

5.2.3 Link catalyst cycles and chelation to evidence

Name: _____ Class: _____ Date: _____

Total: 16 marks

KEY WORDS evidence • conditions

Objective

Link catalyst cycles and chelation to evidence. All questions and marking guidance are original.

1 Key knowledge and worked examples

A catalyst is regenerated. Add its steps and cancel intermediates to recover the overall reaction. Homogeneous catalysts share a phase with reactants; heterogeneous catalysts act at a different-phase surface. Product-catalysed acceleration is autocatalysis.

■ Worked method

$\text{S}_2\text{O}_8^{2-} + 2\text{Fe}^{2+} \rightarrow 2\text{SO}_4^{2-} + 2\text{Fe}^{3+}$, followed by $2\text{Fe}^{3+} + 2\text{I}^- \rightarrow 2\text{Fe}^{2+} + \text{I}_2$, gives $\text{S}_2\text{O}_8^{2-} + 2\text{I}^- \rightarrow 2\text{SO}_4^{2-} + \text{I}_2$. Iron ions are regenerated. Replacing six water ligands with three bidentate ligands releases more free particles, often giving a favourable entropy change without increasing coordination number.

2 Practice

2.1 Define homogeneous and heterogeneous catalysis, giving one example of each from this unit. [2]

2.2 Add the two worked iron steps and identify the regenerated species. [2]

2.3 Explain why carbon monoxide binding to haemoglobin interferes with oxygen transport. [2]

3 Exam-style questions

3.1 Use $\text{V}_2\text{O}_5 + \text{SO}_2 \rightarrow \text{V}_2\text{O}_4 + \text{SO}_3$ and $2\text{V}_2\text{O}_4 + \text{O}_2 \rightarrow 2\text{V}_2\text{O}_5$ to derive the overall equation. Explain the role of variable oxidation states. [4]

3.2 An acidified manganate(VII)/ethanedioate mixture starts slowly then speeds up. Explain this without claiming reactant concentrations rise. [3]

3.3 Six water ligands are replaced by three bidentate en ligands. Explain why the product may be favoured and why “twice as many bonds” is incorrect. [3]

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

2.1 Homogeneous: same phase, for example aqueous iron ions catalysing iodide/peroxodisulfate. Heterogeneous: different phase, for example solid V_2O_5 with gaseous SO_2/O_2 .

2.2 $\text{S}_2\text{O}_8^{2-} + 2\text{I}^- \rightarrow 2\text{SO}_4^{2-} + \text{I}_2$; Fe^{2+} is regenerated via Fe^{3+} .

2.3 CO competes for binding to haem Fe^{2+} , strongly occupying sites needed for reversible oxygen binding.

3.1 Double the first step; cancel $2\text{V}_2\text{O}_5$ and $2\text{V}_2\text{O}_4$, giving $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$. Vanadium changes oxidation state and returns, providing an alternative pathway.

3.2 Mn^{2+} product acts as catalyst. Its concentration builds up and supplies more catalysed pathway. Later reactant depletion slows the reaction.

3.3 Six free waters replace three free en particles, often increasing entropy. Each en gives two donor bonds, so both complexes have six metal–donor bonds/coordination six.