1.1. Introduction

Water analysis -

1. Water is a clear, tasteless and odorless liquid that we find everywhere on earth.

2. It's made a two molecules first is hydrogen atomn and second is a oxygen atomn which chemist write H_2O

3. The earth's 71% surface area is occupied by water and the remaining 29% by land.

4. This water is 97% are avaliable on earth Surface.

5. This water is can not be used directly for drinking, agricultural and industrial purpose.

6. Hance, we are totally dependent on rain. water and it necessary to store water avaliable from rain

7. In our daily life water is used for drinking, bathing, cooking and washing purpose.

1.2 Importance of water:-

1. Water is super important for Plants, animals and even humans need it to survive we drink it to stay hydrate and it helps plants grow too.

2. Without food human being can survive for a number of days, but water is such an essential thing without one cannot survive

1.3 Properties of water

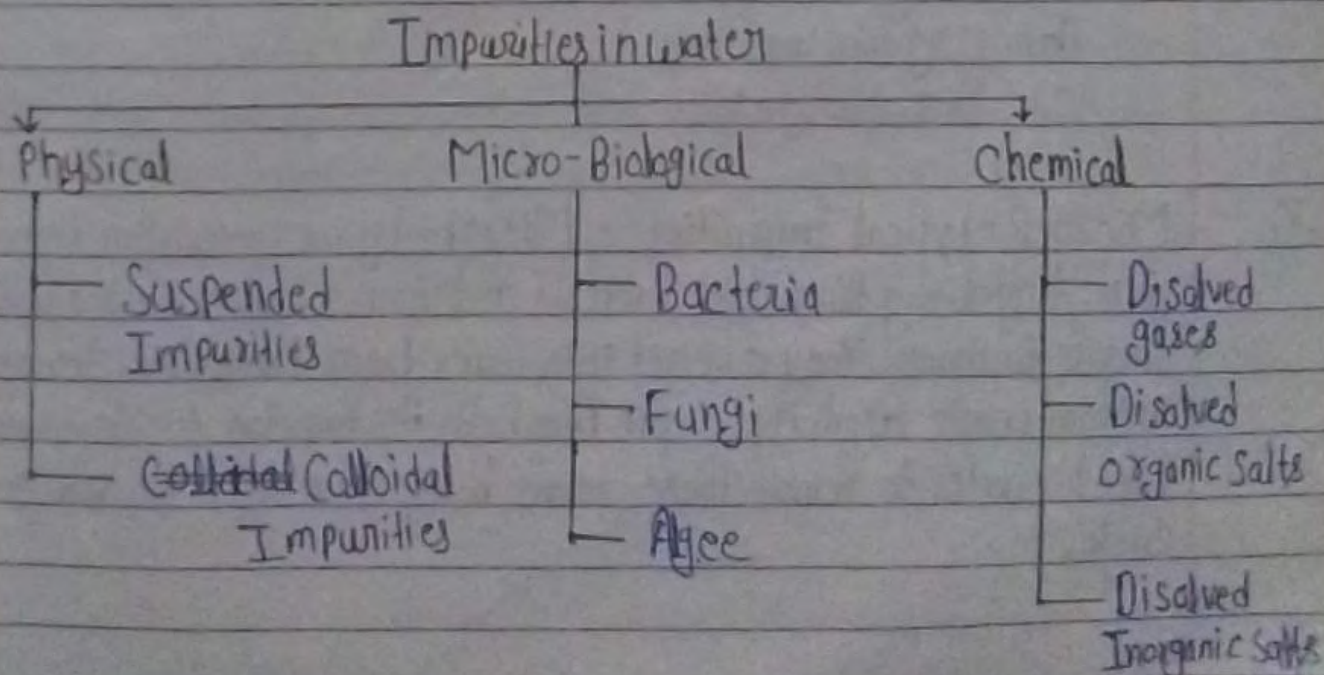Water can exist as solid ice, liquid water or gas vapor. depending on the temperature

(a) Liquid at Room Temperature — water is usually found as a liquid at room temperature, which means it flows easily and take the shape of its container.

(b) Transparent — water is clear and transparent, allowing us to see through it to the bottom of lakes, rivers and oceans.

(c) Tasteless and Odorless — Pure water does not have a taste or smell, making it pleasent to drink and us in cooking.

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USE OF WATER

1.7

(a) Drinking— we drink water to satisfy our thirsty and keep our body healthy.

(b) Cooking — water is used for boiling, steaming and preparing food like rice, pasta and soups.

(c) cleaning— water is used for washing dishes, clothes and surfaces to keep them clean.

(d) Bathing — we use water for showering and bathing to stay clean and fresh.

(e) Watering Plants — water is used to give plants the moisture they need to grow.

IMPURITIES IN WATER

1.8

Impurities in water

Physical — Micro-Biological — Chemical

Physical:
— Suspended Impurities
— Colloidal Colloidal Impurities

Micro-Biological:
— Bacteria
— Fungi
— Algee

Chemical:
— Disolved gases
— Disolved organic Salts
— Disolved Inorganic Salts

1. Physical Impurities :- Physical Impurities in water refer to substances or particles that are physically present in the water but are not dissolved. These impurities can include

(a) Suspended Solids - Solid particle that float or sink in water but are not dissolved. These can Include sediment, sand and other debris.

(b) Floating Debris (colloidal impurities):- Larger objects like leaves, twigs, plastic or other debris that can be seen floating on the surface of water.

2. Chemical Impurities — Chemical impurities in water are things that mix into the water and change its properties. They can be minerals, like salt or iron or things from pollution like pesticides or oil. These impurities can make the water taste different or even unsafe to drink.
These impurities are three types, they are-
(a) Inorganic impurities.
(b) Organic impurities.
(c) Dissolved gases.

3. Micro-Biological Impurities — Microbiological impurities in water are tiny living things like bacteria and viruses that can make water unsafe to drink. They can get into water from things like sewage, animal waste or dirty runoff from fields its important to clean our or treat water to remove these germs before drinking it to avoid getting sick.

1 6   Sources of water

Sources of water are places where we can find water. They include things like rivers, lakes, steams, Ponds, wells and even rain. These Sources provide us with the water we need for drinking, cooking, washing and many other daily activities.
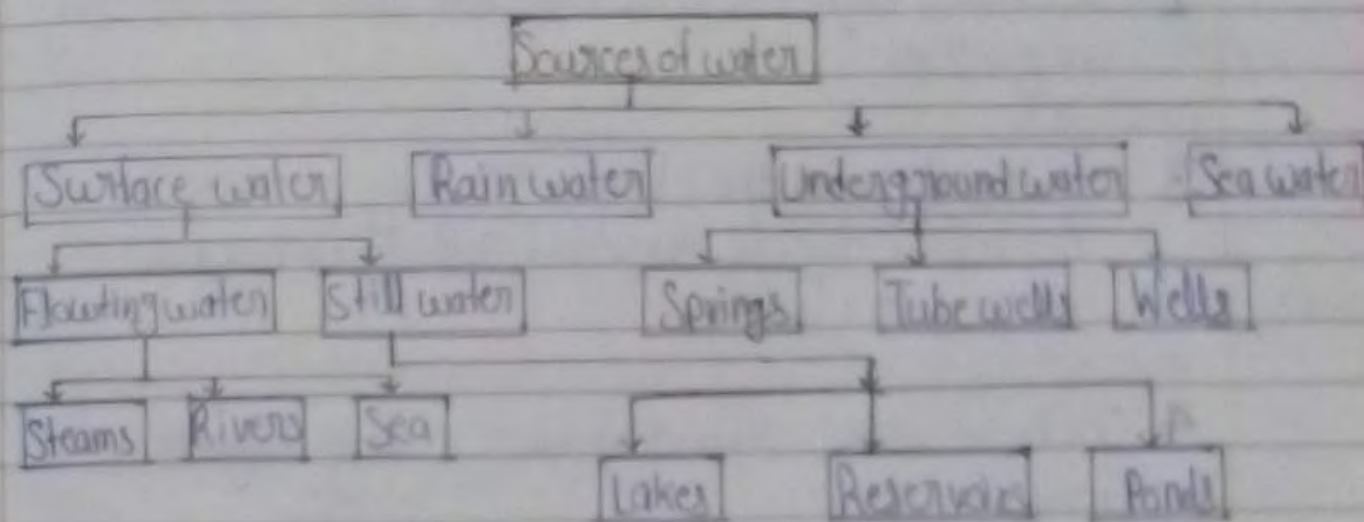
(a) Surface water - This includes water found on the surface of Earth. Such as rivers, lakes, steams and and ponds.

(b) Rain water - water that falls from the sky as precipitation including rain, Snow, sleet and hail.

(c) Underground water - water that is stored beneath the Earth's surface in soil and rock formations. accessed through wells and aquifers.

L.2

Hard Water and Soft Water -

HARD WATER

Defination :-

1.   water which does not produce foam with soap is known as hard water.

2. Contains high levels of minerals like calcium and magnesium

3. In hard water the cleaning property of soap is depressed due to dissolved salt. It is Bad for washing & cleaning.

4. In hard water, skin and hair, causing dryness and irritation.

Soft Water

Defination :-

1. Water which produce foam with soap is known as soft water.

2. Contains low level of minerals

3. Soft water is used to daily rution like cooking, washing and cleaning.

4. In Soft water, skin and hair feeling smooth and moisturized

18   <u>Types of Hardness</u>

<div align="center">Types of Hardness</div>

① Temparary Hardness
   by-Carbonate Hardness
   Alkaline Hardness
   ex- $CaCO_3$, $MgCO_3$,
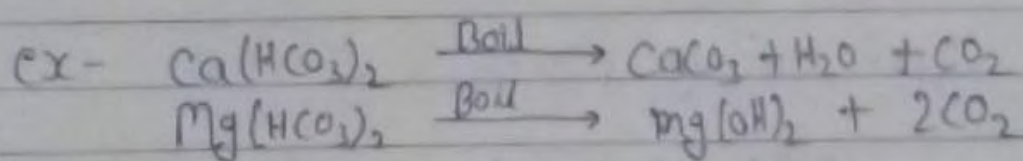 $Ca(HCO_3)_2$, $Mg(HCO_3)_2$

② Parmanent Hardness
   carbonate Hardness
   Non-Alkaline Hardness
   ex- $MgCl_2$, $CaSO_4$, $MgSO_4$,
       $FeSO_4$, $Al_2(SO_4)_3$

<u>Temparary Hardness</u>

1. It is due to the presence of disolve carbonate and by-carbonate of calcium and magnesium is known as temparary hardness.

2. The hardness of water which can easily removed by simple boiling of water is known as temparary hardness

ex- $Ca(HCO_3)_2$ $\xrightarrow{\text{Boil}}$ $CaCO_3 + H_2O + CO_2$

      $Mg(HCO_3)_2$ $\xrightarrow{\text{Boil}}$ $Mg(OH)_2 + 2CO_2$

3. It is also known as carbonate hardness or Alkaline Hardness

④ It is determine by typression with HCl using methic orange tri as intigrathen.
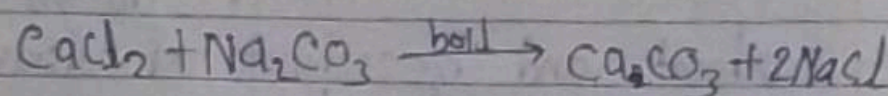
Parmanent Hardness :-

1. It is due to the ~~present~~ presence of disolve chloride and sulphate of ca, mg and Al is known as parmanent hardness.
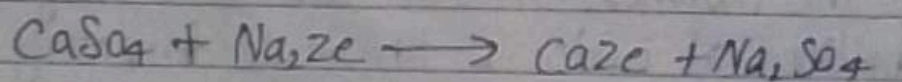
2. The hardness of water which still remain after boiling of water is known as permanent hardness
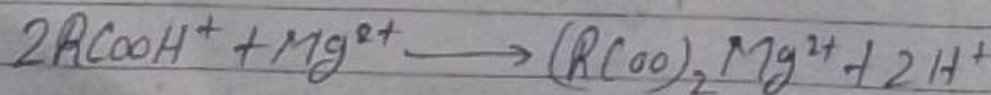
3. It cannot be destroy by boiling. It can be removed by —

(i) Lime Soda process

$$CaCl_2 + Na_2CO_3 \xrightarrow{boil} Ca_2CO_3 + 2NaCl$$

(ii) zealight process :-

$$CaSo_4 + Na_2Ze \longrightarrow CaZe + Na_2So_4$$

(iii) Ayan exchange process

$$2RCooH^+ + Mg^{2+} \longrightarrow (RCoo)_2 Mg^{2+} + 2H^+$$

Total Hardness :- Total hardness is the measure of the concentration of calcium (Ca^{2+}) and ~~mg~~ magnesium (Mg^{2+}) ions present in water.

Total Hardness (mg/L as $caco_3$) = calcium hardness + magnesium hardness

or

Total Hardness = Tomparary Hardness + Parmanent Hardness

Table for multiplication factor of Salts/ions

Constituent Solution	molar mass	n-factor	chemical equivalent $= \dfrac{\text{molar mass}}{\text{n-factor}}$	multiplication factor for converting into eq of $CaCO_3$
$Ca(HCO_3)_2$	162	2	$162/2 = 81$	$100/(2\times81) = 100/162$
$Mg(HCO_3)_2$	146	2	$146/2 = 73$	$100/(2\times73) = 100/146$
$CaSO_4$	136	2	$136/2 = 68$	$100/(2\times68) = 100/136$
$MgSO_4$	120	2	$120/2 = 60$	$100/(2\times60) = 100/120$
$CaCl_2$	111	2	$111/2 = 55.5$	$100/(2\times55.5) = 100/111$
$MgCl_2$	95	2	$95/2 = 47.5$	$100/(2\times47.5) = 100/95$
$CaCO_3$	100	2	$100/2 = 50$	$100/(2\times50) = 100/100$
$MgCO_3$	84	2	$84/2 = 42$	$100/(2\times42) = 100/84$
CO_2	44	2	$44/2 = 22$	$100/(2\times22) = 100/44$
$Mg(NO_3)_2$	148	2	$148/2 = 74$	$100/(2\times74) = 100/148$
HCO_3^-	61	1	$61/1 = 61$	$100/(2\times61) = 100/122$
OH^-	17	1	$17/1 = 17$	$100/(2\times17) = 100/34$
$NaAlO_2$	82	1	$82/1 = 82$	$100/(2\times82) = 100/164$
$FeSO_4.7H_2O$	278	2	$278/2 = 139$	$100/(2\times139) = 100/278$
H^+	1	1	$1/1 = 1$	$100/(2\times1) = 100/2$
CO_3^{2-}	60	2	$60/2 = 30$	$100/(2\times30) = 100/60$
$Al_2(SO_4)_3$	392	6	$342/6 = 57$	$100/(2\times57) = 100/114$

12   Formula of Degree of Hardness :-

$$CaCO_3 \ eq \ = \ \text{mass of Hardness producing Substance} \times \text{multiplication factor}$$

13   Degree of Hardness :-

Degree of hardness define as the term of equivalent amount of $CaCO_3$ because of taken of $CaCO_3$ it is insoluable in water easily calculated, easily filtered its molecular weight is 100.

$$1 \text{ mole of } CaCO_3 = 100g \text{ of } CaCO_3$$

$$1 \text{ mole of } Mg(HCO_3)_2 = 146g \text{ of } mg(HCO_3)_2$$

$$1 \text{ mole of } mgcl_2 = 95y \text{ of } Mgcl_2$$

4 Types of Degree of Hardness :-

① PPM (Parts Per Million) :-

• Part of $CaCO_3$ in 1 million part of water.

• It's define as the number of parts of the $CaCO_3$ equivalent.

• Present in 10^6 part of water

$$1 \text{ ppm} = 1 \text{ part of } CaCO_3 \text{ in } 10^6 \text{ parts of water}$$

(ii) mg/L (ppm)

- Number of milligram of calcium carbonate ($CaCO_3$) present in 1 litre of water.

$$1 mg/L = 1 mg \text{ of } CaCO_3 \text{ eq hardness in 1 litre of water}$$

$$1 ppm = 1 mg/L$$

$$\frac{m}{V} = \rho \qquad \rightarrow \text{ in case of water } \rho = 1$$

$$m = V$$

$$1L = 1 kg = 1000 g = 1000 \times 1000 mg$$

$$1L = 10^6 mg$$

$$1 mg/L = \frac{1 mg}{10^6 mg} = \frac{1}{10^6} = 1 ppm$$

$$\boxed{1 mg/L = 1 ppm}$$

(iii) °Cl (Degree clarke) :-

- Number of parts of calcium carbonate ($CaCO_3$) present in 70000 parts of water.

- It is define as the number of parts of $CaCO_3$ eq if is hardness power 70000 parts of the water is known as clarke.

$$1°Cl = 1 Part \text{ of } CaCO_3 \text{ eq per 70000 part of water}$$

(iv) **°Fr (Degree French):-**

- Number of parts of calcium carbonate ($CaCO_3$) present in 10^5 part of water.

- It is define as the number of part of the $CaCO_3$ eq it is tendency power 10^5 parts of the water is known as French.

$$1°Fr = 1 \text{ part of } CaCO_3 \text{ eq per } 10^5 \text{ part of water}$$

Note:-

Relationship between various units of hardness:-

$$1 ppm = 1 \text{ part per } 10^6 \text{ parts of water}$$
$$1°Fr = 1 \text{ part per } 10^5 \text{ parts of water}$$
$$\text{and} \quad 1°Cl = 1 \text{ part per } 70,000 \text{ parts of water}$$

$$\therefore 10^6 ppm = 10^5 °Fr = 70,000 °Cl$$

Hence, $1 ppm = 0.1°Fr = \cancel{70,000} = 0.07°Cl = 1 mg/l$

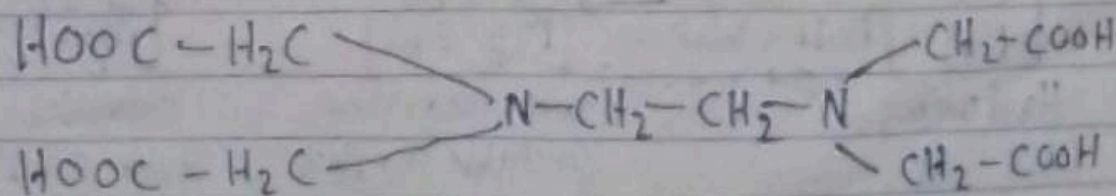| ↘	ppm	mg/l	°Fr	°Cl
ppm	1	1	0.1	0.07
mg/l	1	1	0.1	0.07
°Fr	10	10	1	0.7
°Cl	1/0.07	1/0.07	1/0.7	1

Classification of water hardness adapted from the WOA

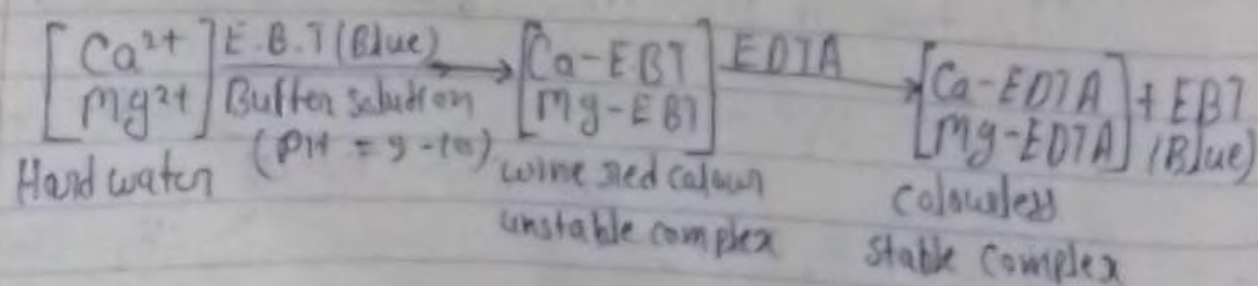| Classification	Soft	Slightly hard	Moderately hard	Hard	Very hard
PPm or mg/L	0-17	17-60	60-126	120-180	180 and above

110

Determination of Hardness by Edta EDTA. method:-

- EDTA is abbreviation of ethylene diamine tetra acetic acid.

- EDTA dissolves dissolves in water with great difficulty and in a very very small quantity.

- On the contra contrary it's di-Sodium salt dissolves in water quickely and completely. Hence for common experimental purpose. in place of EDTA. It's di-Sodium derivative is used.

- EDTA is a hexadentate ligand. It binds the metal ions in water i.e. Ca^{2+} or Mg^{2+} to give highly stable chelate complex (These metal ions are bonded via oxygen or nitrogen from EDTA molecule). Therefore this method is called as Complexometric Titration.

Structure of EDTA (Ethylene diamine tetra actic acid)

$HOOC-H_2C$
$HOOC-H_2C$
$N-CH_2-CH_2-N$
CH_2-COOH
CH_2-COOH

Principle of EDTA method:-

- The di-Sodium Salt of EDTA forms complexes with Ca^{2+} and Mg^{2+} as well as with many other metal cations in aqueous Solution.

- Thus the total hardness of a hardwater Sample, can be determine by titrating Ca^{2+} and Mg^{2+} present in the Sample with di-Sodium Salt of EDTA (Na_2 EDTA) Solution, using ammonical buffer Solution containing NH_4Cl. NA_4OH of P^H 10 using Eriohrome Black-T (EBT) as the metal indicator.

- At P^H 10, EBT indicator form wine red coloured unstable complex with Ca^{2+} and Mg^{2+} ions in hard water.

- This Complex is broken by EDTA Solution during titration, giving stable complex with ions and releasing EBT indicator Solution which is blue in color. Hence the colour changed is from wine red to blue (EBT's own colour).

- Thus noting noting the colour change, the point of equa equivalence can be trapped and hardness of water can be determined by this method

$$\begin{bmatrix} Ca^{2+} \\ Mg^{2+} \end{bmatrix} \xrightarrow[\text{Buffer solution}]{E.B.T (Blue)} \begin{bmatrix} Ca-EBT \\ Mg-EBT \end{bmatrix} \xrightarrow{EDTA} \begin{bmatrix} Ca-EDTA \\ Mg-EDTA \end{bmatrix} + EBT$$

Hard water $(PH = 9 - 10)$ wine red colour   colourless   (Blue)

unstable complex   Stable complex

Advantages of EDTA method:-

* Greater accuracy
* Highly rapid
* Highly convenient

1.11 ## Alkalinity and its determination:-

Alkalinity:

* It can be defined as "the concentration of the salts present in water which increases the concentration of OH^- ions due to the hydrolysis there by rising P^H of water to alkaline range".

* Natural water when found alkaline, it is generally due to the presence of HCO_3^-, SiO_3^{2-} and sometimes CO_3^{2-} ions. In addition to the above the alkalinity of boiler water is also due to the presence of OH^- & PO_4^{3-} ions.

  The extent of alkalinity depends on the presence of ions which broadly can be categorized as presence of.

(i) OH^- only (ii) CO_3^{2-} only (iii) HCO_3^- only (iv) OH^- & CO_3^{2-} together. (v) HCO_3^- & CO_3^{2-} together.

* Hydroxide and ~~bycarbonates~~ bicarbonates do not exist together because ~~hydroxide~~ hydroxyle ions react with bicarbonate ions to form carbonate ions. Therefore existence of hydroxyle and bicarbonate ions together is ruled out.

$$OH^- + HCO_3^- \longrightarrow CO_3^{2-} + H_2O$$

The alkalinity of natural water is due to the presence of hydroxides, carbonates and bicarbonates of calcium and magnesium. Alkalinity is a measure of the ability of water to neutralize the acids. The constituents causing alkalinity in natural water are as fallows:-

This is determined by titrating the sample with a standered solution of a strong acid. when the pH of the sample is above 8.3. titration is first carried out using phenolphthalein indicator. At the end point when indicator changes from pink to colourless. the p^H is lowered to about 4.5 due to addition of HCl. At this point complete nutralization of hydroxide and conversion of all the carbonate into bicarbonate accur. The alkalinity measured upto this point is called phenophthele alkalinity. [P] titration is continued using methyl orange indicator. The color changes from yellow to red and shows complete nutralization of all the bicarbonate ions.

When standered acid solution is added to alkaline water following reaction takes place.

$$OH^- + H^+ \longrightarrow H_2O$$
$$CO_3^{2-} + H^+ \longrightarrow HCO_3^-$$
$$HCO_3^- + H^+ \longrightarrow H_2O + CO_2$$

P

M
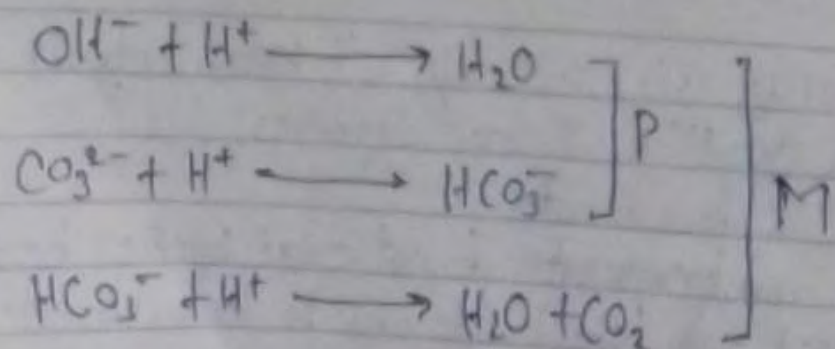
The total volume of acid used in both the stages corresponds to the neutralization of hydroxide, carbonate and bicarbonate and is thus a measure of total alkalinity. [M]

Calculation of Alkalinity of water by following table :-

Alkalinity	OH^- (PPm)	CO_3^- (PPM)	HCO_3^- (PPm)
P = 0	0	0	M
P = ½M	0	2P	0
P < ½M	0	2P	(M-2P)
P > ½M	(2P-M)	2(M-P)	0
P = M	P=M	0	0

Significance :-

(1) For calculating the amount of lime and soda required for water softening.

(2) In conditioning boiler feed water highly alkaline water may to caustic embrittlement and also may cause deposition of precipitates and sludge in boiler tubes and pipes.

(3) Bicarbonates of of calcium and magnesium induce temporary temporary hardness in water, which if untreated, cause scale formation in boilers.

Numerical based on Hardness & strength :-

formell

Formula for Determination of Hardness

1) $Hardness = Strength(in\ mg/L) \times \dfrac{chemical\ equivalent\ wt\ of\ CaCO_3}{chemical\ equivalent\ wt\ of\ hardness\ producing\ Salt.}$

2) $CaCO_3\ eq = mass\ of\ hardness\ producing\ substances \times multiplication\ factor$

Q- A water sample contain 408 mg of $CaSO_4$ per litre. Calculate the hardness in term $CaCO_3$ eq.

Solution Given that

water sample - 408 mg/l of $CaSO_4$

and $CaCO_3$ eq = ?

$\therefore$ $CaCO_3$ eq = $\dfrac{mass\ of\ hardness}{Producing\ Substance}$ × $\dfrac{multiplication\ factor}{Producing\ substance}$

$CaCO_3$ eq = $408 \times \dfrac{100}{136}$ mg/l

$CaCO_3$ eq = 300 mg/L

Q- Find the $CaCO_3$ eq, Temporary Hardness, Permanent Hardness and Total Hardness of these salts and its value in mg/l, °Cl and °F.

Salts	Amount in mg/L
$Ca(HCO_3)_2$	5
$Mg(HCO_3)_2$	7
$MgCO_3$	4
$MgCl_2$	8
$CaCl_2$	3
$CaSO_4$	9

Solution

Salt	Amount in mg/L	multiplication factor	$CaCO_3$ eq
$Ca(HCO_3)_2$	5	100/162	3·08 mg/L
$Mg(HCO_3)_2$	7	100/146	4·79 mg/L
$MgCO_3$	4	100/84	4·76 mg/L
$MgCl_2$	8	100/95	8·42 mg/L
$CaCl_2$	3	100/111	2·7 mg/L
$CaSO_4$	9	100/136	6·61 mg/L

Temporary Hardness = 7·88 mg/L

Parmanent Hardness = 22·5 mg/L

Total Hardness = 30·38 mg/L

Hardness	in mg/L	in °Fr	in °CL
Temporary	7·88 mg/L	0·78	0·55
Parmanent	22·5	2·24	1·57
Total	30·38	3·03	2·12

Numerical Problems

Q- 60 ml of Standered hardwater, calculate 1mg of pure CaCO₃ per litre consumed 30 ml of EDTA EDTA. 60ml water sample consumed 35 ml of EDTA Solution using the EBT as Indicator calculate the total hardness of water sample in ppm.

Solve:- Given that

$$\text{Standered hardwater} = 60 ml$$
$$\text{EDTA} = 30 ml$$
$$\text{Water Sample} = 60 ml$$
$$\text{EDTA} = 35 ml$$

$$\frac{S.H.W}{S.H.W} = 1mg = 1ml$$

(1) Standardization of EDTA solution -

<u>1 ml of standard hardwater contains 1mg of CaCO₃</u>

Now

$$30 \text{ ml of EDTA} = 60 \text{ ml of SWH}$$
$$30 \text{ ml of EDTA} = 60×1 \text{ mg of CaCO₃}$$
$$1 \text{ ml of EDTA} = \frac{60}{30} \text{ mg of CaCO₃}$$

$$1 \text{ ml of EDTA} = 2 \text{ mg of CaCO₃}$$

~~(i) Determination of Permanent hardness~~
(ii) Determination of total Hardness of water -

$$60 \text{ ml of water Sample} = 35 \text{ ml of EDTA}$$
$$60 \text{ ml of water Sample} = 35×1 \text{ ml of EDTA}$$
$$60 \text{ ml of water Sample} = 35×2 \text{ mg of CaCO₃}$$
$$60 \text{ ml of water Sample} = 70 \text{ mg of CaCO₃}$$

1ml of water sample = $\dfrac{70}{60}$ mg of CaCO₃

1L of water sample = $\dfrac{70 \times 1000}{60}$ mg of CaCO₃

1L of water sample = 1166 mg of CaCO₃

Hence, total hardness of water = 1166 mg = 1166 PPM

Q 100ml of standard hardwater calculate 1.5mg of pure CaCO₃ per litre consumed 44ml of EDTA 50 ml of water sample consumed 20ml of the same EDTA solution using the EBT indicator calculate the total hardness of water in ppm and °cl unit.

Solve Given that

Standard hardwater = 100ml
EDTA = 44ml
Water Sample = 50ml
EDTA = 20ml

~~1ml S.W~~
1ml SHW = 1.5 mg CaCO₃

Step-1 Standardization of EDTA Solution

1ml of Standard hardwater contains 1.5mg of CaCO₃

Now

44 ml of EDTA = 100 ml of S.H.W
44 ml of EDTA = 100 × 1.5 mg of CaCO₃
44 ml of EDTA = 150 mg of CaCO₃

1 ml of EDTA = $\frac{15}{44}$ mg of $CaCO_3$

1 ml of EDTA = 3.40 mg of $CaCO_3$

(ii) Determination of total hardness sw. of water =

50 ml of water sample = 20 ml of EDTA

50 ml of water sample = 20×1 ml of EDTA

50 ml of water sample = 20 × 3.40 mg of $CaCO_3$

50 ml of water Simple = 68 mg of $CaCO_3$

1 ml of water sample = $\frac{68}{50}$ mg of $CaCO_3$

1 L of water Sample = $\frac{68}{50}$ × 1000 mg of $CaCO_3$

1 L of water Sample = 1360 mg of $CaCO_3$

Hence, Total hardness of water = 1360 mg = 1360 ppm

Total hardness = 95.2 °Cl

③- Calculate the hardness of a water sample, whose 20 ml required 3ml EDTA. 10 ml of standard calcium chloride solution, whose strength is equivalent to 300 mg of $CaCO_3$ per 200 ml, required 20 ml of the same EDTA solution.

Ans.   20 ml of EDTA = 200 ml of hardwater
$$= 200 \times 300 \text{ mg of } CaCO_3 \text{ eq hardness}$$
$$= 6 \times 10^4 \text{ mg of } CaCO_3 \text{ eq hardness}$$

Thus, 1ml of EDTA = $\dfrac{6 \times 10^4}{20}$ = 3000 of $CaCO_3$ eq

Determination of hardness of water sample

20 ml of sample water = 30 ml of EDTA = 30 × 3000

Thus, 1L of sample water = $\dfrac{30 \times 3000}{20}$

$$= 4500 \text{ mg of } CaCO_3 \text{ eq hardness}$$

Q) One gm of $CaCO_3$ was dissolved in dilute HCL and the solution was made to one litre by del dilution. 50 ml of this solution required 40ml of EDTA solution, while 50ml of the sample water required 20ml of EDTA solution. Calculate total hardness of water sample.

Solve - We Calculate the total hardness in two steps -

(i) Standarization of EDTA Solution

1000ml of standard water = 1g of $CaCO_3$
or 1ml of standard water = 1mg of $CaCO_3$

Now, 40ml of EDTA Solution = 50 ml of standard water

40 ml of EDTA Solution = 50×1 mg of $CaCO_3 \uparrow$

$\therefore$ 1ml of EDTA Solution = $\dfrac{50}{40}$ mg of $CaCO_3$

(ii) Determination of total hardness of water sample

Further, 50 ml of sample water = 20 ml of EDTA Solution
= $\dfrac{20 \times 50}{40}$ mg of $CaCO_3 \uparrow$

1000 ml of sample water = $\dfrac{20 \times 50 \times 1000}{40 \times 50}$ mg of $CaCO_3 \uparrow$

= 500 mg of $CaCO_3$

Total hardness = 500 mg/L or 500ppm

Q- 10ml CaCo₃ of Strength 1gm/litre required 8ml EDTA on titration. 10 ml of a water sample required 6ml of the same EDTA solution on titration. Calculate the total hardness of water sample.

Sol⁻ i) Standardization of EDTA Solution

$$1L \text{ of Standard water} = 1g \text{ of } CaCO_3$$

$$\therefore 1ml \text{ of standard water} = 1mg \text{ of } CaCO_3$$

Now, 8ml of EDTA = 10 ml of standard water

∴ 8ml of EDTA sol. = 10×1mg of $CaCO_3$

∴ 1ml of EDTA sol. = $\dfrac{10}{8}$ mg of $CaCO_3$

ii) Determination of total hardness of water sample

Further, 10ml of sample water = 6ml of EDTA solution

$$= \dfrac{6 \times 10}{8} \text{ mg of } CaCO_3$$

10 ml of sample water = $\dfrac{6 \times 10}{8} \times 10$ mg of $CaCO_3$

$$= 75 \text{ mg of } CaCO_3$$

Total hardness = 75 mg/L or 75 ppm

Q- 50 ml of standard hard water containing 1000 mg of pure $CaCO_3$ per litre. consumed 20 ml of EDTA solution. Using erieto eriochrome black-T as indicator, calculate the total hardness of water sample in ppm.

Ans (i) Standardization of EDTA solution.

50 ml of standard water = 1000 mg of $CaCO_3$
1 ml of standard water = 20 mg of $CaCO_3$
Now, 20 ml of EDTA = 50 ml of standard hard water
                    = 50×20 mg of $CaCO_3$ eq hardness

Hence 1 ml of EDTA = $\frac{50 \times 20}{20}$ = 50 mg of $CaCO_3$ eq hardness

(ii) Determination of total hardness of water sample

50 ml of Sample water = 25 ml of EDTA
                      = 25×50 mg of $CaCO_3$ eq hardness
Hence, 1000 ml of Sample water = $\frac{25 \times 50 \times 1000}{50}$

                               = 25000 mg of $CaCO_3$ eq hardness
Thus, total hardness of water = 25000 ppm

Q- 100 ml of standard hard water containing 1.5 mg of pure $CaCO_3$ per ml consumed 44 ml of EDTA. 50 ml of a water sample consumed 20 ml of the same EDTA solution, using eriochrome black-T as indicator, calculate the total hardness of water sample in ppm and °Cl units.

Solve (i) Standardization of EDTA solution

$\quad\quad$ 100 ml of standard water = 1.5 mg of $CaCO_3$
$\quad\quad$ 1 ml of standard water = 0.015 mg of $CaCO_3$
$\quad\quad$ Now 44 ml of EDTA = 100 ml of standard hard water
$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad = 100 \times 0.015$ mg of $CaCO_3$
$\quad\quad$ 1 ml of EDTA $= \dfrac{100 \times 0.015}{44} = \dfrac{1.5}{44} = 0.034$ mg of $CaCO_3$

(ii) Determination of total hardness of water sample

$\quad\quad$ 50 ml of sample water = 20 ml of EDTA
$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad = 20 \times 0.034$ mg of $CaCO_3$
$\quad\quad$ Hence, 1000 ml of sample water $= \dfrac{20 \times 0.034}{50} \times 1000$

$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad = 13.6$ mg of $CaCO_3$ eq hardness
$\quad\quad$ 1 PP = 1 mg/L
$\quad\quad$ So, $\quad\quad = 13.6$ PPm

$\quad\quad$ 1 PPm = 0.07 °Cl
$\quad\quad$ So, 13.6 PPm = 13.6 × 0.07 °Cl
$\quad\quad\quad\quad\quad\quad\quad\quad = 0.952$ °Cl

Q- One gram of $CaCO_3$ was dissolved in dil. HCl and the solution diluted to one litre. 100 mg 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 water sample when titrated against EDTA consumed 20 ml of ☆ solution. Calculate total, permanent and temporary hardness of water sample in ppm.

Solve   i) Standardization of EDTA solution

1000 ml of standard water = 1g of $CaCO_3$

1 ml of standard water = 1mg of $CaCO_3$.

Now 90 ml of EDTA = 100 ml of standard water

90 ml of EDTA = 100×1 mg of $CaCO_3$

1 ml of EDTA $= \dfrac{100}{90}$ mg of $CaCO_3$

ii) Determination of hardness

Further, 100 ml of sample water = 40 ml of EDTA solution

$= \dfrac{40 \times 100}{90}$ mg of $CaCO_3$

1000 ml of Sample water = $\dfrac{40 \times 100}{90} \times \dfrac{1000}{100}$ mg of $CaCO_3$

Total hardness $= \dfrac{4000}{9} = 444.44$ mg/L $= 444.44$ ppm

Also, 100 ml of boiled Sample water = 20 ml of EDTA solution

$= \dfrac{20 \times 100}{90}$ mg of $CaCO_3$

1000 ml of boiled Sample water = $20 \times \dfrac{100}{90} \times \dfrac{1000}{100}$ mg of $CaCO_3$

$$\text{Parmanent hardness} = \frac{2000}{50} = 222.22\,ppm$$

Hence,

$$\text{temporary hardness} = 444.44 - 222.22 = 222.22\,ppm$$

(6- 0.5g of $CaCO_3$ was dissolved in HCl and the solution was made to 500 ml with distilled water. 50 ml of this solution required 25 ml of EDTA solution for titration. 50 ml of hardwater sample required 20 ml of EDTA. After boiling 50 ml of boiled water sample required 15 ml of the same EDTA. Calculate each type of hardness in mg/L.

Solution **(i) Standardization of EDTA solution**

500 ml of standard water = 0.5g of $CaCO_3$

or   1 ml of standard water = 1mg of $CaCO_3$

Now, 25 ml of EDTA Solution = 50 ml of standard water

Also, 25 ml of EDTA Solution = 50×1 mg of $CaCO_3$

1 ml of EDTA Solution = $\frac{50}{25}$ mg of $CaCO_3$

(ii) Determination of total hardness of water sample

Further, 50 ml of Sample water = 20 ml of EDTA solution

$$= \frac{20×50}{25}\,mg\;of\;CaCO_3$$

500 ml of Sample water = $\frac{20×50×500}{25×50}$ = 400 mg of $CaCO_3$

Total hardness = 400 mg/L

50 ml of boiled water sample = 15 ml of EDTA Solution

$$= \frac{15}{50} \text{ mg of } CaCO_3$$

Thus 1L of water Sample $= \frac{15}{50} \times 1000 = 300 \text{ mg of } CaCO_3$

Parmanent Hardness = 300 mg/L

Temporary hardness = Total hardness - Parmanent hardness
$$= 900 - 300$$
$$= 100 \text{ mg/L}$$

① - 0.28 g of $CaCO_3$ was dissolved in 1 litre of water. 100 ml of this water on titration required 28 ml of EDTA. 100 ml of unknown hard water sample required 33 ml of EDTA. after boiling and cooling 100 ml of thy sample required 10 ml of EDTA. Calculate the temporary hardness of water.

Solve (i) Standardization of EDTA Solution
Given, 1L of Standard hardwater contains 0.28 gm $CaCO_3$. Hence, each ml of standard hardwater contains 0.28 mg $CaCO_3$.
As,
28 ml of EDTA = 100 ml of Standard hardwater
$$= 100 \times 0.28$$
$$= 28 \text{ mg of } CaCO_3$$
$$1 \text{ ml of EDTA} = \frac{28}{28} = 1 \text{ mg of } CaCO_3$$

(ii) Determination of hardness of water.
Given, 100 ml of unknown hardwater sample = 33 ml of EDTA
$$= 33 \times 1$$
$$= 33 \text{ mg of } CaCO_3$$

1000 mg (or 1L) of unknown hard water sample = $\frac{33}{100}$ × 1000

= 330 mg $CaCO_3$ eq hardness

Total hardness = 330 PPm

100 ml of boiled water = 10 ml of EDTA

= 10 r1

= 10 mg of $CaCO_3$ eq hardness

∴ 1000 ml (or 1L) of boiled water = $\frac{10}{100}$ × 1000 = 100 mg of $CaCO_3$ eq hardness

Permanent hardness of water = 100 ppm

Hence, temporary hardness = Total hardness − Permanent hardness

= 330 − 100 = 230 ppm

Q- 100 ml of a water sample on titration with N/50 H_2SO_4 gave a titre value of 8.5 ml to phenolphthalein end point and 170 ml to methyl orange end point. Calculate alkalinity of water sample.

Solve 100 ml water sample on titration with $\frac{N}{50}$ H_2SO_4 required

= 8.5 ml $\frac{N}{50}$ H_2SO_4

∴ 100 ml × N_P = 8.5 ml × $\frac{N}{50}$

Normality, N_P = $\frac{8.5}{100}$ × $\frac{1}{50}$ N

Now, Strength of alkalinity of upto phenolphthalein end point in terms of $CaCO_3$ eq.,

$$P = N_p \times 50 \times 1000 \, ppm$$

$$P = \frac{8.5}{100} \times \frac{1}{50} \times 50 \times 1000 = 85 \, ppm$$

As, 100 ml of water sample upto methyl orange end point consumed

$$= 8.5 + 17 \, ml \text{ of } \frac{N}{50} H_2SO_4$$

$$100 \times N_m = 25.5 \frac{N}{50}$$

$$N_m = \frac{25.5}{100} \times \frac{1}{50} N$$

Strength upto methyl orange end point in terms of $CaCO_3$ equivalent,

$$M = N_m \times 50 \times 1000 \, ppm$$

$$= \frac{25.5}{100} \times \frac{1}{50} \times 50 \times 1000 \, ppm = 255 \, ppm$$

Since, $P > \frac{1}{2} M$. Hence, $\sim CO_3^{2-}$ and HCO_3^- ions present,

and alkalinity due to $CO_3^{2-} = 2P = 2 \times 85 = 170 \, ppm$

and alkalinity due to $HCO_3^- = M - 2P = 255 - 170 = 85 \, ppm$

Hence, the given water sample contains CO_3^{2-} alkalinity = 170 ppm and HCO_3^- alkalinity = 85 ppm

Ⓠ 100 ml of a water sample required 20 ml of $\frac{N}{50}$ H_2SO_4 for neutralization to phenophthalein end point. After this methyl orange indicator was added to this and further acid required was 15 ml. calculate the type and extent of alkalinity.

Solve 100 ml of water sample on titration with $\frac{N}{50}$ H_2SO_4 required

$$= 20 \text{ ml of } \frac{N}{50} H_2SO_4$$

$$100 \text{ ml} \times N_p = 20 \times \frac{N}{50} H_2SO_4$$

$$100 \text{ ml} \times N_p = \frac{20 \times N}{50}$$

$$N_p = \frac{20}{100} \times \frac{1}{50} N$$

Now, Strength of alkalinity upto phenolphthalein end point in terms of $CaCO_3$ eq

$$P = N_p \times 50 \times 1000 \text{ ppm}$$

$$P = \frac{20}{100} \times \frac{1}{50} \times 50 \times 1000 \text{ ppm}$$

$$P = 200 \text{ ppm}$$

As, 100 ml of water sample upto methyl orange end point consumes

$$= 20 + 15 = 35 \times \frac{N}{50} H_2SO_4$$

$$100 \times N_M = \frac{35 \times N}{50}$$

$$N_M = \frac{35}{100} \times \frac{N}{50}$$

Strength upto methyl orange end point in terms of $CaCO_3$ eq

$$M = N_m \times 50 \times 1000 ppm$$

$$M = \frac{35}{100} \times \frac{1N}{50} \times 50 \times 1000 ppm = 350 ppm$$