Numerical on Finding Total Hardness

Example-1 Express the following constituents as $CaCO_3$ eq.: (1) 162 mg/L of $Ca(HCO_3)_2$, (2) 111 mg/L of $CaCl_2$, and (3) 117 mg/L NaCl, Given: At mass: Ca = 40, C = 12, O = 16, H = 1, Na = 23, Cl = 35.5

Solution: (1) $Ca(HCO_3)_2$ as $CaCO_3$ eq. = 162 x 100/162 = 100 mg/l, here n-factor = 2

(2) $CaCl_2$ as $CaCO_3$ eq. = 111 x 100/111= 100 mg/l, here n-factor = 2

(3) NaCl as $CaCO_3$ eq. = 117 x 100/2 x 58.5 = 100 mg/l, **here n-factor = 1**

Example-2 A water sample contains 136 mg/L of $CaSO_4$. Calculate the hardness as equivalent amount of $CaCO_3$. (At mass of Ca = 40, S = 32, O = 16)

Solution: Equivalent of $CaCO_3$ = 136 x [100/(2 x 136/2) = 100 ppm

Example-3 How many gram of $MgSO_4$ dissolved per litre gives 200 ppm of hardness as equivalent amount of $CaCO_3$. (At mass: Mg = 24, S = 32, O = 16)

Solution: Equivalent of $CaCO_3$ = (S, strength of hardness substance in mg/L) x [100/ (2 x M/n-factor)]

So, (S, strength of hardness substance in mg/L) = Equivalent of $CaCO_3$/ [100/ (2 x M/n-factor)]

Or S = 200/[100/(120)] = 240 mg/L = 0.24 g/L

Example-4 A sample of water on analysis was found to contain the following impurities:

Impurity	**$Ca(HCO_3)_2$**	**$Mg(HCO_3)_2$**	**$MgSO_4$**	**$CaSO_4$**	**K_2SO_4**
Quantity (mg/L)	**4**	**6**	**8**	**10**	**10**
Mol Wt.	**162**	**146**	**120**	**136**	**134**

Calculate the temporary, permanent, and total hardness of water in ppm, ^{0}Fr and ^{0}Cl.

Solution: *N.B.: K_2SO_4 is a non-hardness constituent.*

Impurity	Quantity (mg/L)	n-factor	Mol. Wt.	$CaCO_3$ eq. in mg/L
$Ca(HCO_3)_2$	4	2	162	4 x (100/162)= 2.47
$Mg(HCO_3)_2$	6	2	146	6 x (100/146)= 4.11
$MgSO_4$	8	2	120	8 x (100/120)= 8.33
$CaSO_4$	10	2	136	10 x (100/136)= 5.88

(i) **Temporary Hardness (due to bicarbonates of Ca and Mg) =** 2.47 + 4.11 = 6.58 ppm = 6.58 x 0.1 ^{0}Fr = 0.658 ^{0}Fr = 6. 58 x 0.07 ^{0}Cl = 0.46 ^{0}Cl

(ii) **Permanent hardness (due to sulphates of Ca and Mg) =** 5.88 + 8.33 = 14.21 ppm = 1.421 **^{0}Cl** = 0.995 ^{0}Cl

(iii) **Total hardness =** 6.58 + 14.21 = 20.79 ppm = 2.079 ^{0}Fr = 0.9947 ^{0}Cl

Example-5

A sample of water on analysis was found to contain the following impurities:

Impurity	$Ca(HCO_3)_2$	$CaSO_4$	$MgCl_2$	$CaCl_2$	NaCl
Quantity (mg/L)	16.2	27.2	9.5	22.2	10
Mol Wt.	162	136	95	111	58.5

Calculate the temporary, permanent, and total hardness of water in ppm, ^{0}Fr and ^{0}Cl.

Impurity	Quantity (mg/L)	n-factor	Mol. Wt.	$CaCO_3$ eq. in mg/L
$Ca(HCO_3)_2$	16.2	2	162	16.2 x (100/162)= 10
$CaSO_4$	27.2	2	136	27.2 x (100/136)= 20
$MgCl_2$	9.5	2	95	9.5 x (100/95)= 10
$CaCl_2$	22.2	2	111	22.2 x (100/111)= 20

Solution:

N.B.: NaCl is a non-hardness constituent.

- **(i)** **Temporary Hardness (due to $Ca(HCO_3)_2$) = 10 mg/L = 10** ppm = 10 x 0.1 ^{0}Fr = 1.0 ^{0}Fr = 10 x 0.07 ^{0}Cl = 0.7 ^{0}Cl
- **(ii)** **Permanent hardness (due to $CaSO_4$, $MgCl_2$, $CaCl_2$) =** 20 + 10 + 20 = 50 mg/L = 50 ppm = 5.0 **^{0}F** = 3.5 ^{0}Cl
- **(iii)** **Total hardness =** 10 + 50 = 60 ppm = 6 ^{0}Fr = 4.2 ^{0}Cl

Example-6 Find the Total hardness of water if water containing 100 mg/L of $Ca(HCO_3)_2$, 200 mg/L of $Mg(HCO_3)_2$ and 250 mg/L NaCl is boiled for 15 minute.

Ans. Total Hardness = 0, as Temporary hardness is removed by boiling. NaCl is non-hardness mass.

Example-7 A water sample contains 150 mg/L of $Ca(HCO_3)_2$, 111 mg/L of $CaCl_2$, 12 mg/L of $MgSO_4$, and 250 mg/L of Na_2SO_4. Find the temporary, permanent and total hardness of water after boiling for 10 minute.

Ans. (i) **$Ca(HCO_3)_2$ can be removed by boiling. So, Temp. Hardness = 0**

Na_2SO_4 is a non-hardness mass.

(ii) Here, Permanent hardness is due to presence of dissolved $CaCl_2$ and $MgSO_4$ in water.

So, at first we have to express these hardness constituents as $CaCO_3$ eq.

$CaCl_2$ as $CaCO_3$ eq. = (111 x 100/111) = 100 mg/L; Molar mass of $CaCl_2$ = 111, n-factor = 2

$MgSO_4$ as $CaCO_3$ eq. = (12 x 100/120) = 10 mg/L; Molar mass of $MgSO_4$ = 120, n-factor = 2

So, **Perm. Hardness** = 100 + 10 = 110 mg/l = 110 ppm = 11 ^{0}Fr = 7.7 ^{0}Cl.

(iii)Total hardness = Temp + Perm. = 0 + 110 = 110 mg/l = 110 ppm = 11 ^{0}Fr = 7.7 ^{0}Cl.

Example-8. A water sample contains 150 mg/L of $NaHCO_3$, 111 mg/L of NaCl, 12 mg/L of K_2SO_4, and 250 mg/L of Na_2SO_4. Find the total hardness of water.

Ans. Total hardness of water = 0 (as all are non-hardness constituents.)