



Engineering Chemistry

CYC 102

Dr. Sukriti


School Of Basic Sciences

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Indian Institute of Information Technology, Una
Himachal Pradesh



Overview

- Numerical problems on determination of hardness
- Summary



Numerical problems

Determination of hardness of water

1. A water sample contains 408 mg of CaSO_4 per litre. Calculate the hardness in terms of CaCO_3 equivalents.

✓ **Solution:**

$$\begin{aligned}\text{Hardness} &= (\text{mass of } \text{CaSO}_4 \text{ in mg/L}) \times \text{Multiplication factor} \\ &= (\text{mass of } \text{CaSO}_4 \text{ in mg/L}) \times \frac{\text{Chemical equivalent of } \text{CaCO}_3}{\text{Chemical equivalent of } \text{CaSO}_4} \\ &= (408 \text{ mg/L}) \times \frac{50}{68} \\ &= 300 \text{ mg/L} = 300 \text{ ppm}\end{aligned}$$



Numerical problems...Contd.

2. How many grams of MgCO_3 dissolved per litre gives 84 ppm of hardness?

Solution:

Hardness = (mass of MgCO_3 in mg/L) \times Multiplication factor

$$\begin{aligned}\text{Hence, mass of } \text{MgCO}_3 \text{ in mg/L} &= (\text{Hardness}) \times \frac{\text{Chemical equivalent of } \text{MgCO}_3}{\text{Chemical equivalent of } \text{CaCO}_3} \\ &= (84 \text{ ppm}) \times \frac{42}{50} \\ &= 70.56 \text{ ppm} = 70.56 \text{ mg/L}\end{aligned}$$

Thus, 70.56×10^{-3} gms of MgCO_3 dissolved per litre gives 84 ppm of Hardness.



Numerical problems...Contd.

3. A sample of water is found to contains following dissolving salts in milligrams per litre: $\text{Ca}(\text{HCO}_3)_2 = 4$, $\text{CaSO}_4 = 8$, $\text{Mg}(\text{HCO}_3)_2 = 6$ and $\text{MgSO}_4 = 10$ Calculate temporary and permanent hardness in ppm, $^\circ\text{Fr}$ and $^\circ\text{Cl}$.

Solution: Step1 Conversion to CaCO_3 equivalents

Constituents	Amount mg/L [A]	Multiplication Factor [M]	CaCO_3 equivalent = [A] \times [M]
$\text{Ca}(\text{HCO}_3)_2$	4	100/162	$4 \times 100/162 = 2.47 \text{ mg/L}$
$\text{Mg}(\text{HCO}_3)_2$	6	100/146	$6 \times 100/146 = 4.11 \text{ mg/L}$
CaSO_4	8	100/136	$8 \times 100/136 = 5.88 \text{ mg/L}$
MgSO_4	10	100/120	$10 \times 100/120 = 8.33 \text{ mg/L}$



Numerical problems...Contd.

Step 2 Determination of temporary hardness

As Temporary hardness is due to bicarbonates of calcium and Magnesium

$$\therefore \text{Temporary hardness} = 2.47 + 4.11 = 6.58 \text{ mg/L}$$

$$\text{As } 1 \text{ mg/L} = 1 \text{ ppm} = 0.1^\circ \text{Fr} = 0.07^\circ \text{Cl}$$

$$\text{Hence, Temporary hardness} = 6.58 \text{ mg/L} = 6.58 \text{ ppm}$$

$$= 6.58 \times 0.1 = 0.658^\circ \text{Fr}$$

$$= 6.58 \times 0.07 = 0.46^\circ \text{Cl}$$

Step 3 Determination of Permanent hardness

As Temporary hardness is due to CaSO_4 and MgSO_4

$$\therefore \text{Permanent Hardness} = 5.88 + 8.33 = 14.21 \text{ mg/L} = 14.21 \text{ ppm}$$

$$= 14.21 \times 0.1 = 1.421^\circ \text{Fr}$$

$$= 14.21 \times 0.07 = 0.995^\circ \text{Cl}$$



Summary

- Hardness can easily be determined using CaCO_3 equivalent.
- Temporary and permanent hardness can be determined separately.



Thank You!