

Transition metal – A2 Chemistry P1 & P3

1. No.3

0 3

This question is about aqueous ions of the metal iron.

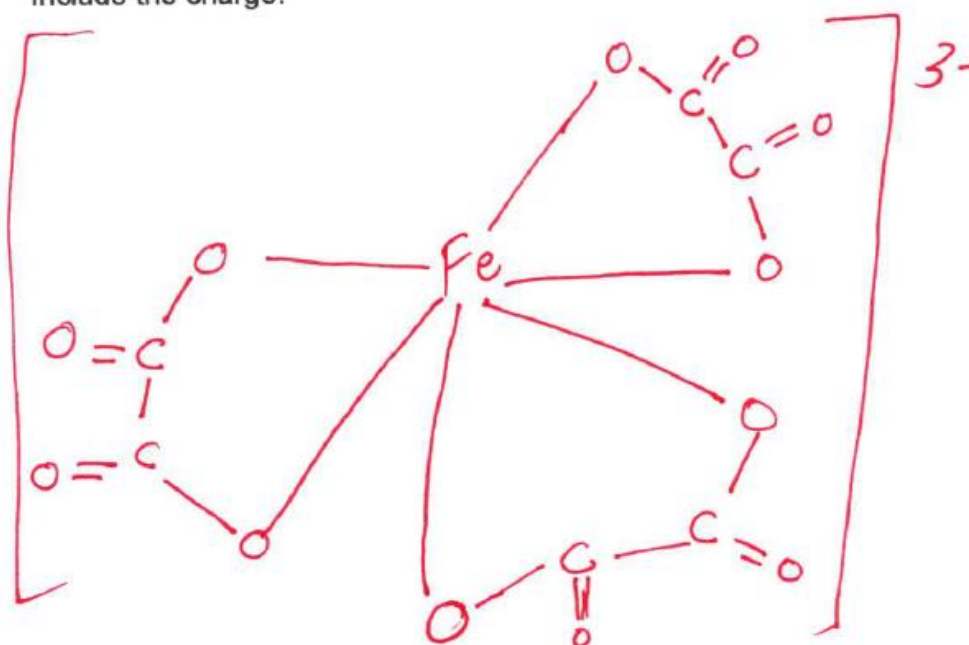
When an aqueous $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ ion reacts with ethanedioate ions, an iron(III) complex ion **X** is formed.

The only ligands in **X** are ethanedioate ions.

0 3 . 1

Draw the structure of **X**.

Include the charge.



[2 marks]

0 3 . 2

The formation of **X** is an example of the chelate effect.

Explain the meaning of the chelate effect.

[2 marks]

The chelate effect is the observation that complexes with bidentate or polydentate ligands are more stable than complexes formed with monodentate ligands. Because when monodentate ligands are replaced by a multidentate ligand, the number of ^{free} particles in solution increases, producing large positive entropy change ΔS .

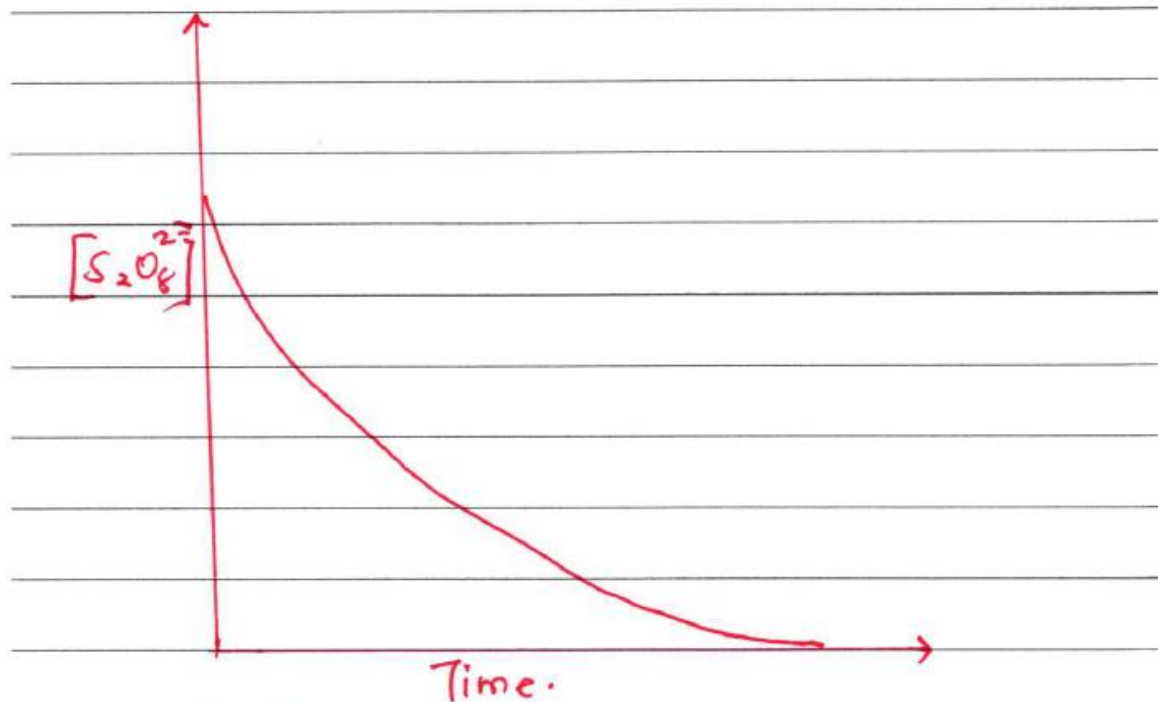
0 3 . 3

Outline how Fe^{2+} ions catalyse the reaction between $\text{S}_2\text{O}_8^{2-}$ ions and I^- ions in aqueous solution.

In your answer you should include

- a sketch graph to show how the concentration of $\text{S}_2\text{O}_8^{2-}$ ions changes over time
- an explanation of how Fe^{2+} ions catalyse the reaction, including equations
- an overall equation for the reaction.

[6 marks]



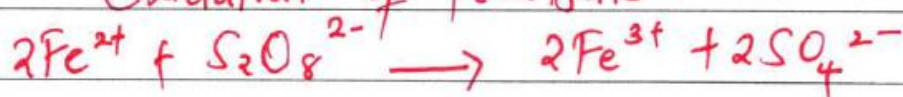
E Catalysis:

Stage 1: Why uncatalysed reaction is slow.

$\text{S}_2\text{O}_8^{2-}$ and I^- are both negatively charged such a reaction requires electron transfer between two anions and has a high activation energy making it slow.

Stage 2: Fe^{2+} interacts with the persulfate enabling electron transfer and lowering activation energy. Iron can change oxidation state Fe^{2+} to Fe^{3+} .

Oxidation of persulfate.



Fe^{3+} oxidises iodide to iodine regenerating Fe^{2+}



Because Fe^{2+} is regenerated, it acts as a catalyst. It provides an alternative two step redox pathway with lower activation energy than direct persulfate + iodide reaction.

Stage c : Add. the two steps Fe species cancel.



Because the catalytic pathway has lower activation energy, the rate of consumption of $\text{S}_2\text{O}_8^{2-}$ is increased making the concentration/time curve steeper at early times when the catalyst is present.

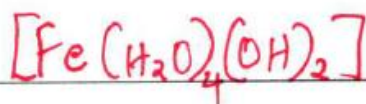
The concentration of $\text{S}_2\text{O}_8^{2-}$ still decreases to completion but more quickly with Fe^{2+}

03.4

A student adds dilute ammonia solution to a solution containing $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ ions.

Give the formula of the precipitate that forms.

[1 mark]



03.5

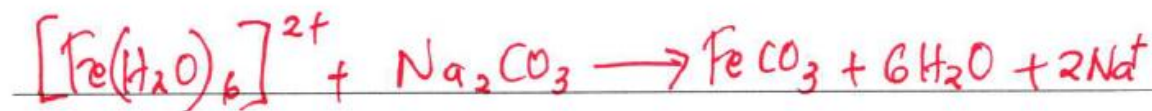
The student adds sodium carbonate solution to a solution containing $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ ions.State **one** observation the student would make.

Give an equation for the reaction.

[2 marks]

Observation Formation of a green precipitate.

Equation



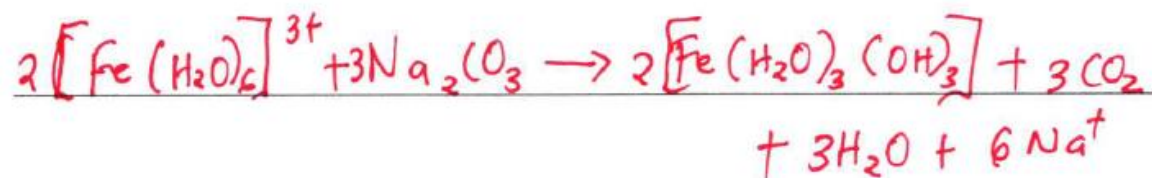
03.6

A solution containing $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ ions changes to a yellow-brown colour after several hours in contact with air.

The student adds sodium carbonate to the yellow-brown solution.

Give an equation for the reaction with sodium carbonate.

[1 mark]



2. No.5

0 5 . 1

Some complexes containing transition metal ions are coloured.

- Explain why some complexes containing transition metal ions are coloured.
- List the factors that affect the colour.
- Describe how colorimetry can be used to determine the concentration of a coloured complex.

[6 marks]

Some are coloured because the d orbitals of the metal ions are split in different energy levels when ligands are present. Electrons absorb energy from visible light to move from lower energy d-orbitals to higher energy d-orbitals. The wavelengths of light absorbed correspond to certain colours and the remaining wavelengths are transmitted or reflected which is the colour we observe.

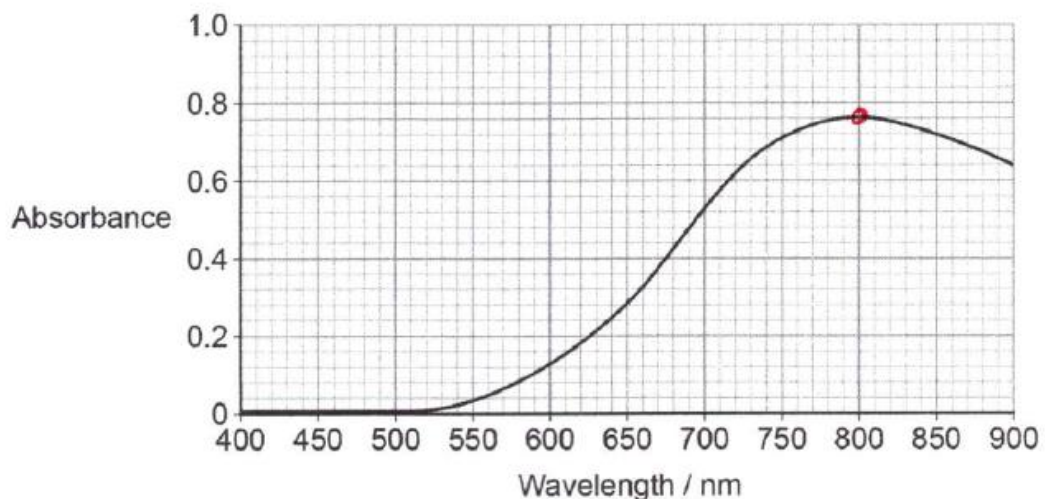
The colour of a complex depends on several factors

- ① Identity of the metal ion ② Oxidation state of the metal ion. ③ Type of ligand surrounding the metal
④ The coordination number and geometry of the complex.
- Colorimetry is used to determine the concentration of a coloured complex solution. A series of standard solutions with known concentrations are prepared and their absorbance values measured with the colorimeter. A calibration curve is then plotted with absorbance on the y-axis and concentration on the x-axis. The absorbance of the unknown solution is measured, and its concentration is determined from the graph by comparing its absorbance.

0 5 . 2

Figure 5 shows the visible spectrum of $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$

Figure 5



Use the wavelength at the peak of the curve in **Figure 5** to calculate the change in energy, in J, of an electron when it absorbs radiation with this wavelength.

the Planck constant, $h = 6.63 \times 10^{-34} \text{ J s}$

speed of light, $c = 3.00 \times 10^8 \text{ m s}^{-1}$

[3 marks]

At 800 nm.

$$\Delta H = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^8}{800 \times 10^{-9}} = 2.48625 \times 10^{-19}$$

Change in energy 2.49×10^{-19} J