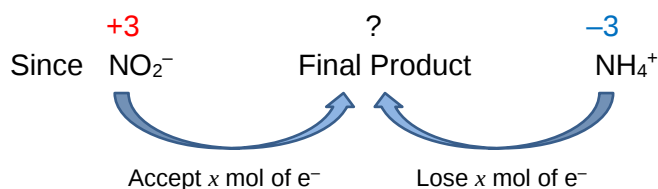
⇒ Oxidation number of Cl decreases from **+7** to **+3**.

- A Cl^- B ClO^- C ClO_2^- D ClO_3^-
- Answer: C

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n_{NaNO_2}	:	$n_{(\text{NH}_4)_2\text{SO}_4}$
0.010	:	0.005

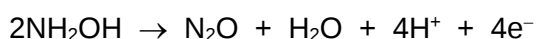
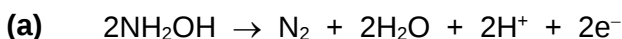
$n_{\text{NO}_2^-}$	:	n_{e^-}	:	$n_{\text{NH}_4^+}$
0.010	:		:	0.010
1	:	x	:	1



$\Rightarrow$ New oxidation number of N = 0

- A** $\overset{0}{\text{N}_2}$ **B** $\overset{+2}{\text{NO}}$ **C** $\overset{+1}{\text{N}_2\text{O}}$ **D** $\overset{-1}{\text{NH}_2\text{OH}}$
- Answer: **A**

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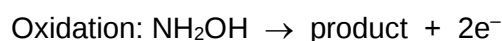
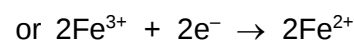
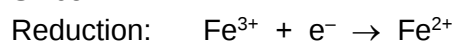


(b) Amount of Fe^{3+} reduced = $10 \times 10^{-3} \times 0.50 = 5.00 \times 10^{-3}$ mol

Amount of NH_2OH reacted = $50 \times 10^{-3} \times 0.050 = 2.50 \times 10^{-3}$ mol

$n_{\text{NH}_2\text{OH}}$	:	n_{e^-}	:	$n_{\text{Fe}^{3+}}$
2.50×10^{-3}	:		:	5.00×10^{-3}
1	:		:	2
1	:	2	:	2

Since



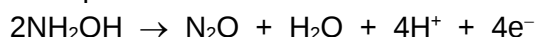
Using $\text{NH}_2\text{OH} \rightarrow \text{product} + 2e^-$,

oxidation number of N in the reactant = oxidation number of N in product + (-2)

Oxidation number of N in product = $-1 - (-2) = +1$

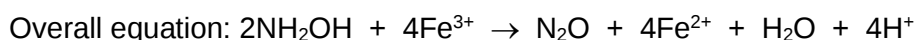
NH_2OH is oxidised to N_2O .

The relevant oxidation half-equation is therefore



in which 1 mole of NH_2OH loses 2 mol of electrons.

NH_2OH is oxidised to N_2O .

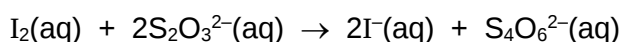


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(a) $[\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}]$ in **FA1** = $\frac{12.1}{2 \times 23.0 + 2 \times 32.1 + 3 \times 16.0 + 5(2 \times 1.0 + 16.0)}$

= 0.04875 mol dm⁻³

= $[\text{S}_2\text{O}_3^{2-}]$ in **FA1**



Amount of $\text{S}_2\text{O}_3^{2-}$ used = $24.40 \times 10^{-3} \times 0.04875 = 1.190 \times 10^{-3}$ mol

Amount of I_2 liberated = $1.190 \times 10^{-3} \div 2 = 5.948 \times 10^{-4}$ mol

Concentration of XO_3^- ions in **FA2** = 7.95×10^{-3} mol dm⁻³

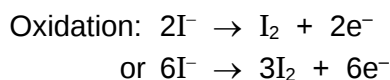
$$\begin{aligned}\text{Amount of } \text{XO}_3^- \text{ which reacted with } \text{I}^- \text{ to form } \text{I}_2 &= 25.0 \times 10^{-3} \times 7.95 \times 10^{-3} \\ &= 1.988 \times 10^{-4} \text{ mol}\end{aligned}$$

$n_{\text{XO}_3^-}$	:	n_{I_2}
1.988×10^{-4}	:	5.948×10^{-4}
1	:	3

Hence, **3 mol** of I_2 is liberated by 1 mol of XO_3^- .

(Note: It must be an integer.)

(b) Since



n_{I_2}	:	n_{e^-}	:	$n_{\text{XO}_3^-}$
3	:		:	1
3	:	6	:	1

+5

Reduction (unbalanced): $\text{XO}_3^- + 6\text{e}^- \rightarrow ?$

$\Rightarrow$ Oxidation number of X decreases from **+5** to **-1**.

Hence, the product obtained is X^- where the oxidation number of X is -1.

(c) Oxidation: $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$

Reduction: $\text{XO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{X}^- + 3\text{H}_2\text{O}$

Overall: $\text{XO}_3^-(\text{aq}) + 6\text{I}^-(\text{aq}) + 6\text{H}^+(\text{aq}) \rightarrow \text{X}^-(\text{aq}) + 3\text{H}_2\text{O}(\text{l}) + 3\text{I}_2(\text{aq})$

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$$\text{Amount of thiosulfate ions} = 0.0500 \times \frac{24.80}{1000} = \underline{1.24 \times 10^{-3} \text{ mol}}$$

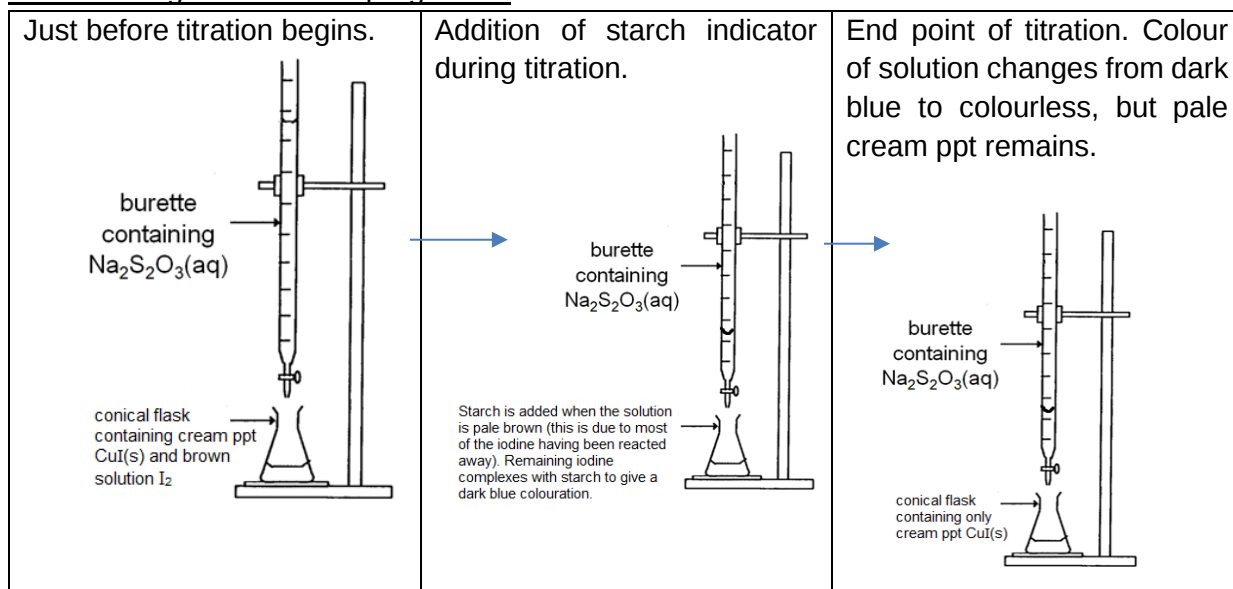
Mole ratio of $\text{Cu}^{2+} : \text{I}_2 : \text{S}_2\text{O}_3^{2-} = 2 : 1 : 2$

Amount of Cu^{2+} in 25.0 cm^3 of diluted solution = amount of $\text{S}_2\text{O}_3^{2-}$
 $= 1.24 \times 10^{-3} \text{ mol}$

$$[\text{Cu}^{2+}] \text{ in diluted solution} = \frac{1.24 \times 10^{-3}}{25.0 \times 10^{-3}} = 0.0496 \text{ mol dm}^{-3}$$

$$[\text{Cu}^{2+}] \text{ in original undiluted solution} = 0.0496 \times \frac{250}{41} = \underline{0.302 \text{ mol dm}^{-3}}$$

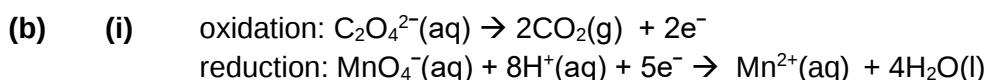
Colour changes as titration progresses



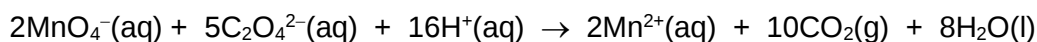
Amount of NaOH used = $14.75 \times 10^{-3} \times 0.100 = 1.475 \times 10^{-3} \text{ mol}$

Amount of $\text{H}_2\text{C}_2\text{O}_4$ present = $1.475 \times 10^{-3} \div 2 = 7.375 \times 10^{-4} \text{ mol}$

$[\text{H}_2\text{C}_2\text{O}_4]$ in solution = $\frac{7.375 \times 10^{-4}}{25.0 \times 10^{-3}} = 0.0295 \text{ mol dm}^{-3}$



Overall:



(ii) Amount of MnO_4^- used = $32.00 \times 10^{-3} \times 0.0205 = 6.560 \times 10^{-4} \text{ mol}$

Total amount of $\text{C}_2\text{O}_4^{2-}$ present = $\frac{6.560 \times 10^{-4}}{2} \times 5 = 1.64 \times 10^{-3} \text{ mol}$

(c) Amount of $\text{C}_2\text{O}_4^{2-}$ from $\text{H}_2\text{C}_2\text{O}_4 = 7.375 \times 10^{-4} \text{ mol}$

Amount of $\text{C}_2\text{O}_4^{2-}$ from $\text{Na}_2\text{C}_2\text{O}_4 = 1.640 \times 10^{-3} - 7.375 \times 10^{-4} = 9.025 \times 10^{-4} \text{ mol}$
 = Amount of $\text{Na}_2\text{C}_2\text{O}_4$

Hence, $[\text{Na}_2\text{C}_2\text{O}_4]$ in solution = $\frac{9.025 \times 10^{-4}}{25.0 \times 10^{-3}} = 0.0361 \text{ mol dm}^{-3}$