

### 3. This question is about dissolved oxygen in water

Aquatic life can only survive because of the oxygen gas dissolved in the water; without it, the water rapidly becomes toxic due to decaying organic matter.

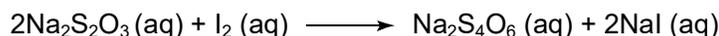
Hence it is important to monitor the dissolved oxygen concentration (DOC) in rivers and lakes – if this falls below  $5 \text{ mg dm}^{-3}$ , most species of fish cannot survive.



One of the most accurate methods for measuring the DOC in water is the *Winkler method*. Under alkaline conditions  $\text{Mn}^{2+}$  is rapidly oxidised to  $\text{Mn}^{3+}$  by dissolved oxygen, producing a pale brown precipitate of  $\text{Mn}(\text{OH})_3$ . A sample of river water is shaken with excess alkaline  $\text{Mn}^{2+}$ , and the resulting pale brown precipitate is then reacted with an excess of potassium iodide, which it oxidises to iodine. The iodine is then determined by a titration with sodium thiosulfate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) solution of known concentration.

- (a) Write balanced symbol equations for:
- the oxidation of  $\text{Mn}(\text{OH})_2$  to  $\text{Mn}(\text{OH})_3$  by aqueous oxygen,
  - the oxidation of KI by  $\text{Mn}(\text{OH})_3$ ,

The equation for the reaction between sodium thiosulfate and iodine is:



- (b) Suggest an indicator for the iodine-thiosulfate titration.

$25.0 \text{ cm}^3$  of a sample of river water treated in this way required  $25.0 \text{ cm}^3$  of  $0.00100 \text{ mol dm}^{-3}$  sodium thiosulfate solution.

- (c) Calculate the concentration of the dissolved oxygen in  $\text{mg dm}^{-3}$ .

Nitrate(III) ions are found to interfere with this method since they too can oxidise iodide ions to iodine. During the reaction, a colourless gas is given off, which instantly turns brown on exposure to the air.

- (d) What is the colourless gas? Give a balanced equation for its reaction in air.
- (e) Write a balanced equation for the oxidation of iodide ions by nitrate(III) ions.

In a modification of the Winkler method to prevent the interference by nitrate(III) ions, a solution of sodium azide,  $\text{NaN}_3$ , is added to the river water. During this reaction, two gases are evolved: nitrogen and  $\text{N}_2\text{O}$ .

- (f) Write a balanced equation for the reaction between nitrate(III) ions and azide ions in aqueous acid.