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Year & Sem. – B. Tech I year, Sem.-I

Subject –Engineering Chemistry

Unit – I (Numerical problems based on Hardness & EDTA)

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Numerical problems based on Hardness & EDTA

Calculation of Hardness Points to be remember:

1. **Before calculating hardness the amount of salts should be converted into their $CaCO_3$ equivalents**

2. **Temporary hardness is due to only carbonates and bicarbonates of Ca^{2+}/ Mg^{2+} or other heavy metals**

3. **Permanent hardness is due to only chlorides, sulphates and nitrates of Ca^{2+}/ Mg^{2+} or other heavy metals**

4. **Sodium, potassium & silica do not case hardness in water (sometime this type of salts are given in numerical problems)**

Example 5. A sample water on analysis has been found to contain following impurities.

$Mg(HCO_3)_2$ = 14.6mg/lit., $MgCl_2$ = 19mg/lit.

$Mg(NO_3)_2$ = 29.6mg/lit., $CaCO_3$ = 10mg/lit.

$MgSO_4$ = 36mg/lit., NaCl = 29mg/lit.

Calculate temporary, permanent and total hardness of water sample in ppm and °Clark.

Solution: Conversion into $CaCO_3$ equivalents.

S.No	Substance	Amount (In mg/lit.) or ppm	Multiplication factor	$CaCO_3$ equivalent (mg/lit.)
1.	$Mg(HCO_3)_2$	14.6	$\frac{100}{146}$	$14.6 \times \frac{100}{146} = 10$
2.	$MgCl_2$	19	$\frac{100}{95}$	$19 \times \frac{100}{95} = 20$
3.	$Mg(NO_3)_2$	29.6	$\frac{100}{148}$	$29.6 \times \frac{100}{148} = 20$
4.	$CaCO_3$	10	$\frac{100}{100}$	$10 \times \frac{100}{100} = 10$
5.	$MgSO_4$	36	$\frac{100}{120}$	$36 \times \frac{100}{120} = 30$

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Temporary hardness due to Mg $(HCO_3)_2$ and $CaCO_3$

$= (10+10)$ mg/lit. of $CaCO_3$ eq.

$= 20$ mg/lit. of $CaCO_3$ eq.

On ppm scale

Since 1 mg/lit. = 1ppm = 0.07°Cl

Temporary hardness $= (20 \times 1) = 20$ ppm

Temporary hardness in °Clark $= 20 \times 0.07 = 1.4$°Cl

$= (MgCl_2 + Mg(NO_3)_2 + MgSO_4)$

$= (20 + 20 + 30)$ mg/lit. of $CaCO_3$ eq.

$= 70$ mg/lit. of $CaCO_3$ eq.

Permanent hardness in ppm = 70 ppm of $CaCO_3$ eq.

Permanent hardness in ° Clark = 4.90° Clark.

Example 6. A sample of water having following data:

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Practice Problems

Q1. Calculate the total, permanent and temporary hardness of water sample which contain the following impurities: $CaCO_3$ = 100 mg/L, $MgCO_3$ = 84 mg/L ,$CaCl_2$ = 111 mg/L , $MgSO_4$ = 60 mg/L, Nacl = 1.2 mg/L.

Q2. Find out the total, permanent and temporary hardness of water sample which contain the following impurities: $Ca(HCO_3)_2$ = 162 mg/L, $Mg(HCO_3)_2$=146 mg/L, $MgCO_3$ = 84 mg/L ,$CaCl_2$ = 111 mg/L , $CaSO_4$ =136 mg/L, $MgSO_4$ = 60 mg/L, NaCl = 1.2 mg/L

Q.3 Calculate the total hardness of a water sample having following composition in ppm. $CaCO_3$=20 degree Cl; MgSO4=4 degree Cl;CaSO4=2 degree Cl;Fe2O3=0.04 degree Cl,MgCl2=4 degree Cl;SiO2=0.09 degree Cl.

Q4. Calculate the total hardness of water in degree Fr and degree Cl from the following analysis of water sample:

$Mg(HCO3)_2$ = 20.8 mg/l; $Mg(NO_3)_2$ = 28.8 mg/l; MgCl2 = 21.0 mg/l; MgSO4 = 20.0 mg/l; CaCO3 = 21.2 mg/l; KCl = 73.2 mg/L.

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Numerical problems based on EDTA

Q1. Standard hard water contains 1.5g of $CaCO_3$ per litre. 50 ml of this solution required 32 ml of EDTA solution while 50 ml of sample water required 16 ml of EDTA solution. The sample water after boiling required 9 ml of EDTA solution. Calculate temporary, permanent and total hardness of sample water.

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Soln. Strength of SHW = 1.5 gm in 1000 ml distilled water

$= \frac{1.5 \times 10^3}{1000} = 1.5$ mg/ml.

50 ml of SHW ≡ 32 ml of EDTA solution

i.e 32 ml of EDTA ≡ (50×1.5) mg of $CaCO_3$ equivalents

1 ml of EDTA = $\left(\frac{50 \times 1.5}{32}\right)$ mg of $CaCO_3$ equivalents

≡ 2.34 mg of $CaCO_3$ equivalent

50 ml of hardwater now requires = 16 ml of EDTA Soln.

1000 ml of hardwater will require $= \left(\frac{16 \times 50 \times 1.5}{32}\right) \times \left(\frac{1000}{50}\right) \left(\begin{matrix} CaCO_3 \\ equv. \end{matrix}\right)$

= ~~750 ppm~~

≡ 748.8

50 ml of this soln = 9 ml of EDTA soln

1000 ml of soln $= \left(\frac{9 \times 50 \times 1.5}{32}\right)\left(\frac{1000}{50}\right)$

= 421.875 ppm

Total hardness = 748.8 ppm

Permanent hardness = 421.875 ppm

Temporary " = (748.8 − 421.875)

= 326.925 ppm

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Formula for Calculating Hardness by EDTA Method

1. **Total Hardness = V_2/V_1 X 1000 ppm**
2. **Permanent Hardness = V_3/V_1 X 1000 ppm**
3. **Temporary Hardness = Total Hardness – Permanent hardness**

Practice questions

Q.1. 1 g of $CaCO_3$ was dissolved in dilute HCl and the solution diluted to one litre . 50 ml of this solution required 40 ml of EDTA solution , while 50 ml of the sample water required 40 ml of EDTA. On the other hand, 50 ml of boiled sample water when titrated against EDTA consumed 20 ml of solution. Calculate each type of hardness in ppm.

Q.2. 250 mg of $CaCO_3$ was dissolved in dilute HCl and the solution diluted to one litre . 50 ml of this solution required 25 ml of EDTA solution , while 50 ml of the sample water required 15 ml of EDTA. On the other hand, 50 ml of boiled sample water when titrated against EDTA consumed 10 ml of solution. Calculate concentration of $Ca(HCO_3)_2$ and $MgCl_2$ in g/L.

Q3. Standard hard water contains 1g of $CaCO_3$ per litre. 100 ml of this solution required 50 ml of EDTA solution while 100 ml of sample water required 18 ml of EDTA solution. The sample water after boiling required 12 ml of EDTA solution. Calculate temporary, permanent and total hardness of sample water.

Q4. Standard hard water contains 15g of $CaCO_3$ per litre. 100 ml of this solution required 50 ml of EDTA solution while 100 ml of sample water required 40 ml of EDTA solution. The sample water after boiling required 20 ml of EDTA solution. Calculate temporary, permanent and total hardness of sample water.

Q5. 1 g of $CaCO_3$ was dissolved in dilute HCl and the solution diluted to one liter. 100 ml of this solution required 90 ml of EDTA solution , while 100 ml of the sample water required 40 ml of EDTA. On the other hand, 100 ml of boiled sample water when titrated against EDTA consumed 20 ml of solution. Calculate each type of hardness in ppm.

Q6. 1 g of $CaCO_3$ was dissolved in dilute HCl and the solution diluted to one litre . 100 ml of this solution required 100 ml of EDTA solution, while 100 ml of the sample water required 50 ml of EDTA. On the other hand, 100 ml of boiled sample water when titrated against EDTA consumed 25 ml of solution. Calculate each type of hardness in ppm.

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Thank you!