6. (continued)

(d) Ammonia is currently being investigated for use in fuel cells.

The reactions taking place at the electrodes are

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

$$2NH_3 + 6OH^- \rightarrow N_2 + 6H_2O + 6e^-$$

(i) Write the overall redox equation for the reaction taking place in the fuel cell. **1**

(ii) Identify the reducing agent in the reaction taking place in the fuel cell. **1**

[Turn over

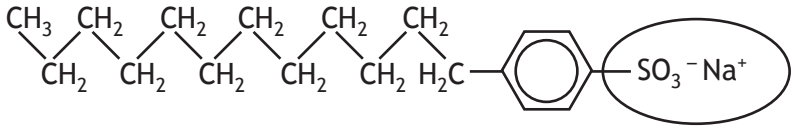
7. Tap water contains a number of dissolved chemicals.

(a) In some parts of the country, tap water contains a high level of dissolved metal salts.

(i) State the term used to describe this type of water. **1**

(ii) Soapless detergents are used with this type of water to prevent insoluble scum forming.

The structure of a typical soapless detergent is shown.



The circled region of the molecule is ionic and dissolves in water.

State the term used to describe this part of the molecule. **1**

7. (a) (continued)

(iii) Calcium ions are commonly found in tap water. The concentration of calcium ions in a tap water sample was determined by titrating with a chemical called EDTA, $C_{10}H_{12}N_2O_8^{4-}$.

A 50.0 cm^3 water sample was collected and reacted with a standard solution of EDTA, with a concentration of 0.0045 mol l^{-1}. The average titre volume was 9.3 cm^3.

$$Ca^{2+}(aq) + C_{10}H_{12}N_2O_8^{4-}(aq) \rightarrow [Ca(C_{10}H_{12}N_2O_8)]^{2-}(aq)$$

Calculate the concentration, in mol l^{-1}, of calcium ions in the tap water. **3**

[Turn over

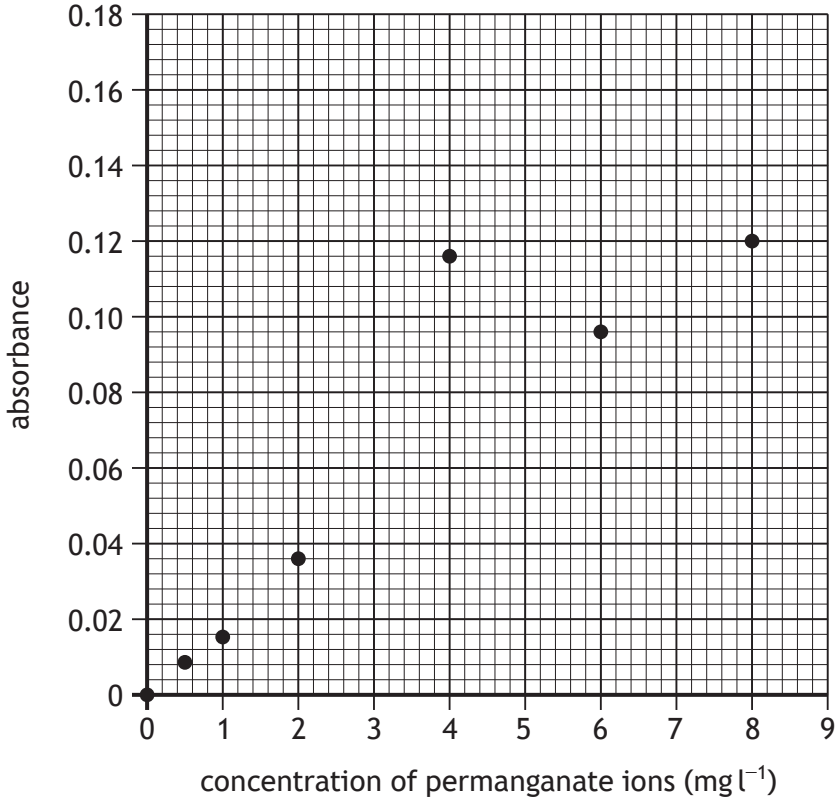
7. (continued)

(b) Another ion found in tap water is manganese(II), Mn^{2+}.

The manganese(II) ions are oxidised to purple permanganate ions, MnO_4^-. The concentration of permanganate ions can be determined by measuring how much light is absorbed by the solution.

The higher the concentration of permanganate ions in the solution, the more light is absorbed.

The absorbances of several standard solutions of permanganate were measured, and the results plotted.



A water sample had an absorbance of 0.08.

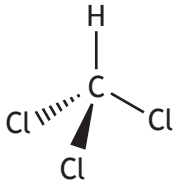
Estimate the concentration of permanganate ions, in mg l^{-1}, in this sample. **1**

7. (continued)

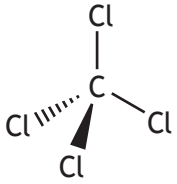
(c) Chlorine is added to tap water to make it safe to drink.

The chlorine can react with substances in the water to produce trichloromethane, $CHCl_3$.

(i) Trichloromethane is more soluble in water than tetrachloromethane due to the polarities of the molecules.



trichloromethane



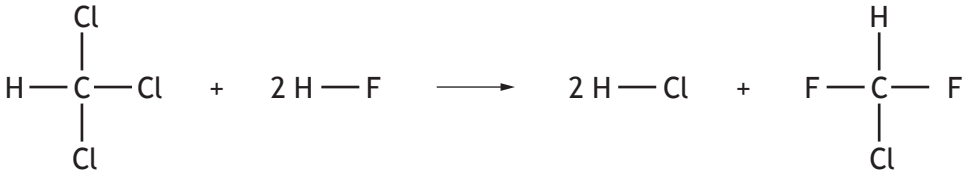
tetrachloromethane

Explain the difference in polarities of trichloromethane and tetrachloromethane molecules. **2**

[Turn over

7. (c) (continued)

(ii) Trichloromethane is used on an industrial scale to produce plastics. The first step in this reaction is to react it with hydrogen fluoride, HF.



Using bond enthalpies and mean bond enthalpies from the data booklet, calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction of trichloromethane with hydrogen fluoride. **2**