QUESTION 12 (16 marks)

The label on a bottle of household bleach states that the minimum concentration of hypochlorite ions, ClO^-, is 5% w/v.

(a) In the bleaching process ClO^- is reduced to Cl^-.

Write a half-equation for this process.

(2 marks)

Credit will be given for the correct use of significant figures in answers to part (b). (1 mark)

(b) The concentration of ClO^- in this household bleach was determined by titration, using sodium thiosulfate ($Na_2S_2O_3.5H_2O$) and acidified potassium iodide (KI).

The steps for this procedure are shown below.

Step 1 A standard solution of 0.2034 mol L^{-1} sodium thiosulfate was prepared.

(i) Calculate the mass, in grams, of $Na_2S_2O_3.5H_2O$ crystals (M = 248.18 g mol^{-1}) used to prepare this standard solution in a 250.0 mL volumetric flask.

(3 marks)

Step 2 A volume of 20.00 mL of the bleach was diluted to 200.00 mL.

Step 3 25.00 mL of the diluted bleach was mixed with an excess of acidified KI solution to ensure that all of the ClO^- had reacted.

The equation for this reaction is shown below:

$$ClO^- + 2I^- + 2H^+ \longrightarrow I_2 + Cl^- + H_2O$$

Step 4 This mixture was then titrated with sodium thiosulfate solution to react with I_2.

The equation for this reaction is shown below:

$$2S_2O_3^{2-} + I_2 \longrightarrow 2I^- + S_4O_6^{2-}$$

(ii) The average titre of 0.2034 mol L^{-1} sodium thiosulfate solution obtained in Step 4 was 33.94 mL.

(1) Calculate the moles of $S_2O_3^{2-}$ in the average titre.

(2 marks)

(2) Hence calculate the moles of I_2 that reacted in Step 4.

(1 mark)

(3) Hence calculate the concentration, in % w/v, of ClO^- (M = 51.45 g mol^{-1}) in the original bottle of household bleach.

(4 marks)

(4) Explain whether the concentration of ClO^- calculated would have been higher or lower if insufficient acidified KI solution had been added in Step 3.

(2 marks)

(iii) Suggest one reason why the actual concentration of ClO^- in bottles of household bleach is often higher than the concentration stated on their labels.

(1 mark)