

Numerical on Calculation of Hardness by CaCO_3 method

Based on equivalence of CaCO_3 .

As the molecular mass of CaCO_3 is 100, calculation of hardness is given in terms of equivalence of CaCO_3 .

All the substances causing hardness should be converted into their respective CaCO_3 equivalent as the matter of convenience.

Conversion factor = Equivalence of CaCO_3 / Mole. Wt. of hardness causing substance

Table for conversion factors

Sr. No.	Hardness causing substance	Mole. wt. of hardness causing substance	Conversion factor for Equivalence of CaCO_3
1	CaCO_3	100	100/100
2	MgCO_3	84	100/84
3	$\text{Ca}(\text{HCO}_3)_2$	162	100/162
4	$\text{Mg}(\text{HCO}_3)_2$	146	100/146
5	CaSO_4	136	100/136
6	MgSO_4	120	100/120
7	CaCl_2	111	100/111
8	MgCl_2	95	100/95
9	CO_2^*	44	100/44
10	NaCl^*	58.5	100/58.5
11	SiO_2^*	60	100/60

*Does not cause any hardness

Formulae:

Conversion factor for Equivalence of CaCO_3 = (Equi. of CaCO_3) / (Mole. Wt. of hardness causing substance)

Equivalence of CaCO_3 = A x B / C

= Amount of hardness causing substance x conversion factor

Where A = Mass of Hardness causing

B = Equi. Of CaCO_3

C = Chemical Equi. of hardness causing substance

Total hardness = Temporary hardness + Permanent hardness

= Carbonate hardness + Non-carbonate hardness

Solved Example 1. Calculate temporary and permanent hardness of water sample having following data

$\text{Mg}(\text{HCO}_3)_2$ = 146 ppm, $\text{Ca}(\text{HCO}_3)_2$ = 162 ppm, MgCl_2 = 190 ppm

Solution:

Substance	Amount in ppm	Mole. Wt.	Conversion factor	Equi. Of CaCO_3
$\text{Mg}(\text{HCO}_3)_2$	146	146	100/146	100
$\text{Ca}(\text{HCO}_3)_2$	162	162	100/162	100
MgCl_2	190	95	100/95	200

$$\begin{aligned}\text{Carbonate Hardness} &= \text{Mg}(\text{HCO}_3)_2 + \text{Ca}(\text{HCO}_3)_2 \\ &= 100 + 100 \\ &= 200 \text{ ppm}\end{aligned}$$

$$\begin{aligned}\text{Non-carbonate Hardness} &= \text{MgCl}_2 + \text{CaCl}_2 + \text{CaSO}_4 \\ &= 200 \text{ ppm}\end{aligned}$$

$$\begin{aligned}\text{Total hardness} &= \text{Carbonate hardness} + \text{Non-carbonate hardness} \\ &= 200 + 200 \\ &= 400 \text{ ppm}\end{aligned}$$

Solved Example 2. Calculate temporary and permanent hardness of water sample having following data

$\text{Mg}(\text{HCO}_3)_2 = 146 \text{ ppm}$, $\text{Ca}(\text{HCO}_3)_2 = 324 \text{ ppm}$, $\text{MgCl}_2 = 190 \text{ ppm}$, $\text{CaCl}_2 = 333 \text{ ppm}$, $\text{CaSO}_4 = 136 \text{ ppm}$

Solution:

Substance	Amount in ppm	Mole. Wt.	Conversion factor	Equi. Of CaCO_3
$\text{Mg}(\text{HCO}_3)_2$	146	146	100/146	100
$\text{Ca}(\text{HCO}_3)_2$	324	162	100/162	200
MgCl_2	190	95	100/95	200
CaCl_2	333	111	100/111	300
CaSO_4	136	136	100/136	100

$$\begin{aligned}\text{Carbonate Hardness} &= \text{Mg}(\text{HCO}_3)_2 + \text{Ca}(\text{HCO}_3)_2 \\ &= 100 + 200 \\ &= 300 \text{ ppm}\end{aligned}$$

$$\begin{aligned}\text{Non-carbonate Hardness} &= \text{MgCl}_2 + \text{CaCl}_2 + \text{CaSO}_4 \\ &= 200 + 300 + 100 \\ &= 600 \text{ ppm}\end{aligned}$$

$$\begin{aligned}\text{Total hardness} &= \text{Carbonate hardness} + \text{Non-carbonate hardness} \\ &= 300 + 600 \\ &= 900 \text{ ppm}\end{aligned}$$

Example 3. Calculate temporary and permanent hardness of water sample having following data

$\text{Mg}(\text{HCO}_3)_2 = 146 \text{ mg./lit.}$, $\text{Ca}(\text{HCO}_3)_2 = 40.5 \text{ mg./lit.}$, $\text{MgCl}_2 = 23.75 \text{ mg./lit.}$, $\text{CaCl}_2 = 55.5 \text{ mg./lit.}$, $\text{CaSO}_4 = 130 \text{ mg./lit.}$, $\text{SiO}_2 = 50 \text{ mg./lit.}$

Example 4. Calculate total hardness of water sample having following data

$\text{MgSO}_4 = 46 \text{ ppm}$, $\text{Ca}(\text{HCO}_3)_2 = 34 \text{ ppm}$, $\text{MgCO}_3 = 90 \text{ ppm}$, $\text{CaCl}_2 = 33 \text{ ppm}$, $\text{CaSO}_4 = 13 \text{ ppm}$,

Example 5. Calculate total hardness of water sample having following data

$\text{Mg}(\text{HCO}_3)_2 = 146 \text{ ppm}$, $\text{Ca}(\text{HCO}_3)_2 = 324 \text{ ppm}$, $\text{MgCl}_2 = 190 \text{ ppm}$, $\text{NaCl} = 56 \text{ ppm}$, $\text{CaSO}_4 = 136 \text{ ppm}$