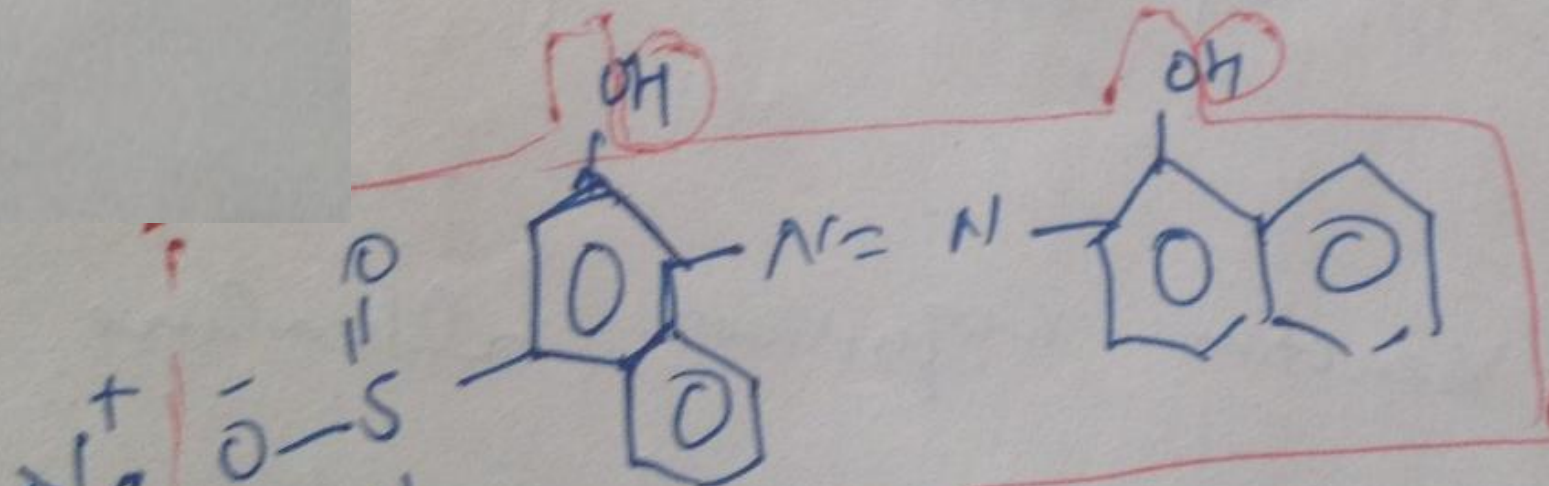
indicates the completion of the reaction)

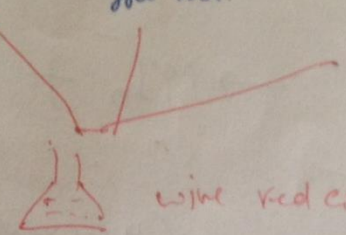


H_2In^-

Ethylene diamine tetraacetic acid

Procedure:

Water sample + Ammonical buffer sol. + E.B.T. indicator (Eriochrome Black-T)



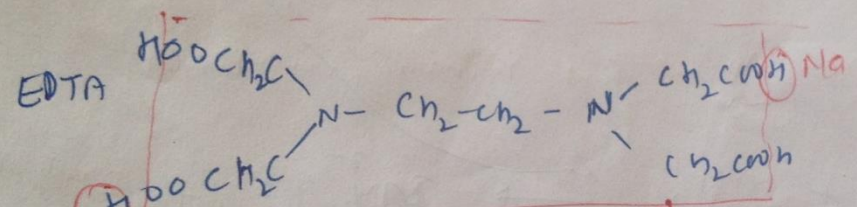
wine red color

↓

Titrate with EDTA (drop-wise)

↓

Blue color



Disodium salt of EDTA (Replace two H by 2 Na)

(Trans form - most stable form)

Na_2H_2Y

↓

EDTA can also be represented as

$H_2Y^{2-} + 2Na^+$

$\rightleftharpoons HIn + H^+$

(Hardness in water due to salts)
(M^{2+})

Ammonical Buffer Sol.
($NH_4OH + NH_4Cl$)

① M^{2+} (Ca, Mg) + HIn^{2-} (Indicator) $\longrightarrow MIn^- + H^+$
(Metal-indicator Complex)
(Wine red color)

② H_2Y^{2-} EDTA + M^{2+} (remaining M-ions in water sample) $\longrightarrow MY^{2-} + 2H^+$
(M-EDTA) Complex

Less Stable

More Stable

→ Now No more Metal ions remain in water

③ $H_2Y^{2-} + MIn^- \longrightarrow MY^{2-} + In^{3-} + 2H^+$

$MY^{2-} + HIn^{2-} + H^+$
Indicator

Buffer Role:

(1) H^+ from eq (1), (2) & (3)

$= \underline{4H^+}$ (1 metal ion)

if Ca, Mg both present (8 H^+ release)

↓

Acidic solution

For reaction required alkaline ↵

Thus use Ammonical Buffer

Indicator

(Blue color)

(End Point)

↳ Why Alkaline required. [M- EDTA complex is stable in alkaline medium] → (No End point)

Q.1 - One litre sample of hard water contains 1 mg of $CaCl_2$ and 1 mg of $MgCl_2$. Find the total hardness in term of $CaCO_3$ per 10^6 part of water by mass.

law of gram equivalence

$CaCl_2$ $\quad$ $CaCO_3$

$$\frac{wt}{eq.wt} = \frac{wt}{eq.wt.}$$

$$\frac{1 \times 10^{-3}}{111/2} = \frac{x}{100/2}$$

$$x = 0.9 \times 10^{-3}\ g$$

$MgCl_2$ $\quad$ $CaCO_3$

$$\frac{wt}{eq.wt.} = \frac{wt.}{eq.wt.}$$

$$\frac{1 \times 10^{-3}}{95/2} = \frac{x}{100/2}$$

$$x = 1.05 \times 10^{-3}\ g$$

Total mass of $CaCO_3$ =

$0.9 \times 10^{-3} + 1.05 \times 10^{-3}$

$= 1.95 \times 10^{-3}$ g

$\because$ 10^3 ml of water having 1.95×10^{-3} g $CaCO_3$

$\therefore$ 10^6 ml of water =

$$\frac{1.95 \times 10^{-3}}{10^3} \times 10^6 = 1.95\ g$$

Q.2. Hardness of water is 200 ppm. The normality and molarity of $CaCO_3$ in the water is

200 ppm $CaCO_3$ means - 200 g of $CaCO_3$ present

10^6 ml / 10^6 g of hard water

$$\text{Molarity} = \frac{m}{M \times V_L}$$

m - Mass of solute in gram

M - Molar mass of solute

V - Volume of solution in litre

$$\text{Molarity} = \frac{200}{100 \times 10^6/1000}$$

$$= 2 \times 10^{-3}$$

$$N = M \times \text{n-factor}$$

$$N = 2 \times 10^{-3} \times 2$$

$$= 4 \times 10^{-3}$$

4. Calculate the hardness of water sample which contain 0.001 mole of $MgSO_4$ dissolved per litre of water.

$MgSO_4$ (Mg^{+2}, CO_3^{-2}) $CaCO_3$ (Ca^{+2}, CO_3^{-2})

$$\frac{\text{wt.}}{\text{eq.wt}} = \frac{\text{wt.}}{\text{eq.wt.}}$$

if n-factor are same

Mole of $MgSO_4$ = Mole of $CaCO_3$

$0.001 = 0.001$

$$n = \frac{\text{wt.}}{\text{M.wt}}$$

$$0.001 = \frac{\text{wt. of } CaCO_3}{100}$$

wt. of $CaCO_3 = 0.1$ g

Mole $MgSO_4$ $CaCO_3$

$$\frac{\text{wt}}{\text{M.wt}} = \frac{\text{wt.}}{\text{M.wt}}$$

∵ 1000 ml of hard water

Contain 0.1 g of $CaCO_3$

∴ 10^6 mL of hard water — $\frac{0.1}{1000} \times 10^6$

$= 100$ g

hardness of water = 100 PPM

Numerical Q: 10ml of SHW (containing 1 gm $CaCO_3$ in 1 Lit distilled water) consumes 10 mL of EDTA Soln. 50 ml of hard water containing ammonical buffer & EBT indicator on titration with EDTA consumes 12 mL of EDTA. Calculate Total hardness of water?

Step 1 Standardization of EDTA

Vol. of SHW = 10 ml (1 g $CaCO_3$ in 1 Lit water)

Vol of EDTA used = 10 ml

Therefore, 10 ml EDTA used for 10 ml SHW (1 gm $CaCO_3$ in 1 Lit water)

= 10 mg $CaCO_3$

1000 mg $CaCO_3$ - 1000 ml H_2O

(1 mg $CaCO_3$ in 1 mL H_2O)

1 mL EDTA = $\frac{10}{10}$ mg $CaCO_3$

= 1 mg $CaCO_3$

Step 2: Determination of total hardness

Vol. of hard water = 50 ml

Vol of EDTA used = 12 ml

from step 1. 1 ml of EDTA = 1 mg $CaCO_3$

12 ml of EDTA = 12 mg $CaCO_3$

50 ml of hard water contains = 12 mg $CaCO_3$ (1 ppm = 1 mg/Lt)

1 ml H W contains = $\frac{12}{50}$ mg $CaCO_3$

1000 ml of = $\frac{12}{50} \times 1000$ mg $CaCO_3$

= 240 mg $CaCO_3$

= 250 ppm Total hardness of water sample

For Temporary & Permanent Hardness.

Step (1): Standardization of EDTA

(2) Total Hardness

we have to boil the sample

Q. Calculate the hardness of a water sample, whose 10 ml is required 10 ml of EDTA. 20 mL of $CaCl_2$ solution, whose strength is equivalent 1.5 g of $CaCO_3$ / Lit, required 30 ml of EDTA Solution

Q. Calculate the hardness of a water sample, whose 10 ml required 10 ml of EDTA. 20 mL of $CaCl_2$ solution, whose strength is equivalent 1.5 g of $CaCO_3$ / Lit, required 30 ml of EDTA Solution.

Solution:

Step (i): Standardization of EDTA solution

Given 1L of SHW contains = 1.5 gm $CaCO_3$

1 ml of SHW contains = 1.5 mg $CaCO_3$

Now 30 ml of EDTA = 20 ml of SHW (i.e, $CaCl_2$ solution)

$= 20 \times 1.5 = 30$ mg $CaCO_3$

So, 1 mL of EDTA = $\frac{30}{30}$ = 1 mg $CaCO_3$ eq.

Step (iii) Determination of Total hardness of water:

10 mL of sample water = 10 mL of EDTA

$= 10 \times 1 = 10$ mg of $CaCO_3$ eq. hardness

1 Lit of sample water = $\frac{10}{10} \times 1000$ mg of $CaCO_3$ eq. hardness

Hence, the total hardness of water sample = 1000 ppm

Q: 50 ml of SHW containing 1 mg of pure $CaCO_3$ per ml consumed 25 ml of EDTA. 50 ml of a water sample consumed 25 ml of the same EDTA solution using eriochrome Black T as indicator. Calculate the hardness of water sample in ppm.

Solution

Step (i): Standardization of EDTA solution

Given 1 ml of standard hard water contains 1 mg $CaCO_3$

Now 25 ml of EDTA = 50 mL of SHW

= 50 mL of $CaCO_3$ equivalent hardness

Hence, 1 ml of EDTA = $\frac{50}{25}$ = 2 mg of $CaCO_3$ eq hardness

Step (ii) – Determination of total hardness of water sample

50 ml of sample water = 25 mL of EDTA

= 25 × 2 = 50 mg of $CaCO_3$ eq hardness

Hence, 1 L of sample water = $\frac{50}{50} \times 1000$ = 1000 mg of $CaCO_3$ eq. hardness

Thus, total hardness of water = 1000 ppm