EEB

L-1

Grading Pattern

20% → Quiz, Assign, Attendance, Presentation.
30% → Mid Term.
50% → End Term

Tuesday off

1) Fundamentals of Aquatic chemistry.
2) Water Pollution.
3) Wastewater Treatment
4) Air Pollution.
5) Solid waste Management.
6) Ecology & biodiversity.
7) Sustainability sustainable Development.

Hydrology → Study of water.
~97% → oceans
~2% → ice caps & glacier.
~0.6% → fresh water (river, ponds, underground water, lakes)

surface water → found in lakes, rivers, streams, ponds, oceans.

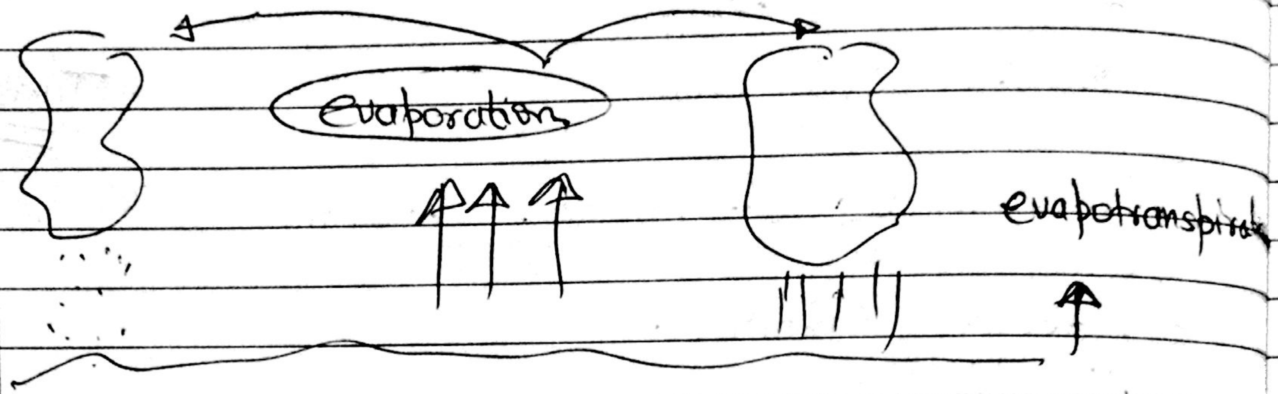
groundwater → beneath earth surface.

Water Cycle / Hydrologic cycle :-

Surface water → water vap.

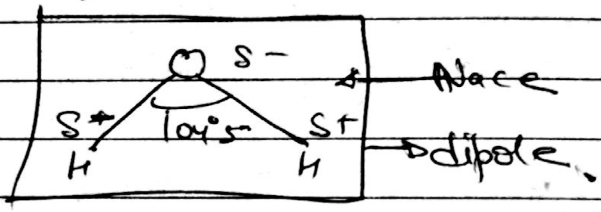
Evapotranspiration ⇒ evaporation of water from land vap from soil + transpiration from plants.

overland, more precipitation but less evaporation and in sea more evaporation but less precipitation.



Water Cycle

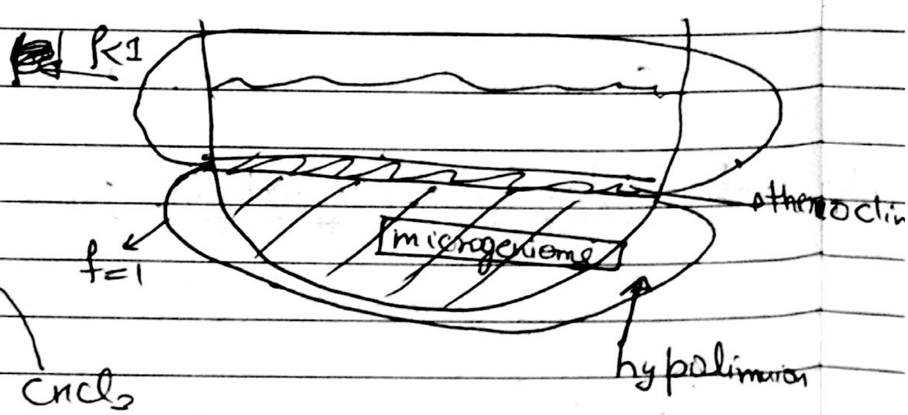
H—O—H

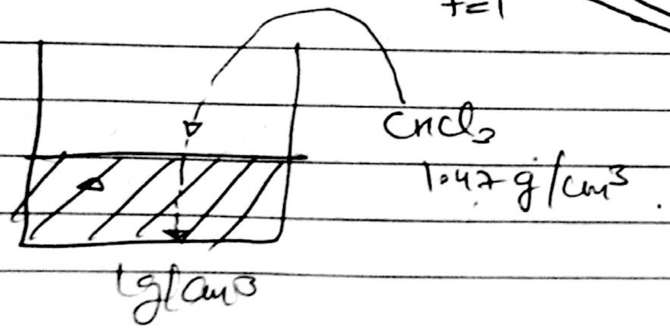


Characteristics of a nonflowing body of water :-

1) Thermal stratification :- $CO_2 + H_2O \xrightarrow{h\nu} \{CH_2O\} + O_2$

$f_s = 1 g/cm^3$

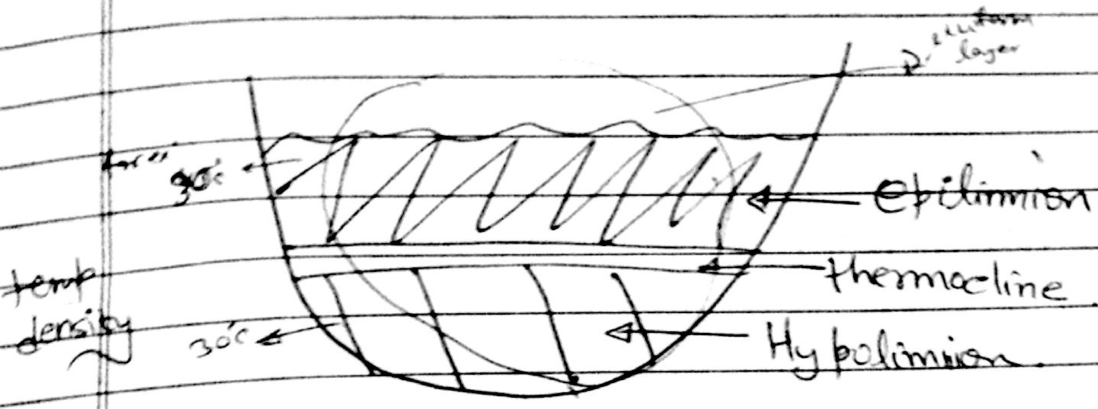




$$\{CH_2O\}_3 + O_2 \xrightarrow{\text{microorganisms}} CO_2 + H_2O + \boxed{\text{new cells}}$$
(S, N, P)

$[SO_4^{2-} + NO_3^{-} + PO_4^{-3}] \rightarrow$ aerobic

$[H_2S, NH_3, PH_3] \rightarrow$ anaerobic (absence of O_2)



Overturn

- There is no such distinct invisible layer if temp is equal as density is same
- Chemical & Physical properties become uniform.

temp : too high → not suitable for aquatic organisms
temp : too low → "

Temp		O_2 Concn
0°C	→	14.74 mg/l
20°C	→	9.1 mg/l
Imp 25°C	→	8.32 mg/l
35°C	→	7.03 mg/l

ocline

L-2

Clausius Clapeyron :-

$$\boxed{\log \frac{C_2}{C_1} = \frac{\Delta H}{2.303 R} \left[\frac{1}{T_1} - \frac{1}{T_2} \right]}$$

C_1 & C_2 → gas concn in water at absolute temp. of T_1 & T_2

ΔH ⇒ heat of solution.
R → gas constant.

Physical Properties :-

Transparency :-

Turbulance :-

Aquatic life :-

→ All living organism are known as BIOTA.

→ Autotrophic organism (Autotroph) :- The organism who are able to generate their own food from simple non-living inorganic molecule like CO_2, O_2

Ex:- Plants.

→ Heterotrophic organisms :- who are not able to generate their own food.

Eg.→ microorganism are subclass of Decomposer.

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* **Productivity :-** The ability of a body of water to generate living materials is known as its productivity.

* **Eutrophication :-** well nourished condition.

Gases in Water :-

Sources :-

① **Oxygen :-** (i) Atmospheric O_2
(ii) photosynthesis.

Uses :- (i) respiration.
(ii) Bio-Decomposition.

② **CO_2 :-** **Sources**
① Atmospheric CO_2
② Respiration.
③ Bio-decomposition.

Uses :- (i) Photosynthesis rxn.

$25°C \Rightarrow$ water $CO_2(aq)$ concn of 1.146×10^{-5} (M).

$\boxed{CaCO_3}$

$$\boxed{CaCO_3 + CO_2(aq) + H_2O \longrightarrow Ca(HCO_3)_2}$$

L-3

Henry's Law :-

$[X_{(aq)}] \propto P_x$ ↳ Partial Pressure

$= K \, P_x$

↑ Henry law constant.

$P_x = [P^0 - P_{H_2O}] \times$ Mole fraction of that gas in the atmosphere

P^0 ↓ atmospheric pressure.

P_{H_2O}: Vapour pressure of water

Water Acidity :-

Acidity is the capacity of water to neutralize $OH^\ominus$.

$H^\oplus$

$$H_2O + CO_2 \rightleftharpoons H_2CO_3$$

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^\ominus \qquad Ka_1$$

$$HCO_3^\ominus \rightleftharpoons H^+ + CO_3^{2-} \qquad Ka_2$$

$$H_2S \rightleftharpoons H^\oplus + HS^\ominus$$

$$HS^\ominus \rightleftharpoons H^\oplus + S^{2\ominus}$$

protein, fatty acids.

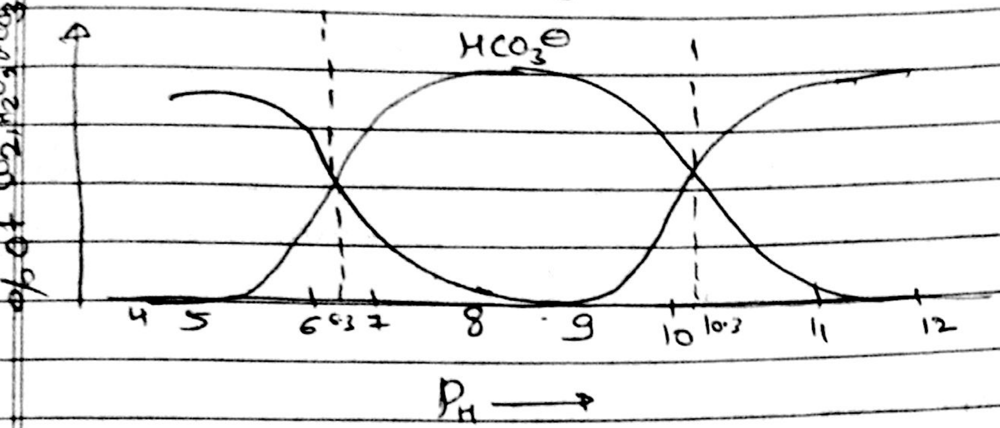
$$CO_2 \rightarrow HCO_3^- \rightarrow CO_3^{2-}$$

$$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^\ominus$$

$$Ka_1 = \frac{[H^+][HCO_3^\ominus]}{[CO_2]\cancel{[H_2O]}} = 4.45 \times 10^{-7}.$$

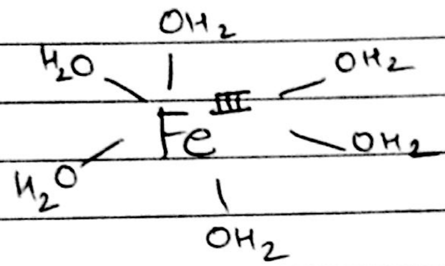
$$ka_2 = \frac{[H^+][CO_3^{2-}]}{[HCO_3^\ominus]} = 4.69 \times 10^{-11}.$$

Distribution Diagram :-



Water Alkalisity :-

Alkalisity is the capacity of water to neutralize H^+.



$$[Fe^{III}(H_2O)_6]^{3+} \rightleftharpoons [Fe(H_2O)_5(OH)]^{2+} + H^+$$

Surface Water Quality :-

pH
Turbidity
Temperature
Quantity of Nitrate $NO_3^{\ominus}$
PO_4^{3-}

L-4

Biochemical oxygen demand (BOD).

Chemical oxygen demand (COD).

BOD → The amount of Oxygen required to decompose Organic material biologically in a given volume of H_2O.

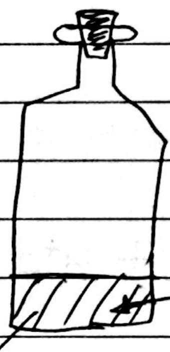
BOD experiment :-

BOD refers to the amount of oxygen required to degrade organic material biologically in a given volume of water.

mg/L

$$\{CH_2O\} + O_2 \xrightarrow{\text{Microorganism}} CO_2 + H_2O$$

1 mol   1 mol



DARK
5 days

$$\boxed{BOD_5 = DO_i - DO_f}$$
$$= 10\,mg/L - 2\,mg/L$$
$$= 8\,mg/L$$

DO_i DO_f
↳ dissolved oxygen initial

10 ml of waste water

1)

2) $DO_f > 0$
$\neq 0$

If $DO_f = 0$.

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(a) Organic matter = amount DO
(a) 10 mole 10 mole
(b) 15 mol 10 mol — 5 mole of organic matter is left ~~de~~ undecomposed.

$$BOD_5 = \frac{DO_i - DO_f}{P} \quad P = \text{dilution factor.}$$

waste water = ww

$$P = \frac{\text{Volume of ww}}{\text{Volume of ww + diluted water}}$$

(1) BOD = 8 mg/L Find mole of O_2

$n = \frac{8\,mg}{32\,g} = 0.00025$ mole of O_2 = no. of mole of organic matter biodegrable

$$P = \frac{\text{Vol. of ww}}{\text{vol of ww + diluted water}} \Rightarrow 0.007$$

L-5

Q A certain sewage treatment plant located on a river typically removes 4.54×10^7 gm of biodegradable organic matter each day. If there were a plant apart and it become necessary to reduce oneday's waste into the river, how many litre of river will lose DO?

Solⁿ- $[O_2(aq)] = k_H (P - P_{H_2O}) \times \%\, O_2$ in air
$= 1.28 \times 10^{-3}$ mol/litre/atm $\times (1 - 0.0313/atm)$
$\times\, 0.2095$
$= 2.60 \times 10^{-4}$ mol/l.

1. amount of DO in water (Henry's law)
2. no. of moles of organic matter present in

$$n = \frac{4.54 \times 10^7}{30 g/mol}$$

$= 1.5 \times 10^6$ moles = no. of moles of O_2 used for decomposition rxn.

lt. of water depleted of DO $= \dfrac{1.5 \times 10^6 \text{ mole}}{2.6 \times 10^{-4} \text{ mole/l}}$

$= 5.6 \times 10^{9}$ l

Q. A ground water sample contain 300mg/L of $HCO_3^{\ominus}$ at pH 10.0

(a) What is the concⁿ of $CO_3^{2\ominus}$?
(b) Calculate the $\boxed{\text{total carbonate alkalinity}}$ in $CaCO_3$?

At P^H 10, total carbonate concⁿ is 73% of HCO_3^- and 27% of CO_3^{2-}.

Ans let Total carbonate be x.

$[HCO_3^{\ominus}] + [CO_3^{2-}] = x$.

73% of x = 300 mg/L

x = 411 mg/L

$[CO_3^{2-}] = (411 - 300) = 111$ mg/L

Total Carbonate alkalinity on $CaCO_3$ = Multiplying factor for $HCO_3^{\ominus}$ as $CaCO_3$ $\times [HCO_3^{\ominus}]$ + Multiplying factor for CO_3^{2-} as $CaCO_3$ $\times CO_3^{2-}$

$$= \frac{\text{eq. wt of } CaCO_3}{\text{eq. wt of } HCO_3^{\ominus}} \times 300 \text{ m/L} + \frac{\text{eq. wt. of } CaCO_3}{\text{eq. wt of } CO_3^{2-}} \times 111 \text{ m/L}$$

$$= \frac{100/2}{61/1} \times 300 \text{ m/L} + \frac{100/2}{60/2} \times 111 \text{ mg/L}$$

$= 431$ mg/L.

COD → Concⁿ of organic substances that can be oxidized by acidified $K_2Cr_2O_7$ at 100°C.

$$3CH_2O + 16H_3O^{\oplus} + 2\overset{+6}{Cr_2}O_7^{2-} \rightarrow 3CO_2 + 27H_2O + 4Cr^{3+}.$$

$$Cr_2O_7^{2-} + \boxed{14}H^{\oplus} + \boxed{6}e^{\ominus} \rightarrow 2Cr^{+3} + \boxed{7}H_2O.$$

L-6

Surface Water Quality :-

Solids can effect the water quality in several ways :-

(1) Drinking water with high dissolved solids may not taste good and have a laxative effect.

(2) Boiler water with high dissolved solids requires pre treatment to prevent scale formation.

(3) Water high in suspended solids may harm aquatic life by clogging fish gills and reducing photosynthesis by blocking sunlight penetration, reduces visibilities of recreational waters.

T.S.S (Total Suspended Solid)

e.g, clay, metal oxides, sulphides, algae, bacteria, fungi, etc.

0.45 um filter

⇒ Sometimes suspended solid (They) are called "filterable solids".

T.D.S :- Total

e.g. dissolved minerals & salts like CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, PO_4^{3-}, NO_3^- etc.

⇒ Sometimes they are called "non filterable" solids

0.45 um filter.

→ If water contained over 500 ppm of such salt, then it is no more potable water.

→ When water contain high concn of dissolved solids then it is termed as saline water.

→ The Concn of dissolved solid in sea water is almost 35000 ppm.

Brakish water :-

When the concn of dissolved solids in water lies somewhere b/w the fresh water & sea water, then it is termed as brakish water.

Comparison of the concn of Major ions in fresh water & sea water :-

Ions	Freshwater	Seawater (ppm)
HCO_3^-	41.0 ppm	0.2
Ca^{2+}	16.0	0.9
Mg^{2+}	14.0	4.9
Na^+	11.0	41.0
Cl^-	8.5	49.0

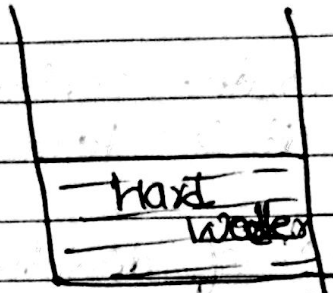
Hardness in Water :-

Ca^{+2} Mg^{+2}

react with $\rightarrow$ $HCO_3^{\ominus}$, $Cl^{\ominus}$, SO_4^{2-}

$\downarrow$ form

ppt.



Soap + hard water $\rightarrow$ ppth
salt foam

$\rightarrow$ In water hardness is that characteristics which "prevents" the lathering of soap.

eg $C_{17}H_{35}COONa + Ca(HCO_3)_2 \longrightarrow (C_{17}H_{35}COO)_2Ca$
Na stearate — Insoluble Ca-stearate

$+ 2NaHCO_3$.

L-7

Q. Calculate the temperory hardness, permanent hardness & total harness of a water sample containing $Mg(HCO_3)_2 = 7.3$ mg/l, $Ca(HCO_3)_2 = 16.2$ mg/l, $MgCl_2 = 9.5$ mg/l, $CaSO_4 = 13.6$ mg/l.

Sol^n: Temporary hardness : Consider only $Mg(HCO_3)_2$: $Ca(HCO_3)_2$

Multiplying factor for $Mg(HCO_3)_2 \times [Mg(HCO_3)_2]$ +

Multiplying factor for $Ca(HCO_3)_2 \times [Ca(HCO_3)_2]$.

$= \frac{100/2}{146/2} \times 7.3$ mg/l $+ \frac{100/2}{162/2} \times 16.2$

$= 15$ mg/l.

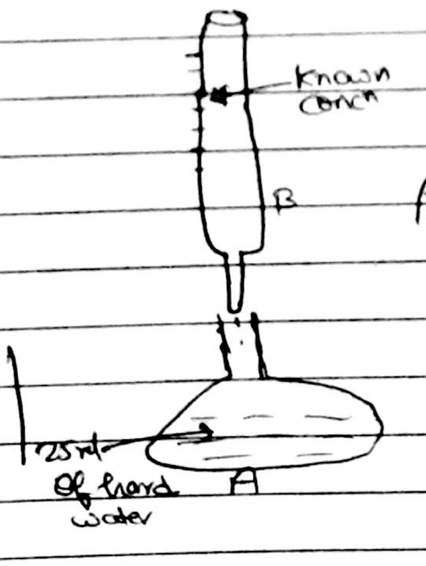
Permanent Hardness → Consider $MgCl_2$ & $CaSO_4$.

$$\Rightarrow \frac{100/x}{95/x} \times 9.5\ mg/l + \frac{100/x}{136/x} \times 13.6\ mg/l$$

$= 20\ mg/l$ (or ppm)

Total hardness = Temp. Hardness + Per. Hardness
= 15 mg/l + 20 mg/l
= 35 mg/l.

Titration :- Titration also known as titrimetry.
This method is used in laboratory for the quantitative chemical analysis to determine the unknown concn of an identified analyte.
Titration is the slow addn of soln of known concn (called titrate) to ~~the~~ the known vol of another soln of known concn until the soln reaches neutralization pt which is often indicated by a colour changes.



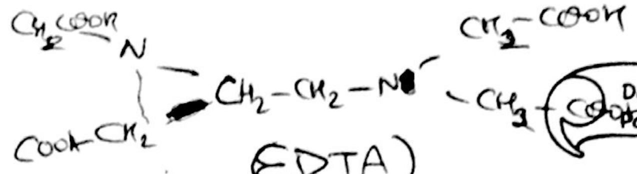
$A + B \rightarrow C + D$

Chang in colour

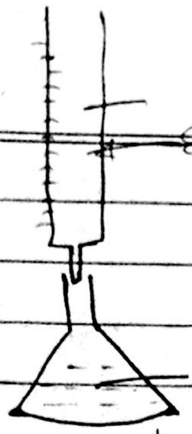
unknown

$\boxed{V_1 S_1 = V_2 S_2}$

Known



(EDTA)



EDTA Soln

Ethyline
Diamine Tetra acetic acid

50 ml
Hard water
Sample + EBT (Eriochrome Black T)
+ Buffer

Wine red

M-EBT + EDTA → M-EDTA + EBT
Blue

Wine red Soln → Blue

(1) Standard harwater Soln (1 gm of $CaCO_3$ + 1000 ml of distill water)

(2) EDTA Soln (3.72 gm of EDTA + 1000 ml of distill water)

(3) Buffer Soln (67.5g of NH_4Cl + 570ml of conc^n NH_3 soln → make up the upto 1000ml)

(4) EBT (0.5g of EBT + 100 ml of alcohol).

(1) Standardization of EDTA soln EDTA v/s std hard water, V_1 ml

(2) Determination of total hardness EDTA v/s Water sample. V_2 ml.

(3) Determination of permanent hardness. EDTA v/s boiled water V_3 ml.

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(1) → 1 gm of $CaCO_3$ was dissolved in 1000 ml of water.
50 ml of std hardwater $\equiv V_1$ ml of EDTA —(i)

& 50ml of std hardwater contain 50 mg of $CaCO_3$ —(ii)

V_1 ml of EDTA = 50 mg. of $CaCO_3$ equivalent hardness —(iii)

& 1ml of EDTA = $\frac{50}{V_1}$ mg of " "

L-8

(1) EDTA V/s std. hardness water :-

V_1 ml EDTA → $CaCO_3$ equivalent hardness
1 ml EDTA $\doteq \frac{50}{V_1}$ mg of $CaCO_3$ equivalent hardness

(2) $\boxed{\text{EDTA V/s water sample}}$ ⟷ (total hardness)
V_2 ml

50 ml of water sample $\equiv V_2$ ml of EDTA sol^n
$= V_2 \times \frac{50}{V_1}$ mg of $CaCO_3$

equivalent hardness

1000 ml " " $= \frac{V_2 \times 50}{V_1 \times 50} \times 1000$ mg " "

$= \frac{V_2}{V_1} \times 1000$ mg/L

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(3) EDTA V/s Boiled water ($\Rightarrow$ Permanent hardness) V_3 ml

1000 ml of Boiled water $= \frac{V_3}{V_1} \times 1000$ ppm.

temp. hardness = total hardness − permanent hardness

$$= \left(\frac{V_2}{V_1} - \frac{V_3}{V_1}\right) \times 1000 \text{ ml}$$

$$= 1000\left(\frac{V_2 - V_3}{V_1}\right) \text{ ppm}.$$

Ex:- 0.5 gm of $CaCO_3$ was dissolved in water & the soln made up to 500 ml with distilled water. 50 ml of that soln req 48 ml of EDTA soln for titration again 50 ml of hardness sample req 15 ml of EDTA and after boiling, the same amt. of hard water required 10 ml of EDTA soln.

Soln:- 500 mg of $CaCO_3$ was dissolved in 500 ml of d.w.

(I) i.e 1 ml of std hard water soln contains

= 1 mg of $CaCO_3$

50 ml of " " "

= 50 mg of $CaCO_3$ — (1)

50 ml of std hardwater sample consumed

= 48 ml of EDTA (2)

48 ml of EDTA soln = 50 mg of $CaCO_3$ equivalent hardness

1 " " " $= \frac{50}{48}$ " " " "

(II) 50 ml of water sample = 15 ml of EDTA

$= 15 \times \frac{50}{48}$ mg of $CaCO_3$

equivalent hardness.

1000 ml of water sample $= \frac{15}{50} \times \frac{50}{48} \times 1000$ ppm

$= 312.4$ ppm.

(III) 50 ml of boiled hard water sample $=$ 10 ml of EDTA

$= 10 \times \frac{50}{48}$ mg of $CaCO_3$

1000 ml " " $= \frac{1000 \times 50}{48 \times 50}$ ppm

$= 208.4$ ppm.

Temp hardness $= (312.4 - 208.4)$ ppm

$= 104$ ppm.

Permanent Hardness :-

a) Na_2CO_3

b) Zeolite, ion exchange method.

c) $Na_2CO_3 + Ca(OH)_2$

d) Polyphosphate Calgon $(P_6O_{18}^{6-})$

Hardness producing substance	chemical rxn with lime & soda	Need
Permanent:- Ca salts	$CaCl_2 + NaCO_3 \rightarrow CaCO_3\downarrow + 2NaCl$	S
	$CaSO_4 + NaCO_3 \rightarrow CaCO_3\downarrow + Na_2SO_4$	S
Mg-salts	$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaSO_4$ $CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$	L+S
	$MgCl_2 + Na_2CO_3 \rightarrow 2NaCl + MgCO_3$ $MgCO_3 + Ca(OH)_2 \rightarrow CaCO_3\downarrow + Mg(OH)_2$	S+L
Temporary:-		
$Ca(HCO_3)_2$	$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$	L
$Mg(HCO_3)_2$	$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + Ca(HCO_3)_2$ $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$	2L