Concentration of solution is generally expressed as

- **Molarity**
- **Normality**
- **Parts per million**

Molarity(M):-Number of gram mole of solute present in one litre of solution.

$$M = \frac{\text{weight of solute in gram per litre of solution}}{\text{Molecular weight of the solute}}$$

$$M = \frac{W \times 1000}{m \times V}$$

Where W=wt.of the solute in gram

m= molar mass of the solute

V= volume of solution in ml

Normality(N):-

Number of gram equivalent of the solute present in one litre of the solution.

Mathematically,

$$N = \frac{\text{No of gram equivalents of solute}}{\text{Volume of solution in litres}}$$

$$= \frac{\text{Weight of solute in grams per litre of solution}}{\text{Equivalent weight of solute}}$$

$$\text{Normality, } N = \frac{W \times 1000}{E \times V\,(ml)}$$

where W = Weight of solute

E = Equivalent weight of the solute

pH of a solution

- Scale of acidity of a solution
- Depends on concentration of hydrogen ion (H+)
- pH scale is a method of expressing hydrogen ion concentration in a solution

Defntion of pH

It is defined as negative logarithm to the base 10 of the concentration of hydrogen ion in a solution.

$$pH = -\log_{10} [H^+]$$

If $[H^+] = [OH^-] \Rightarrow$ the solution is neutral

If $[H^+] > [OH^-] \Rightarrow$ the solution is acidic (H^+ is more than OH^-)

If $[H^+] < [OH^-] \Rightarrow$ the solution is basic (H^+ is less than OH^-)

Q.Is pure water is acidic or basic?

Ans:-pure water is neutral.It contain equal amount of H+ions and OH- ions

Ionic product of water

1. Ionization of water molecules

   $H_2O \rightleftarrows H^+ + OH^-$

2. Equilibrium Constant , $K = \frac{[H^+][OH^-]}{[H_2O]}$

3. Rearranging the equation, $K[H_2O] = [H^+][OH^-]$

4. $[H_2O] \approx 1$ then $Kw = [H^+][OH^-]$

Where Kw is the ionic product of water

$$Kw = [H^+][OH^-]$$

Ionic product of water is the product of concentration of H+ ions and OH- ions in water

$$K_w = [H^+][OH^-]$$

The value of Kw

The ionic product of water at 25°C (298 K) is:

$$Kw = [H^+] \times [OH^-] = 10^{-7}M \times 10^{-7}M$$

$$= 10^{-14}\ M^2 \quad \text{(Where M = moles/litre)}$$

$$A+B \rightleftarrows C+D$$

$$K=\frac{[C][D]}{[A][B]}$$

$$K*1=Kw$$

pH , pOH and pKW

These terms are defined by the equations

$$pH = -\log_{10}[H^+]$$

$$pOH = -\log_{10}[OH^-]$$

$$pKw = -\log_{10} Kw$$

For pure water at 25°C,

$[H^+] = 10^{-7}M$ therefore $p^H = -\log_{10}[H^+] = -\log_{10}10^{-7} = 7$

$[OH^-] = 10^{-7}M$ therefore $p^{OH} = -\log_{10}[OH^-] = -\log_{10}10^{-7} = 7$

$Kw = 10^{-14}\ M^2$ therefore $p^{Kw} = -\log_{10}Kw = -\log_{10}10^{-14} = 14$

on between pH , pOH and pKW

The ionic product of water $Kw = [H^+] \times [OH^-]$.

Taking logarithms to the base 10 on both sides and putting the ve signs,

$$-\log_{10} Kw = -\log_{10} \{[H^+] \times [OH^-]\}$$

$$= -\{\log_{10}[H^+] + \log_{10}[OH^-]\}$$

$$= -\log_{10}[H^+] + -\log_{10}[OH^-], \text{ or}$$

4' $pKw = pH + pOH$

Since Kw is a constant, p^{Kw} is also a constant. At 25°C it is equal to 14 . So whenever pH increases, pOH must decrease and vice versa to keep their sum a constant.

Relation between pH and pKw

p^H	p^{OH}	p^{K_w}
7	7	14
6	8	14
8	6	14
5	9	14
9	5	14
4	10	14
10	4	14
14	0	14
0	14	14

1. Calculate the pH of a solution having hydrogen ion concentration.

   I. **⊏H+⊐= 1M**
   II. **⊏H+⊐=0.001M**
   III. **⊏H+⊐=10^{-8}**
   IV. **⊏H+⊐=10^{-13}**

Determination of pH

pH can be determined by using

a) pH meter
b) pH paper
c) Universal indicator

Application of pH:-

1. To find out acidic ,basic or nuetral nature of a medium.
2. In production of potable water
3. In agriculture
4. In electroplating
5. In digestive system
6. In textile industry
7. In sugar industry
8. In chemical industry
9. In food preservation
0. pH of human blood =7.36 to7.42, a change in pH by 0.2 result in death hence pH is impotant to maintain our health.

Buffer solution

A solution which resist the change in pH on addition of small amount of acid and base in it.

Two types of buffer solution

1.Acidic buffer-a mixture of weak acid and its salt with strong base

eg-Acetic acid and sodium acetate

2. Basic buffer- a mixture of weak base and its salt with strong acid

Eg-ammonium hydroxide and ammonium chloride

Buffer capacity- The capacity of a buffer to resist the change in pH.

$$\text{Buffer capacity } (\beta) = \frac{\text{no.of moles of acid and base added to 1L}}{\text{Change in the pH value}}$$

Application of buffer-

1. To maintain pH of blood
2. In complexometric titration
3. In microbiology

Standard solution-

A solution of known concentration is called standard solution.

Titration;-

The process of adding the solution taken in the burette dropwise to a fixed volume of other solution taken in the conical flask till the endpoint ,is called titration.

End point-

The stage at which the reaction is just completed.

Indicators-

The endpoint is detected with the help of some substance is called indicators. They exhibit a marked colour change at the endpoint.

Acid -base titration

Two type;- **i) Acidimetry-determination of amount of base in a solution by titrating with a standard acid solution.**

ii) Alkalimetry;- determination of amount of acid in a acid solution by titrating against a standard base solution.

pH range of indicators-

orange red to golden yellow.

Indicator	pH Range	Colour	
		Acid Medium	Basic Medium
Phenolphthalene	8.3 - 10	Colourless	Pink
Methyl Orange	3.1 - 4.5	Pink	Yellow
Litmus	4.5 - 8.3	Red	Blue

Choice of indicators in acid -Base titration

- **Titration of strong acid against strong base:-**

  Eg- $HCl/HNO_3/H_2SO_4$ VS NaOH/KOH

  Methyl orange or Phenolphthalein

- **Titration of weak Acid Against Strong Base**

  Eg-Oxalic acid/Acetic acid vs NaOH/KOH

  Phenolphthalein

- **Titration of Strong acid against Weak Base**

  $HCl/HNO_3/H_2SO_4$ vs Na_2CO_3/K_2CO_3

  Methyl orange

- **Titration of Weak acid against weak Base**

  Oxalic acid/Acetic acid vs Na_2CO_3/K_2CO_3

  Titration has no sharp pH change ,none of the indicator cannot be used

Principle of Volumetric analysis;-

N1V1=N2V2

N1=normality of titrant

V1=volume of titrant

N2=normality of titrate

V2=volume of titrate

1. 500ml of a decinormal solution is diluted by adding 300ml of water.what is the normality of resulting solution?

V1=24Ml
N1=?
V2=20ml
N2=0.1N
V1N1=V2N2
Then N1=V2N2/V1
=20*0.1/24
=0.083N
v=400ml
E=49gm
N=0.083N
N=w*1000/E*V
Then w=N*E*V/1000
=0.08*49*400/1000
=1.63gm

w=0.252g
v=200ml
E=45g

N=w*1000/E*V
=0.252*1000/45*200
=0.028N

Calculate the normality of KoH solution containing 1.4g kOH in 700ml?

w=1.4g

V=700ml

E=56gm

N=w1000/EV

=1,4*1000/56*700

=0.0357N

Calculate the pH of o.02M NaOH?

[OH]=0.02M

pOH=-log[OH]

=-log[0.02]

=1.69

pH+pOH=pKw=14

So pH=14-pOH

=14-1.69

=12.30

WATER

Physical properties of water:-

1. Pure water is colourless,odourless and tasteless.
2. It freezes at 0^0c and boils at $100\ ^0$c.
3. Water molecules are polar.
4. Water molecules are V-shaped.
5. Its density is $1g/cm^3$.
6. Pure water is poor conductor of electricity.

SOFT AND HARD WATER

SOFT WATER:-

- Water which produce lather readily with soap solution is called soft water.
- The dissolved impurities such as bicarbonates ,chlorides and sulphates of calcium and magnesium are **not** present in soft water.

HARD WATER

- Does not produce lather with soap.
- It contain impurities like bicarbonates and chlorides, sulphates of calcium and magnesium.

1. **why hard water does not produce lather with soap?**

- **Soap is sodium salt of fatty acids**
- **Soap react with dissolved impurities like bicarbonates or chlorides of calcium and magnesium to form a precipitate .**

Soft water

- Produce lather with soap
- Does not contain dissolved impurities like bicarbonates , chlorides of Ca and Mg
- Does not produce ppt with soap.

Hard water

- Not produce lather with soap
- contain dissolved impurities like bicarbonates , chlorides of Ca and Mg
- produce ppt with soap

Advantages of soft and hard water

Soft water

Soft water is suitable for

1. **Cooking**
2. **Bathing**
3. **Laundry purpose**
4. **Dying textiles**

Hard water

1. **Contain Ca and Mg ions required for health.**
2. **Does not dissolve out lead from lead pipe used in water supply system.**

Disadvatages of soft and hard water

Soft water

1. It dissolves the lead of pipes leading lead poisoing.
2. Does not contain salts of Ca and Mg which required for healthy life.

Hard water

1. Pulses does not cook well
2. Wastage of soap
3. Wastage of fuel in boilers
4. Not suitable for dying and printing , sugar industry etc...

Types of hardness

A) **Temporary hardness**

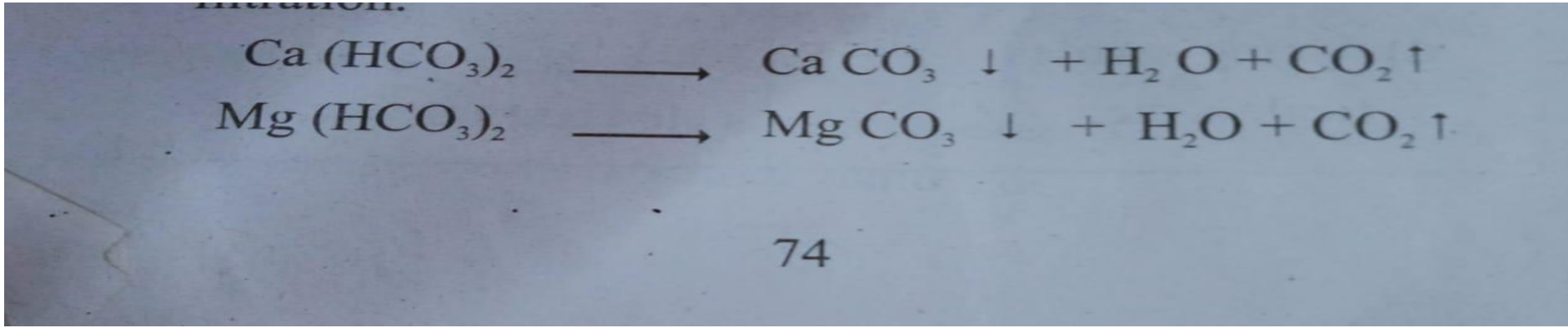
B) Permenant hardness

Temporary hardness:- caused by the presences of dissolved bicarbonates of Ca and Mg.

Methods of removing temporary hardness

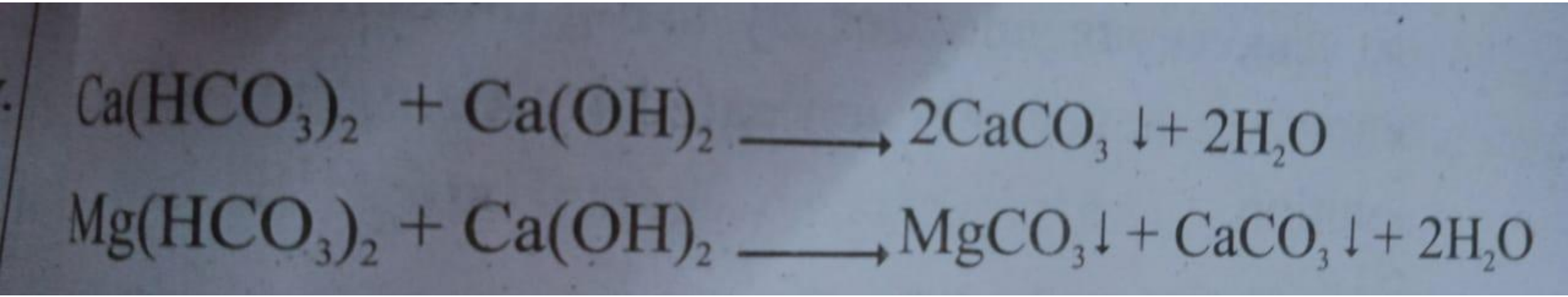
1.Boling:

- ★ By boiling the dissolved bicarbonates decomposed to insoluble carbonates and CO2 gases,
- ★ The precipitated carbonates are removed by filtration.



2) clarke's process

Required quantity of slaked lime $Ca(OH)_2$ is added to water, the ca and Mg ions are precipitated as insoluble carbonates. It can removed by filtration.



PERMANENT HARDNESS OF WATER

Caused by the presence of chlorides or sulphates of calcium and magnesium.

- **It can be removed by ion exchange method**

Ion exchange method

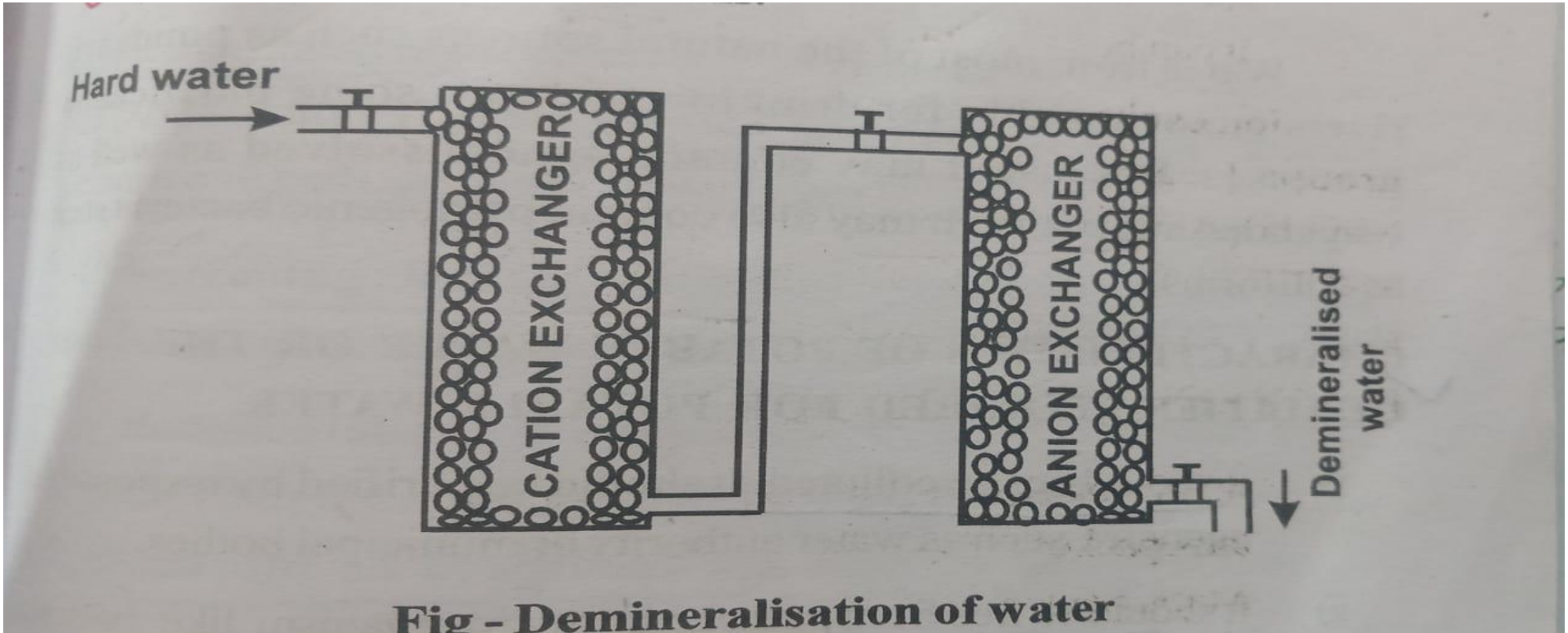


Fig - Demineralisation of water

- **Hard water is first passed through a tank A packed with cation exchange resin, Then passed through tank B packed with anion exchange resins.**

- **Cation exchange resin (E-H) are capable of removing all positive cations like Ca^{2+},Mg^{2+}**

$$2E\text{-}H + \mathbf{Ca^{2+}} \longrightarrow E_2\text{-}Ca + 2H^+$$

$$2E\text{-}H + \mathbf{Mg^{2+}} \longrightarrow E_2\text{-}Mg + 2H^+$$

- This acidic water then passed through tank B contain anion exchange resin (E-OH)to remove all anions like Cl^-,$SO4^{2-}$.

$E\text{-}OH + Cl^- \rightarrow E\text{-}Cl + OH^-$

$E\text{-}OH + SO4^{2-} \rightarrow E_2\text{-}SO4 + 2OH^-$

This method is also called as demineralisation of water

https://www.youtube.com/watch?v=ctlHNf1s6RM

Potable water (drinking water)

Characteristics of potable water;

1. It should not be polluted.
2. It should be free from pathogen
3. It should be clear,odourless and safe to drink.
4. It should not have bad taste.
5. pH should be around 7.
6. It should be reasonably soft.

Treatment process to make potable water.

Q.what are the steps involving for the preparation of potable water for municipal supply?(15 marks)

There are mainly two steps:-

A) Clarification

The removal of coarse,dispersed and colloidal impurities from water, is called clarification.

It have 1)screening
2)sedimentation
3)coagulation
4)filtration

B) **sterilization:-**

The removal of all pathogenic micro organisms is called sterilization.

It can be done by

a) **sterilization by chlorine(chlorination)**
b) **sterilization by bleaching powder.**
c) **sterilization by ozone**.

clarification

1) **screening:-**

The removal of coarse soils , gravels,or slit from water by using bar screens or mesh screens.

2)**sedimentation:-**

Water is allowed to stand undisturbed in big tanks for 6 to 12 hours.this is remove the suspended particles by settling down by the force of gravity.

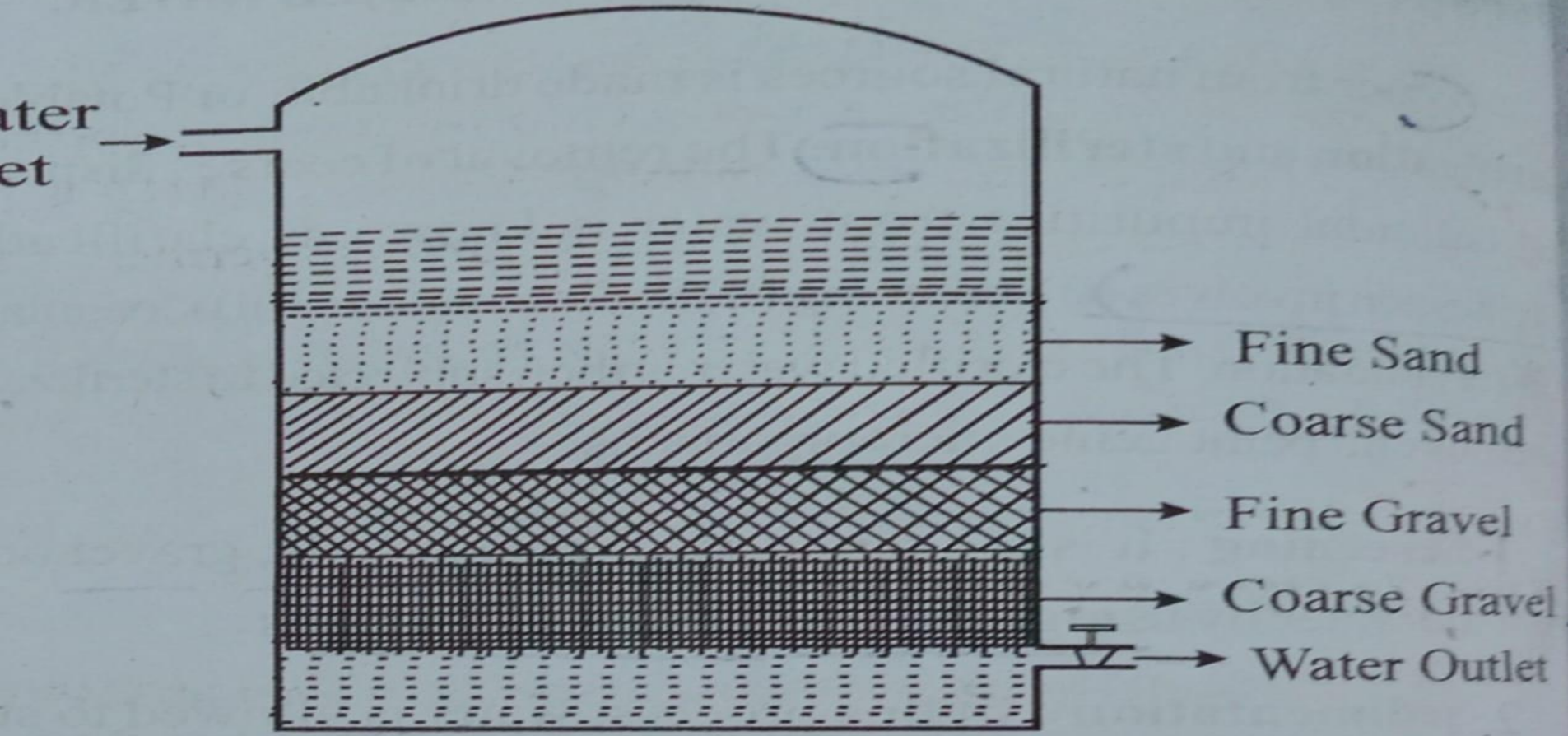
3)**coagulation:-**

This is to remove the unsettled impurities of colloidal nature by forcing them to settle down by adding certain chemicals called coagulants. Ex-alum.

4) Filtration:-

The insoluble impurities are removed from water by means of filters.

- Filtration tank is a rectangular tank made of concrete.
- Thick topper layer sand placed over coarse sand layer and graded gravels
- It provided with an inlet for water and an outlet for clear water at the bottom.
- In pressure filter , the filtering material is kept in closed cylinder and water is forced in to the filter by pressure.
- This make the filtration make fast.



Filtration Tank

Sterilization

a) **sterilization by chlorine(chlorination)**

- Chlorine gas or chlorine water can be used.
- Cl reacts with water to water to form hypochlorous acid(HOCl).
- It dissociate to give nascent oxygen which destroys all germs.

- $Cl_2 + H_2O \longrightarrow HOCl + HCl$
- $HOCl \longrightarrow HCl + (o)$

2)sterilization by bleaching powder.

- l gm of bleaching powder ($CaOCl_2$) added to 1000L of water
- Hypochlorous acid(HOCl) and nascent oxygen produced which kill all the germs.

- $CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + Cl_2$
- $Cl2 + H_2O \longrightarrow HOCl + HCl$
- $HOCl \longrightarrow HCl + (o)$

3)**sterilization by ozone**.

Ozone gas (O_3) passed through water , nascent oxygen is generated . It kill all the germs.

$$O_3 \rightarrow O_2 + (o)$$

FLOW CHART

Production of potable water for municipal supply