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## Engineering Chemistry

- 1) 20 ml of standard hard water (containing 1.2g  $\text{CaCO}_3$  per litre) required 35 ml of EDTA. 50 ml of hard water sample required 30 ml of same EDTA. 100 ml of hard water sample after boiling required 25 ml of same EDTA. Calculate various hardness.

→ Step 1: Strength of hard water = 1.2 g/l

$$= \frac{1200}{1000} \text{ mg of } \text{CaCO}_3 \text{ per ml}$$
$$= 1.2 \text{ mg of } \text{CaCO}_3 \text{ per ml}$$

Step 2: 20 ml of standard  
hard water = 35 ml of EDTA

20 ml of standard  
hard water =  $(20 \times 1.2) \text{ mg of } \text{CaCO}_3$

$$\therefore 1 \text{ ml of EDTA} = \frac{20 \times 1.2}{35} = 0.685 \text{ mg of } \text{CaCO}_3$$

Step 3:

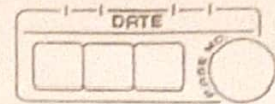
50 ml of hard water sample = 30 ml of EDTA

$$\therefore 1000 \text{ ml of hard water sample} = \left( \frac{1000 \times 30}{50} \right) \times 0.685$$

$$= 411 \text{ ppm}$$

$$\therefore \text{Total Hardness} = 411 \text{ ppm}$$



Step 4

100 ml boiled hard water = 25 ml of EDTA

$$\therefore 1000 \text{ ml of boiled hard water} = \frac{1000 \times 25}{100} \times 0.685$$

$$= 171.25 \text{ ppm}$$

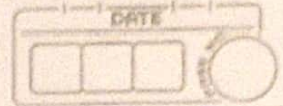
$$\therefore \text{Permanent hardness} = 171.25 \text{ ppm.}$$

Now,

$$\begin{aligned} \text{Temporary hardness} &= \text{Total hardness} - \text{Permanent hardness} \\ &= 411 - 171.25 \\ &= 239.75 \text{ ppm.} \end{aligned}$$

$$\therefore \text{Total hardness} = 411 \text{ ppm, Permanent hardness} = 171.25 \text{ ppm}$$
$$\text{Temporary Hardness} = 239.75 \text{ ppm.}$$





Q 2) 0.5 gm of  $\text{CaCO}_3$  was dissolved in  $\text{HCl}$  and the solution made up to 500 ml with distilled water. 50 ml of the solution requires 45 ml of EDTA solution for titration. 50 ml of hard water sample requires 15 ml of EDTA and after boiling and filtering required 10 ml of EDTA solution. Calculate temporary hardness and total hardness of water.

→ Step 1

$$\begin{aligned}\text{Strength of standard hard water} &= 0.5 \text{ gm } \text{CaCO}_3 / 500 \text{ ml water} \\ &= 500 \text{ mg } \text{CaCO}_3 / 500 \text{ ml water} \\ &= 1 \text{ mg/ml}\end{aligned}$$

Step 2

50 ml of standard hard water = 45 ml EDTA solution

$\therefore$  45 ml of EDTA solution = 50 mg  $\text{CaCO}_3$  equivalent

$\therefore$  1 ml of EDTA solution =  $\frac{50}{45}$  mg  $\text{CaCO}_3$  equivalent.

Now,

50 ml water sample = 15 ml of EDTA solution.

$\therefore$  Hardness of sample =  $\left[15 \times \frac{50}{45}\right]$  mg  $\text{CaCO}_3$  equivalent for 50 ml hardness

$\therefore$  Hardness per litre of sample =  $\left[15 \times \frac{50}{45}\right] \times \frac{1000}{50}$  mg/l

$\therefore$  Total hardness = 333.33 ppm



Step 3

50 ml water sample after boiling = 10 ml EDTA solution

$$\therefore \text{Permanent hardness of sample} = \left(10 \times \frac{50}{45}\right) \text{ mg CaCO}_3 \text{ for 50 ml}$$

$$\therefore \text{Permanent hardness of 1 litre sample} = \left(10 \times \frac{50}{45}\right) \times \frac{1000}{50} \text{ mg/l}$$

$$\therefore \text{Permanent hardness} = 222.22 \text{ ppm}$$

$$\begin{aligned} \therefore \text{Temporary hardness} &= \text{Total hardness} - \text{Permanent hardness} \\ &= 333.33 - 222.22 \end{aligned}$$

$$\therefore \text{Temporary hardness} = 111.11 \text{ ppm}$$

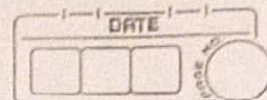
~~Temporary~~

Hence,

Total hardness = 333.33 ppm, Permanent hardness = 222.22 ppm

Temporary hardness = 111.11 ppm





- 3) In the process of determination of Hardness, standard hard water sample was prepared by dissolving 2.5 g  $\text{CaCO}_3$  and making solution up to 1 litre. 50 ml of above hard water required 45 ml of EDTA. 50 ml of unknown hard water sample consumed 30 ml EDTA solution using Erio-Black T indicator. The unknown hard water sample was boiled and filtered. 50 ml of this boiled solution required 20 ml of EDTA. Calculate hardness of all types of unknown hard water sample.

→ Step 1

$$\begin{aligned}\text{Strength of water sample} &= 2.5 \text{ g/litre} \\ &= 2500/1000 \text{ mg of } \text{CaCO}_3 \text{ per ml} \\ &= 2.5 \text{ mg of } \text{CaCO}_3 \text{ per ml.}\end{aligned}$$

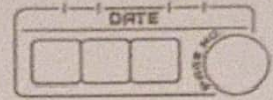
Step 2

$$\begin{aligned}50 \text{ ml of standard hard water} &= 45 \text{ ml of EDTA} \\ 50 \text{ ml of standard hard water} &= (50 \times 2.5) \text{ mg of } \text{CaCO}_3 \\ \therefore 1 \text{ ml of EDTA} &= \frac{50 \times 2.5}{45} \\ &= 2.777 \text{ mg of } \text{CaCO}_3 \text{ equivalent.}\end{aligned}$$

Step 3

$$\begin{aligned}50 \text{ ml of hard water sample} &= 30 \text{ ml of EDTA} \\ \therefore 1000 \text{ ml of hard water sample} &= \left( \frac{1000 \times 30}{50} \right) \times 2.777 \\ \therefore \text{Total hardness} &= 1666.2 \text{ ppm}\end{aligned}$$





Step 4 :

10 ml boiled hard water = 20 ml of EDTA

$$\therefore 1000 \text{ ml of boiled hard water} = \frac{1000 \times 20 \times 2.777}{50}$$

$$= 1110.8 \text{ ppm}$$

$$\therefore \text{Permanent hardness} = 1110.8 \text{ ppm}$$

$$\begin{aligned}\therefore \text{Temporary hardness} &= \text{Total hardness} - \text{Permanent hardness} \\ &= 1666.2 - 1110.8 \\ &= 555.4 \text{ ppm.}\end{aligned}$$

Hence,

Total hardness = 1666.2 ppm, Permanent hardness = 1110.8 ppm,

Temporary hardness = 555.4 ppm