Digital Assignment - 1

ENGINEERING CHEMISTRY

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◆ Section - 1

Q1. A water sample contains 204 mg of $CaSO_4$ per litre. Calculate hardness in terms of $CaCO_3$ equivalent.

Soln:

Amount of calcium sulphate in water sample = 204 mg/L

Molar mass of $CaSO_4$ = 40 + 32 + (16 × 4) g

= 136 g

Chemical equivalent of $CaSO_4$ = $\frac{136}{2}$ = 68 g

Also, equivalent wt. of $CaCO_3$ = 50 g

∴ Hardness (in terms of $CaCO_3$ equivalent)

$$= \left[\text{mass of hardness causing substance in mg/L} \times \frac{\text{eqv. wt. of } CaCO_3}{\text{chem. eqv. of } CaSO_4} \right]$$

$$= \left[204 \times \frac{50}{68} \right] \text{ppm}$$

= 150 ppm.

Q2. A sample of water on analysis has been found to contain the following in ppm. Calculate the temporary and permanent hardness of the water.

Sl. No.	Impurity	Quantity (in ppm)
1.	$Ca(HCO_3)_2$	4.86
2.	$CaSO_4$	6.80
3.	$MgSO_4$	8.40

Sol^{n}:

1. $Ca(HCO_3)_2$ causes temporary hardness.

Molar mass of $Ca(HCO_3)_2 = 40 + 2(1+12+48)\ g$

$= 162\ g$

chemical equivalent of $Ca(HCO_3)_2 = \frac{162}{2}\ g = 81\ g$

$\therefore$ Temporary hardness $= \left(4.86 \times \frac{50}{81}\right)$ ppm

$= 3$ ppm.

2. $CaSO_4$ causes permanent hardness.

Molar mass of $CaSO_4 = 40 + 32 + 64 = 136\ g$.

chemical equivalent of $CaSO_4 = \frac{136}{2} = 68\ g$

Also, equivalent wt. of $CaCO_3 = 50\ g$

$\therefore$ Permanent hardness $= \left(6.80 \times \frac{50}{68}\right)$ ppm

$= 5$ ppm

3. $MgSO_4$ causes permanent hardness.

Molar mass of $MgSO_4 = 24 + 32 + 64 = 120\ g$.

Chemical equivalent of $MgSO_4 = \frac{120}{2} = 60\ g$.

Eqv. wt. of $CaCO_3 = 50\ g$.

$\therefore$ Permanent hardness $= \left(8.40 \times \frac{50}{60}\right)$ ppm

$= 7$ ppm.

Hence, Temporary hardness = 3 ppm, & permanent hardness $= (5+7)$ ppm

$= 12$ ppm.

Q3. 0.5 gram of $CaCO_3$ was dissolved in dil. HCl and the solution diluted to one litre (1000 mL). 50 mL of this solution required 45 mL of EDTA solution while 50 mL of hard water sample required 18 mL of EDTA solution. On the other hand, 50 mL of the boiled sample of hard water when titrated against EDTA consumed 9 mL of the solution. Find out each type of hardness with steps and express it in ppm of $CaCO_3$ equivalents.

Sol^n:

1 L solution contains = 0.5 g of $CaCO_3$.

$\therefore$ 1 mL solution contain = 0.5 mg of $CaCO_3$.

Also, 45 mL of EDTA is required for = 50 mL of sol^n

= 50 x 1 mL sol^n

= 50 x 0.5 mg of $CaCO_3$.

$\therefore$ For neutralisation,

1 mL of EDTA is required for = $50 \times \frac{1}{2} \times \frac{1}{45}$ mg of $CaCO_3$

= $\frac{5}{4}$ mg of $CaCO_3$

For Total hardness,

50 mL of hard water = 18 mL of EDTA solution.

$\therefore$ 1 L of hard water = $\frac{18}{50} \times 1000 \times \frac{5}{9}$ mg of $CaCO_3$

= 200 mg of $CaCO_3$

= 200 ppm.

For permanent hardness,

50 mL of boiled hard water = 9 mL of EDTA sol^n.

$\therefore$ 1 L of boiled hard water = $\frac{9}{50} \times 1000 \times \frac{5}{9}$ mg of $CaCO_3$

= 100 ppm.

Hence, Temporary hardness = Total hardness − permanent hardness

= (200 − 100) ppm

= 100 ppm.

Q4. Two water samples A and B were analyzed for their salt contents. Sample A was found to contain 168 mg/L of $Mg(HCO_3)_2$ and 2 gm of $CaCO_3$ per 500 mL. Sample B was found to contain 820 mg/L $Ca(NO_3)_2$ and 2 mg/L of silica. Determine the hardness in all the above water samples in ppm.

Soln:

- Sample - A: contains:
  - 168 mg/L $Mg(HCO_3)_2$
  - 2 g/500 mL $CaCO_3$

For $Mg(HCO_3)_2$:

molar mass of $Mg(HCO_3)_2$ = $24 + 2(1 + 12 + 3\times16)$ g

= 146 g

& its equivalent wt. = $\frac{146}{2}$ = 73 g.

∴ Hardness = $\left(168 \times \frac{50}{73}\right)$ ppm

= 115.06 ppm

For $CaCO_3$:

molar mass of $CaCO_3$ = $(40 + 12 + 3\times16)$ g

= 100 g.

∴ Hardness = $\left(\frac{(2\times1000)\text{ mg}}{500 \times \frac{1}{1000}} \times \frac{50}{\frac{100}{2}}\right)$ ppm

= 4000 ppm

∴ Total hardness

$= (4000 + 115.06)$ ppm $= 4115.06$ ppm

• Sample-B :

contains → • 820 mg/L $Ca(NO_3)_2$

• 2 mg/L SiO_2

For $Ca(NO_3)_2$:

Molar mass of $Ca(NO_3)_2 = 40 + 2(14 + 16\times3)$ g

$= 164$ g

Chemical equivalent of $Ca(NO_3)_2 = \frac{164}{2} = 82$ g

∴ Hardness $= \left(820 \times \frac{50}{82}\right)$ ppm

$= 500$ ppm

For SiO_2 :

Molar mass of $SiO_2 = (28 + 2\times16)$ g $= 60$ g

Chemical equivalent of $SiO_2 = \frac{60}{4} = 15$ g

∴ Hardness $= \left(2 \times \frac{50}{15}\right)$ ppm

$= 6.66$ ppm

Hence, Total hardness

$= (500 + 6.66)$ ppm

$= 506.66$ ppm

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Q5. 25 mL of standard hard water (containing 10g $CaCO_3$ per litre) required 30 mL of EDTA solution for end point. 100 mL of water sample required 20 mL of EDTA solution; while same water after boiling and cooling required 15 mL EDTA solution. Calculate carbonate and non-carbonate hardness of water.

Soln:

1 L of boiled water (hard) ⟶ 10g of $CaCO_3$

∴ 1 mL of boiled hard water ⟶ 10 mg of $CaCO_3$.

For neutralisation,

30 mL of EDTA is reqd. for = 25 mL of boiled hard water

∴ 1 mL of EDTA = $\frac{25}{30}$ × 1 mL of " " "

= $\frac{25}{30}$ × 10 mg of $CaCO_3$

= $\frac{25}{3}$ mg of $CaCO_3$

For Total hardness,

100 mL of water sample requires = 20 mL of EDTA.

∴ 1 L of water sample " = $\frac{20}{100}$ × 1000 mL of EDTA

= $\frac{20}{100}$ × 1000 × $\frac{25}{3}$ mg of $CaCO_3$

$= \frac{5000}{3}$ ppm

$= 1666.66$ ppm

For permanent hardness,

100 mL of boiled water sample = 15 mL of EDTA.

∴ 1 L of boiled water sample = $\frac{15}{100} \times 1000 \times \frac{15}{3}$ mg of $CaCO_3$

i.e., Non-carbonate hardness = 1250 ppm.

Hence, Temporary hardness = (Total hardness − permanent hardness)

i.e. Carbonate hardness = (1666.66 − 1250) ppm

= 416.66 ppm.

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