

Moles question worked example (2)

Use the following experimental data to deduce an equation for the reaction between chlorine and sodium thiosulphate in aqueous solution, and explain your reasoning.

3.10g of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ were dissolved in water to give 250cm^3 of solution, and chlorine was swept through until reaction was complete. Excess chlorine was then swept from the solution using gaseous nitrogen.

25.0cm^3 samples of the resulting solution were found

- to require 12.5cm^3 of 1.00mol dm^{-3} KOH for neutralization
- to require 10.0cm^3 of 1.00mol dm^{-3} AgNO_3 to complete the precipitation of chloride ions
- to give 0.583g of white precipitate when treated with an excess of aqueous BaCl_2

Parts a), b) and c) tell you that the products are H^+ , Cl^- and SO_4^{2-} respectively, and the Na^+ will still remain in solution. From the data you need to work out the amounts of each, and their ratios.

amount of $\text{S}_2\text{O}_3^{2-}$

$$\begin{aligned} &= \text{mass} / \text{RMM} && [\text{RMM of } \text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} = 248 \text{ gmol}^{-1}] \\ &= 3.10\text{g} / 248\text{gmol}^{-1} \\ &= 0.0125 \text{ mol} \end{aligned}$$

This amount was in the 250cm^3 vessel. Therefore, there was $1/10^{\text{th}}$ in the 25cm^3 samples.
i.e. amount of $\text{S}_2\text{O}_3^{2-} = 1.25 \times 10^{-3} \text{ mol}$

amount H^+

is equal to the amount of KOH in the neutralisation $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$

$$\begin{aligned} \text{moles (KOH)} &= (\text{conc.} \times \text{vol.}) / 1000 \\ &= (1 \times 12.5) / 1000 \\ &= 1.25 \times 10^{-2} \text{ mol} \end{aligned}$$

amount Cl^-

is equal to the amount of $\text{AgNO}_3(\text{aq})$ in the precipitation $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$

$$\begin{aligned} \text{moles (AgNO}_3) &= (\text{conc.} \times \text{vol.}) / 1000 \\ &= (1 \times 10) / 1000 \\ &= 1.00 \times 10^{-2} \text{ mol} \end{aligned}$$

amount SO_4^{2-}

is equal to the amount of $\text{BaSO}_4(\text{s})$ formed in the precipitation $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$

$$\begin{aligned} \text{moles (BaSO}_4) &= \text{mass} / \text{RMM} && [\text{RMM of BaSO}_4 = 233 \text{ gmol}^{-1}] \\ &= 0.583\text{g} / 233\text{gmol}^{-1} \\ &= 2.5 \times 10^{-3} \text{ mol} \end{aligned}$$

amount	$(\text{S}_2\text{O}_3^{2-})$	(Cl_2)	\rightarrow	(H^+)	(Cl^-)	(SO_4^{2-})
ratio	1.25×10^{-3}			1.25×10^{-2}	1.00×10^{-2}	2.5×10^{-3}
equation	$\text{S}_2\text{O}_3^{2-} +$	4Cl_2	\rightarrow	10H^+	$+ 8\text{Cl}^-$	$+ 2\text{SO}_4^{2-}$