

Example 1.27 1 g of CaCO_3 is dissolved in 1 l of distilled water. 50 ml of solution consumes 45 ml of EDTA solution for titration. 50 ml of hard water sample requires 25 ml of EDTA solution for titration. Same water on boiling and filtering requires 15 ml of EDTA solution. Calculate the temporary, permanent, and total hardness of water.

Solution

Step 1

$$\begin{aligned}\text{Strength of SHW} &= 1 \text{ g}/1000 \text{ ml} \\ &= 1 \times 1000 \text{ mg}/1000 \text{ ml} \\ 1 \text{ ml of SHW} &= 1 \text{ mg of } \text{CaCO}_3/\text{ml} \\ \therefore 1 \text{ ml of SHW} &= 1 \text{ mg of } \text{CaCO}_3/\text{ml}\end{aligned}$$

Step 2

$$\begin{aligned}50 \text{ ml of SHW} &= 45 \text{ ml of EDTA} \\ 50 \times 1 \text{ mg of } \text{CaCO}_3 &= 45 \text{ ml of EDTA} \\ 50/45 \text{ mg of } \text{CaCO}_3 &= 1 \text{ ml of EDTA} \\ \therefore 1 \text{ ml of EDTA} &= 1.11 \text{ mg of } \text{CaCO}_3\end{aligned}$$

Step 3

$$\begin{aligned}50 \text{ ml of HW} &= 25 \text{ ml of EDTA} \\ 50 \text{ ml of HW} &= 25 \times 1 \text{ ml of EDTA} \\ 50 \text{ ml of HW} &= 25 \times 1.11 \text{ mg of } \text{CaCO}_3 \\ \therefore 1000 \text{ ml of hard water} &= 25 \times 1.11 \times 1000/50 \text{ ppm} \\ \therefore \text{Total hardness of water sample} &= 555 \text{ ppm}\end{aligned}$$

Step 4 After boiling and filtering

$$\begin{aligned}50 \text{ ml of boiled water} &= 15 \text{ ml of EDTA} \\ 50 \text{ ml of boiled water} &= 15 \times 1 \text{ ml of EDTA} \\ 50 \text{ ml of boiled water} &= 15 \times 1.11 \text{ mg of } \text{CaCO}_3 \\ \therefore 1000 \text{ ml of boiled water} &= 15 \times 1.11 \times 1000/50 \text{ ppm} \\ \therefore \text{Permanent hardness of water sample} &= 333 \text{ ppm}\end{aligned}$$

Step 5

$$\begin{aligned}\text{Temporary hardness} &= \text{Total hardness} - \text{Permanent hardness} \\ &= 555 - 333 \text{ ppm} \\ \text{Temporary hardness} &= 222 \text{ ppm}\end{aligned}$$

Example 1.28 1 g of CaCO_3 is dissolved in 1 l of distilled water. 50 ml of solution consumes 38 ml of EDTA solution for titration. 50 ml of hard water sample requires 29 ml of EDTA solution for titration. Same water on boiling and filtering requires 13 ml of EDTA solution. Calculate the temporary, permanent, and total hardness of water.

Solution

Step 1

$$\begin{aligned}\text{Strength of SHW} &= 1 \text{ g} / 1000 \text{ ml} \\ &= 1 \times 1000 \text{ mg} / 1000 \text{ ml} \\ 1 \text{ ml of SHW} &= 1 \text{ mg of } \text{CaCO}_3 / \text{ml} \\ \therefore 1 \text{ ml of SHW} &= 1 \text{ mg of } \text{CaCO}_3 / \text{ml}\end{aligned}$$

Step 2

$$\begin{aligned}50 \text{ ml of SHW} &= 38 \text{ ml of EDTA} \\ 50 \times 1 \text{ mg of } \text{CaCO}_3 &= 38 \text{ ml of EDTA} \\ 50/38 \text{ mg of } \text{CaCO}_3 &= 1 \text{ ml of EDTA} \\ \therefore 1 \text{ ml of EDTA} &= 1.3 \text{ mg of } \text{CaCO}_3\end{aligned}$$

Step 3

$$\begin{aligned}50 \text{ ml of HW} &= 29 \text{ ml of EDTA} \\ 50 \text{ ml of HW} &= 29 \times 1 \text{ ml of EDTA} \\ 50 \text{ ml of HW} &= 29 \times 1.3 \text{ mg of } \text{CaCO}_3 \\ \therefore 1000 \text{ ml of hard water} &= 29 \times 1.3 \times 1000/50 \text{ ppm} \\ \therefore \text{Total hardness of water sample} &= \mathbf{754 \text{ ppm}}\end{aligned}$$

Step 4 After boiling and filtering

$$\begin{aligned}50 \text{ ml of boiled water} &= 13 \text{ ml of EDTA} \\ 50 \text{ ml of boiled water} &= 13 \times 1 \text{ ml of EDTA} \\ 50 \text{ ml of boiled water} &= 13 \times 1.3 \text{ mg of } \text{CaCO}_3 \\ \therefore 1000 \text{ ml of boiled water} &= 13 \times 1.3 \times 1000/50 \text{ ppm} \\ \therefore \text{Permanent hardness of water sample} &= \mathbf{338 \text{ ppm}}\end{aligned}$$

Step 5

$$\begin{aligned}\text{Temporary hardness} &= \text{Total hardness} - \text{Permanent hardness} \\ &= 754 - 338 \text{ ppm} \\ \text{Temporary hardness} &= \mathbf{416 \text{ ppm}}\end{aligned}$$

Example 1.29 0.5 g of CaCO_3 is dissolved in HCl and the solution is made up to 1000 ml with distilled water. 50 ml of this solution requires 40 ml of EDTA solution for titration. 50 ml of hard water sample requires 19 ml of EDTA solution and after boiling and filtering requires 6.8 ml of EDTA solution. Calculate temporary hardness of water.

Solution

Step 1

$$\begin{aligned}\text{Strength of SHW} &= 0.5 \text{ g} / 1000 \text{ ml} \\ &= 0.5 \times 1000 \text{ mg} / 1000 \text{ ml} \\ 1 \text{ ml of SHW} &= 0.5 \text{ mg of } \text{CaCO}_3 / \text{ml} \\ \therefore 1 \text{ ml of SHW} &= 0.5 \text{ mg of } \text{CaCO}_3 / \text{ml}\end{aligned}$$

Step 2

$$\begin{aligned}50 \text{ ml of SHW} &= 40 \text{ ml of EDTA} \\ 50 \times 0.5 \text{ mg of } \text{CaCO}_3 &= 40 \text{ ml of EDTA} \\ 25/40 \text{ mg of } \text{CaCO}_3 &= 1 \text{ ml of EDTA} \\ \therefore 1 \text{ ml of EDTA} &= 0.62 \text{ mg of } \text{CaCO}_3\end{aligned}$$

Step 3

$$\begin{aligned}50 \text{ ml of HW} &= 19 \text{ ml of EDTA} \\ 50 \text{ ml of HW} &= 19 \times 1 \text{ ml of EDTA} \\ 50 \text{ ml of HW} &= 19 \times 0.62 \text{ mg of } \text{CaCO}_3 \\ \therefore 1000 \text{ ml of hard water} &= 19 \times 0.62 \times 1000/50 \text{ ppm} \\ \therefore \text{Total hardness of water sample} &= 235.6 \text{ ppm}\end{aligned}$$

Step 4 After boiling and filtering

$$\begin{aligned}50 \text{ ml of boiled water} &= 6.8 \text{ ml of EDTA} \\ 50 \text{ ml of boiled water} &= 6.8 \times 1 \text{ ml of EDTA} \\ 50 \text{ ml of boiled water} &= 6.8 \times 0.62 \text{ mg of } \text{CaCO}_3 \\ \therefore 1000 \text{ ml of boiled water} &= 6.8 \times 0.62 \times 1000/50 \text{ ppm} \\ \therefore \text{Permanent hardness of water sample} &= 84.32 \text{ ppm}\end{aligned}$$

Step 5

$$\begin{aligned}\text{Temporary hardness} &= \text{Total hardness} - \text{Permanent hardness} \\ &= 235.6 - 84.32 \text{ ppm} \\ \text{Temporary hardness} &= 151.28 \text{ ppm}\end{aligned}$$