[Numerical for Practice]

(i) Convert the total hardness of water samples in ppm & meq./L from the following

a) 20.23° clarke b) 31.8° Fr [Practice]

Sol: 1 ppm ≡ 0.07° Cl

1° Cl ≡ 14.3 ppm

∴ 20.23° Cl ≡ 14.3 × 20.23 = 289.3 ppm

1 meq./L ≡ 0.35° Cl

1° Cl ≡ 0.286 meq/L

20.23° Cl ≡ 0.286 × 20.23 = 5.79 meq/L

(ii) How many Gms & mgs ~~litres~~ of $FeSO_4$ dissolved per litre gives 215 ppm hardness?
(Fe = 56, S = 32, O = 16, Ca = 40, C = 12)

Sol: Mol. wt of $CaCO_3$ = 100 g

Mol. wt of $FeSO_4$ = 56 + 32 + 64 = 152 g

∴ $FeSO_4$ ≡ $CaCO_3$

152 g ≡ 100 g

This means, 100 ppm $CaCO_3$ eqvt hardness ≡ 152 ppm of $FeSO_4$

∴ 215 ppm hardness = $\frac{152 \times 215}{100}$ = 326.8 mg/L ($FeSO_4$ ppm)

= 0.3268 g/L $FeSO_4$

(iii) Calculate temporary hardness & permanent hardness of water sample from the following data:

$Mg(HCO_3)_2$ = 14.6 mg/L $MgCl_2$ = 9.5 mg/L

$MgSO_4$ = 12 mg/L $Mg(NO_3)_2$ = 14.8 mg/L

$Ca(HCO_3)_2$ = 16.2 mg/L $CaSO_4$ = 13.6 mg/L

NaCl = 5.85 mg/L $NaHCO_3$ = 10 mg/L

SiO_2 = 2 mg/L CO_2 = 0.02 L

Soln

Constituents		Multiplication factor	$CaCO_3$ equivalent hardness ppm (mg/L)
$Mg(HCO_3)_2$	[T]	100/146	$\frac{100}{146} \times 146 = 10$ ppm
$MgCl_2$	[P]	100/95	$\frac{100}{95} \times 9.5 = 10$ ppm
$MgSO_4$	[P]	100/120	$\frac{100}{120} \times 12 = 10$ ppm
$Mg(NO_3)_2$	[P]	100/146	$\frac{100}{146} \times 14.6 = 10$ ppm
$Ca(HCO_3)_2$	[T]	100/162	$\frac{100}{162} \times 16.2 = 10$ ppm
$CaSO_4$	[P]	100/136	$\frac{100}{136} \times 13.6 = 10$ ppm
NaCl	–	Non hardness causing impurity	
$NaHCO_3$	–	Non hardness causing impurity	
SiO_2	–	Non hardness causing –11–	
CO_2	–	Non hardness causing –11–	

Temporary Hardness = 10 + 10 = 20 ppm

Permanent Hardness = 10 + 10 + 10 + 10 = 40 ppm

Total hardness = 60 ppm

iv) 50 ml of standard hard water (1.2 g $CaCO_3$/litre) requires 45 ml EDTA solution.
100 ml of water sample consumes 14 ml EDTA solution.
100 ml of boiled & filtered water sample consumes 9 ml of EDTA solution.
Calculate all types of hardness of sample.

Soln: 1000 ml standard hard water ≡ 1.2 g of $CaCO_3$ eqnts
≡ 1200 mg of $CaCO_3$ eqnts

∴ 1 ml of SHW ≡ $\frac{1200}{1000}$ = 1.2 mg of $CaCO_3$ eqnts

Now, 50 ml SHW ≡ 50 × 1.2 = 60 mg $CaCO_3$ eqnts

∴ 45 ml EDTA ≡ 60 mg $CaCO_3$ eqnts.

1 ml EDTA ≡ $\frac{60}{45}$ = 1.33 mg $CaCO_3$ eqnts.

Now, 100 ml unknown hard water
≡ 14 ml EDTA
≡ 14 × 1.33
≡ 18.62 mg of $CaCO_3$ eqnts.

Equivalents = Eqnts

100 ml unknown sample ≡ 18.62 mg of $CaCO_3$ eqnts.

∴ 1000 ml unknown sample ≡ $\frac{18.62 \times 1000}{100}$
= 186.2 mg/L
[Total Hardness = 186.2 ppm]

Now, 100 ml boiled filtered water ≡ 9 ml EDTA
= 9 × 1.33 ≡ 11.97 mg $CaCO_3$ eqnts.

∴ 1000 ml boiled filtered water ≡ 119.7 ppm
[Permanent hardness = 119.7 ppm]
[Temporary Hardness = 186.2 − 119.7 = 66.5 ppm]

[Standard Hard water = SHW]

(v) Standard hard water contains 20 g/L $CaCO_3$, requires 25 ml EDTA solution when 30 ml SHW titrated with EDTA. 100 ml of sample water required 30 ml EDTA solution.
The same sample after boiling & filtration required 20 ml EDTA. Calculate Temporary hardness of sample water.

Sol^n Strength of SHW $\equiv$ 20 g/L = 20000 mg/1000 ml

$\equiv$ 20 mg/ml

$\because$ 30 ml SHW $\equiv$ 25 ml EDTA solution.

$\therefore$ 1 ml EDTA $\equiv \frac{30 \times 20}{25}$ mgs $CaCO_3$ eq^{nt} hardness

$\equiv$ 24 mgs $CaCO_3$ eq^{nt}

Now, 100 ml water Sample $\equiv$ 30 ml EDTA

$\equiv 30 \times 24$ mgs $CaCO_3$ eq^{nt}

$\equiv$ 720 mgs $CaCO_3$ eq^{nt}

$\therefore$ 1000 ml water Sample $\equiv 720 \times \frac{1000}{100} = 7200$ ppm

[Total hardness = 7200 ppm]

100 ml water sample after boiling & filtration = 20×24

= 480 mgs $CaCO_3$

$\therefore$ 1000 ml water sample = $480 \times \frac{1000}{100} = 4800$ ppm

Permanent hardness = 4800 ppm.

[Temporary Hardness = 7200 − 4800 = 2400 ppm]

[Lime-Soda method]

$$\text{Lime Requirement for Softening} = \frac{74}{100}\Big[\text{Temp.}\ Ca^{2+} + 2 \times \text{Temp.}\ Mg^{2+} + \text{Perm.}\ (Mg^{2+} + Fe^{2+} + Al^{3+}) + CO_2 + H^+\ (HCl \text{ or } H_2SO_4) + HCO_3^- - NaAlO_2\Big]$$

all in terms of $CaCO_3$ eqvt.

$$\times \frac{\text{Volume of water}}{1000} \times \frac{100}{\%\ \text{Purity}}\ \text{gms.}$$

$$\text{Soda Requirement for Softening} = \frac{106}{100}\Big[\text{perm.}\ (Ca^{2+} + Mg^{2+} + Al^{3+} + Fe^{2+}) + H^+\ (HCl \text{ or } H_2SO_4) - HCO_3^-\Big]$$

all in terms of $CaCO_3$ eqvt.

$$\times \frac{\text{Volume of water}}{1000} \times \frac{100}{\%\ \text{Purity}}\ \text{gms.}$$

Calculate, lime (80% Pure) and Soda (90% Pure) required to soften 10^6 litres of water containing the following impurities.

$Mg(HCO_3)_2 = 14.6$ mg/L $Ca(HCO_3)_2 = 8.1$ mg/L

$CaCl_2 = 11.1$ mg/L $MgSO_4 = 12$ mg/L

$H_2SO_4 = 49$ mg/L $CO_2 = 44$ mg/L

Solution: Let us find $CaCO_3$ equivalent of all impurities.

Impurities mg/L	Multiplication Factor	$CaCO_3$ eqnt (mg/Lit)	Requirement
→ $Mg(HCO_3)_2$	100/146	$\frac{100}{146} \times 14.6 = 10$	2×L
→ $Ca(HCO_3)_2$	100/162	$\frac{100}{162} \times 8.1 = 5$	L
→ $CaCl_2$	100/111	$\frac{100}{111} \times 11.1 = 10$	S
→ $MgSO_4$	100/120	$\frac{100}{120} \times 12 = 10$	L+S
→ H_2SO_4	100/98	$\frac{100}{98} \times 49 = 50$	L+S
→ CO_2	100/44	$\frac{100}{44} \times 44 = 100$	L

Lime Requirement = $\frac{74}{100}$ [$CaCO_3$ eqnt of: $Ca(HCO_3)_2 + 2 \times Mg(HCO_3)_2 + MgSO_4 + H_2SO_4 + CO_2$] $\times \frac{\text{Vol. of water}}{1000} \times \frac{100}{\%\text{Purity}}$ gms

$= \frac{74}{100}[5 \times (2 \times 10) + 10 + 50 + 100] \times \frac{10^6}{1000} \times \frac{100}{80}$ gm

Lime Requirement $= \frac{74}{100} \times 185 \times 1000 \times \frac{100}{80}$ gm $= 171125$ gm

Soda Requirement $= \frac{106}{100}$ [$CaCO_3$ eqnt of: $CaCl_2 + MgSO_4 + H_2SO_4$] $\times \frac{\text{Vol. of water}}{1000} \times \frac{100}{\%\text{Purity}}$ gm

$= \frac{106}{100}[10 + 10 + 50] \frac{10^6}{1000} \times \frac{100}{90}$ gm

Soda Requirement = 82444.4 gm