Unit - 1 Water

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 or 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.

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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 temprature

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

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

(C) Tasteless and Oderless - Pure water does not have a taste or smell, making it pleasent to drink and us in cooking.

1.4 USE OF WATER

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

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

1.5 IMPURITIES IN WATER

Impurities in water

- Physical
  - Suspended Impurities
  - ~~Colloidal~~ Colloidal Impurities
- Micro-Biological
  - Bacteria
  - Fungi
  - Algee
- Chemical
  - Disolved gases
  - Disolved organic Salts
  - Disolved Inorganic Salts

Unit-1

Water

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.

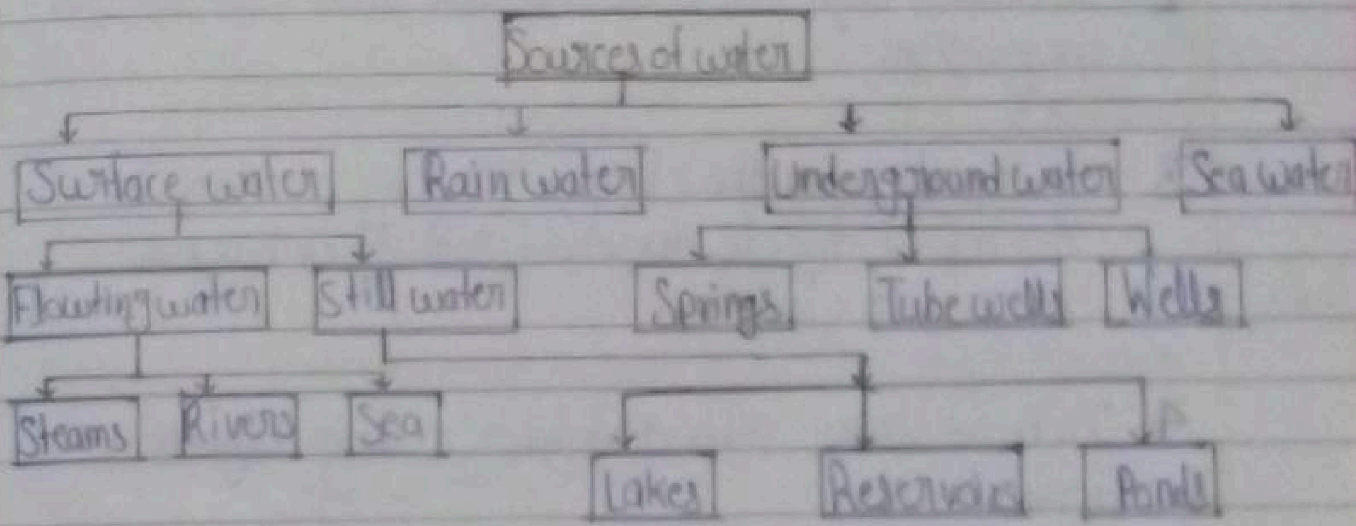
(b) Floating Debris (colloidal impurities):- Larger objects like leaves, twigs plastic or other debris that can be seem floating on the surface of water.

2 Chemical Impurities - Chemical impurities in water are things that mix into the water and change its properties. They can be minirals, 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 ~~out~~ 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, Streams and and ponds

(b) Rain water- water that falls from ~~the~~ 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

L2 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 clearing property of soap is depressed due to dissolved salt. It is Bad for washing & clearing.

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 rutien like cooking, washing and cleaning.

4. In Soft water, Skin and hair feeling Smooth and moisturized

18 ## Types of Hardness

Types of Hardness

① Temparary Hardness	② Parmanent Hardness
by-carbonate Hardness	carbonate Hardness
Alkaline Hardness	Non-Alkaline Hardness
ex- $CaCO_3$, $MgCO_3$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$	ex- $MgCl_2$, $CaSO_4$, $MgSO_4$, $FeSO_4$, $Al_2(SO_4)_3$

Temparary Hardness:-

1. It is due to the presence of dissolve 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- $$Ca(HCO_3)_2 \xrightarrow{Boil} CaCO_3 + H_2O + CO_2$$
$$Mg(HCO_3)_2 \xrightarrow{Boil} Mg(OH)_2 + 2CO_2$$

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) zeolight process :-

$$CaSO_4 + Na_2Ze \longrightarrow CaZe + Na_2SO_4$$

(iii) Ayan exchange process

$$2RCOOH^+ + Mg^{2+} \longrightarrow (RCOO)_2Mg^{2+} + 2H^+$$

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 = Temparary Hardness + Parmanent Hardness

Table for multiplication factor of Salts/ions

Constituent Salution	molar mass	n-factor	chemical equivalent = molar mass / n-factor	multiplication factor for converting into eq of $CaCO_3$
$Ca(HCO_3)_2$	162	2	162/2 = 81	100/(2×81) = 100/162
$Mg(HCO_3)_2$	146	2	146/2 = 73	100/(2×73) = 100/146
$CaSO_4$	136	2	136/2 = 68	100/(2×68) = 100/136
$MgSO_4$	120	2	120/2 = 60	100/(2×60) = 100/120
$CaCl_2$	111	2	111/2 = 55.5	100/(2×55.5) = 100/111
$MgCl_2$	95	2	95/2 = 47.5	100/(2×47.5) = 100/95
$CaCO_3$	100	2	100/2 = 50	100/(2×50) = 100/100
$MgCO_3$	84	2	84/2 = 42	100/(2×42) = 100/84
CO_2	44	2	44/2 = 22	100/(2×22) = 100/44
$Mg(NO_3)_2$	148	2	148/2 = 74	100/(2×74) = 100/148
HCO_3^-	61	1	61/1 = 61	100/(2×61) = 100/122
OH^-	17	1	17/1 = 17	100/(2×17) = 100/34
$NaAlO_2$	82	1	82/1 = 82	100/(2×82) = 100/164
$FeSO_4 \cdot 7H_2O$	278	2	278/2 = 139	100/(2×139) = 100/278
H^+	1	1	1/1 = 1	100/(2×1) = 100/2
CO_3^{2-}	60	2	60/2 = 30	100/(2×30) = 100/60
$Al_2(SO_4)_3$	342	6	342/6 = 57	100/(2×57) = 100/114

12 **Formula of Degree of Hardness :-**

$CaCO_3$ eq = mass of Hardness producing Substance × 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 mole of $CaCO_3$ = 100g of $CaCO_3$

1 mole of $Mg(HCO_3)_2$ = 146g of $Mg(HCO_3)_2$

1 mole of $MgCl_2$ = 95g 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 PPM = 1 Part of $CaCO_3$ in 10^6 parts of water

(ii) milligram/litre (mg/L)

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

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

$$1\,PPm = 1\,mg/L$$

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

$$m = V$$

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

$$1L = 10^6\,mg$$

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

$$\boxed{1\,mg/L = 1\,PPm}$$

(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. of its hardness per 70000 parts of the water is known as clarke.

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

(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 :-

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

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

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

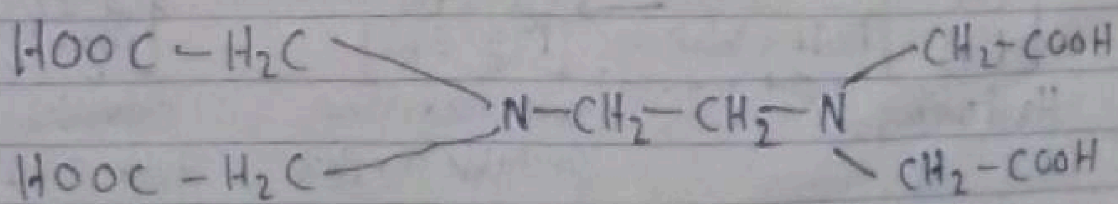
Classification of water hardness adapted from the WQA

Classification	Soft	Slightly hard	Moderately hard	Hard	very hard
ppm or mg/L	0-17	17-60	60-120	120-180	180 and above

11. ## Determination of Hardness by ~~Edta~~ EDTA method:

- EDTA is abbrieviation of ethylene diamine tetra acetic acid.
- EDTA ~~dissolves~~ dissolves in water with great difficulty and in a very very small quantity.
- On the ~~contr~~ contrary it's di-Sodium salt dissolves in water quickely and completly. Hence for common experimental purpose. in place of EDTA. It's di-Sodium derivateve 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)



Principle of EDTA method:-

- The di-Sodium salt of EDTA forms complexes with Ca^{2+} ~~ang~~ 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 ~~that~~ titrating Ca^{2+} and Mg^{2+} present in the Sample with di-Sodium salt of EDTA (Na_2EDTA) Solution, using ammonical buffer solution containing $NH_4Cl \cdot NH_4OH$ of p^H 10 using Eriochrome Black-T (EBT) as the metal indicator.

- At p^H 10, EBT indicator from 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 ~~nothing~~ noting the colour change, the point of ~~equa~~ equivalence can be trapped and hardness of water can be determined by this method

$$\underset{\text{Hard water}}{\begin{bmatrix} Ca^{2+} \\ Mg^{2+} \end{bmatrix}} \xrightarrow[\substack{\text{Buffer solution} \\ (pH = 9-10)}]{\text{E.B.T (Blue)}} \underset{\substack{\text{wine red colour} \\ \text{unstable complex}}}{\begin{bmatrix} Ca-EBT \\ Mg-EBT \end{bmatrix}} \xrightarrow{\text{EDTA}} \underset{\substack{\text{colourless} \\ \text{Stable Complex}}}{\begin{bmatrix} Ca-EDTA \\ Mg-EDTA \end{bmatrix}} + \underset{\text{(Blue)}}{EBT}$$

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 pH 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 accurs The alkalinity measured upto this point is called phenophthalein alkalinity. [P] tibration 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.

$$\left.\begin{array}{l} \left.\begin{array}{l} OH^- + H^+ \longrightarrow H_2O \\ CO_3^{2-} + H^+ \longrightarrow HCO_3^- \end{array}\right] P \\ HCO_3^- + H^+ \longrightarrow H_2O + CO_2 \end{array}\right] M$$

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
$P=\frac{1}{2}M$	0	2P	0
$P<\frac{1}{2}M$	0	2P	$(M-2P)$
$P>\frac{1}{2}M$	$(2P-M)$	$2(M-P)$	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:-

~~Formula~~

Formula for Determination of Hardness

1) Hardness = Strength (in mg/L) × chemical equivalent wt. of $CaCO_3$ / chemical equivalent wt. of hardness producing Salt.

(2) $CaCO_3$ eq = mass of hardness producing substances × multiplication factor

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

Solution Given that

water sample = 408 mg/L of $CaSO_4$

and $CaCO_3$ e_q = ?

$\therefore$ $CaCO_3$ e_q = mass of hardness Producing Substance × multiplication factor Producing Substance

$CaCO_3 \; e_q = 408 \times \frac{100}{136} \; mg/L$

$CaCO_3 \; e_q = 300 \; mg/L$

Q- Find the $CaCO_3$ e_q, Temporary Hardness, Permanent Hardness and Total Hardness of these salts and it's value in mg/L, °cl and °Fr

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 $CaCO_3$ per litre consumed 30 ml of ~~ETD~~ 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

Standered hardwater = 60ml
EDTA = 30ml
Water Sample = 60ml
EDTA = 35ml

~~S.W.H~~
S.H.W = 1mg = 1ml

(i) Standardization of EDTA solution -

1ml of standard hardwater contains 1mg of $CaCO_3$

Now

30 ml of EDTA = 60 ml of SWH
30 ml of EDTA = 60×1 mg of $CaCO_3$
1ml of EDTA = $\frac{60}{30}$ mg of $CaCO_3$

1ml of EDTA = 2 mg of $CaCO_3$

~~(ii) Determination of Permanent hardness -~~

(ii) Determination of total Hardness of water -

60 ml of water sample = 35 ml of EDTA
60 ml of water Sample = 35×1 ml of EDTA
60 ml of water Sample = 35×2 mg of $CaCO_3$
60 ml of water Sample = 70 mg of $CaCO_3$

1ml of water sample = $\frac{70}{60}$ mg of $CaCO_3$

1L of water sample = $\frac{70}{60} \times 1000$ mg of $CaCO_3$

1L of water sample = 1166 mg of $CaCO_3$

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

Q 100ml of standard hardwater calculate 1.5mg of pure $CaCO_3$ 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.h.w~~
1ml Shw = 1.5 mg $CaCO_3$

Step-1 Standardization of EDTA Solution

1ml of Standard hardwater contains 1.5 mg of $CaCO_3$

Now

44 ml of EDTA = 100ml of S.H.W
44 ml of EDTA = 100×1.5 mg of $CaCO_3$
44 ml of EDTA = 150 mg of $CaCO_3$

1 ml of EDTA = $^{15}/_{44}$ mg of $CaCO_3$
1 ml of EDTA = 3.40 mg of $CaCO_3$

(ii) Determination of total hardness ~~etc~~ of water

50 ml of water sampl = 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 sample = 68 mg of $CaCO_3$

1 ml of water sample = $^{68}/_{50}$ mg of $CaCO_3$

1L of water sample = $^{68}/_{50}$×1000 mg of $CaCO_3$

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

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

Total hardness = 95.2°Cl

Q. Calculate the hardness of a water sample, whose 20 ml required 3 ml 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 × 300 mg of $CaCO_3$ eq hardness
= 6×10^4 mg of $CaCO_3$ eq hardness

Thus, 1 ml of EDTA = $\frac{6 \times 10^4}{20}$ = 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 = $\frac{30 \times 3000}{20}$
= 4500 mg of $CaCO_3$ eq hardness

Q One gm of $CaCO_3$ was dissolved in dilute HCl and the solution was made to one litre by dil 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

1000 ml 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 $CaCO_3$

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

(ii) Determination of total hardness of water sample

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

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

= 500 mg of $CaCO_3$

Total hardness = 500 mg/L or 500ppm

Q- 10ml $CaCO_3$ of strength 1gm/litre requires 8ml EDTA on titration. 10 ml of a water sample requires 6ml of the same EDTA solution on titration. Calculate the total hardness of water sample.

Sol: (i) Standardization of EDTA Solution

1L of Standard water = 1g of $CaCO_3$

$\therefore$ 1ml of standard water = 1mg of $CaCO_3$

Now 8ml of EDTA = 10 ml of standard water

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

$\therefore$ 1ml of EDTA sol. = $\frac{10}{8}$ mg of $CaCO_3$

(ii) Determination of total hardness of water sample

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

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

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

= 75 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 ~~erio~~ 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 = $\frac{25 \times 50}{50} \times 1000$
= 25000 mg of $CaCO_3$ eq hardness
Thus, total hardness of water = 25000 ppm

(c) 100ml of sthandard hard water containing 1·5 mg of pure $CaCO_3$ per ml consumed 44 ml of EDTA. 50ml 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

100ml of standard water = 1·5mg of $CaCO_3$
1ml of standard water = 0.015 mg of $CaCO_3$
Now 44 ml of EDTA = 100 ml of standard hard water
= 100 × 0.015 mg of $CaCO_3$

$$1\text{ml of EDTA} = \frac{100 \times 0.015}{44} = \frac{15}{44} = 0.034 \text{ mg of } CaCO_3$$

(ii) Determination of total hardness of water sample

50 ml of sample water = 20 ml of EDTA
= 20 × 0.034 mg of $CaCO_3$

$$\text{Hence, } 1000\text{ml of sample water} = \frac{20 \times 0.034}{50} \times 1000$$

= 13.6 mg of $CaCO_3$ eq hardness

1PP = 1mg/L
So, = 13·6 PPm

1PPm = 0·07°Cl
So, 13·6 PPm = 13.6 × 0.07 °Cl
= 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 $CaCO_3$
1ml 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 $CaCO_3$

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

(ii) Determination of hardness
Further, 100 ml of sample water = 40 ml of EDTA solution
$= \frac{40 \times 100}{90}$ mg of $CaCO_3$

$\therefore$ 1000 ml of sample water = $\frac{40 \times 100}{90} \times \frac{1000}{100}$ mg of $CaCO_3$

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

Also, 100 ml of boiled sample water = 20 ml of EDTA solution
$= 20 \times \frac{100}{90}$ mg of $CaCO_3$

$\therefore$ 1000 ml of boiled sample water = $20 \times \frac{100}{90} \times \frac{1000}{100}$ mg of $CaCO_3$

Parmanent hardness = $\frac{2000}{90}$ = 222.22 PPm

Hence,

temporary hardness = 444.44 − 222.22 = 222.22 PPM

Q- 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 = 0.5 g of $CaCO_3$

or 1 ml of standard water = 1 mg 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

$= \frac{20 \times 50}{25}$ mg of $CaCO_3$

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

Total hardness = 400 mg/L

50 ml of boiled water sample = 15 ml of EDTA Solution
$= \frac{15}{50}$ mg of $CaCO_3$

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

Parmanent Hardness = 300 mg/L

Temporary hardness = Total hardness − Parmanent hardness
= 400 − 300
= 100 mg/L

Q - 0.28 g of $CaCO_3$ was dissolved in 1litre 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 this 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 mg of $CaCO_3$
1 ml of EDTA $= \frac{28}{28} = 1$ 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 mg of $CaCO_3$

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

$= 330$ mg $CaCO_3$ eq hardness

Total hardness $= 330$ ppm

100 ml of boiled water $= 10$ ml of EDTA

$= 10 \times 1$

$= 10$ mg of $CaCO_3$ eq. hardness

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

$\therefore$ Parmanent hardness of water $= 100$ ppm

Hence, temporary hardness = Total hardness − parmanent 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 17.0 ml to methyl orange end point. Calculate alkalinity of water sample.

Solve 100 ml water simple on titration with $\frac{N}{50}$ H_2SO_4 requires

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

$\therefore$ $100 \text{ ml} \times N_P = 8.5 \text{ ml} \times \frac{N}{50}$

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

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

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

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

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

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

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

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

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

$$M = N_m \times 50 \times 1000 \text{ ppm}$$

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

Since, $P > \frac{1}{2} M$ Hence, 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 ~~at~~ HCO_3^- alkalinity $= 85$ ppm

Q. 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

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

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

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

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

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

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

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

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

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

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

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