WATER

Q1) What are the different types of Impurities in water?

Ans: The impurities present in water are classified  
as:  
1). Dissolved impurities: dissolved impurities may organic or inorganic.  
Inorganic impurities: the carbonates, bicarbonates, sulphates, chlorides of calcium,  
magnesium, iron potassium and aluminium.  
Organic impurities: Organic water products, amino acids, proteins, etc. Gases: O2, CO2,  
Oxides of nitrogen and sulphur, H2S etc

2). Suspended impurities: It is of two types:  
1. Inorganic- sand & clay;  
2. Organic- vegetable and animal matter.

3) Biological Impurities: Micro-organisms like pathogenic bacteria, fungi, algae, etc.  
  
Q2) What is hardness of water?

Ans: The hardness of water refers to the presence of dissolved salts such as bicarbonates, sulphates, chlorides, and nitrates of bivalent metal ions like Ca+2 and Mg+2.

Hard water is the water that does not produce lather or produces very little lather with soap, while soft water readily produces a lot of lather when mixed with little soap.

Q3) What are different types of Hardness? Explain.

Ans: TYPES OF HARDNESS  
The hardness of water is of two types-  
(1) Temporary hardness (or) Carbonate hardness  
(2) Permanent hardness (or) Non-Carbonate  
hardness

(1) Temporary Hardness: Temporary hardness is caused by two dissolved bicarbonate salts  
Ca(HCO3)2 and Mg(HCO3)2. The hardness is called “Temporary Hardness” because it can be removed easily by means of boiling.  
  
Ca(HCO3)2 + Heating → CaCO3↓ + H2O + CO2↑  
Mg(HCO3)2 + Heating → Mg(OH)2↓ + 2CO2↑

(2) Permanent Hardness: Permanent hardness of water is due to the dissolved chlorides,  
sulphates and nitrates of calcium and magnesium. These salts are CaCl2, CaSO4, Ca(NO3)2, MgCl2, MgSO4, Mg(NO3)2. These hardness cannot be removed easily by boiling. Hence it is called “Permanent Hardness”. Only chemical treatment can remove this hardness.  
  
   
Total Hardness Of Water = Temporary Hardness + Permanent Hardness

Q4) What are the disadvantages of Hard Water?

Ans: The following are the disadvantages when hard  
water is used for various purpose:  
(i) DOMESTIC USE:  
(a) Washing and Bathing: Hard water does not form lather easily with soap, so soap is wasted.

(b) Drinking: Hard water causes bad effects on our digestive system. Sometimes, stone formation takes place in kidneys.

(c) Cooking: The boiling point of water is increased due to the presence of salts. Hence, more fuel and time are required for cooking.

(ii) INDUSTRIAL USE:  
(a) Textile Industry: Hard water causes wastage of soap. Precipitates of calcium and magnesium soap adhere to the fabrics and cause problem such difference in colour shades, dull shades, patches, etc.

(b) Paper Industry: Calcium and Magnesium salts in water may affect the quality of paper.

(c) Sugar Industry: Water containing sulphates, carbonates, nitrates affects the crystallisation of sugar.

(d) Pharmaceutical Industry: Hard water may form some undesirable products while preparation of pharmaceutical products.

Overall, the disadvantages of hard water can lead to increased costs, reduced efficiency, and negative health effects.

Q5) How is Hardness of Water measured?

Q6) What are The Units of Hardness?

Ans: The 5 different units in which the hardness of water is expressed as given below-

(1) Parts per million (PPM): PPM is the number of parts of CaCO3 equivalent hardness per 106 parts of water.

i.e., 1 PPM = 1 part of CaCO3 equivalent hardness in 106 parts of water.

(2) Milli grams Per Litre (mg/litre): mg/L is the number of milligrams of CaCO3 equivalent hardness present per litre of water.  
i.e., 1 mg/L = 1 mg of CaCO3 equivalent hardness in 1L of water.  
But 1 L water weighs = 1 kg of water  
1 kg = 1000 gms = 1000 x 1000 mg = 106 mg  
∴ 1 mg/L = 1mg of CaCO3 equivalent per 106 mg of water  
= 1 part of CaCO3 equivalent per 106 parts of water  
∴ 1 mg/L = 1 ppm

(3) Degree Of Clarke (oCl): It is number of grains (1/7000 lb) of CaCO3 equivalent hardness per gallon (10 lb) of water.

(or)

It is defined as the number of parts of CaCO3 equivalent hardness per 70,000 parts of water.  
∴ 1 oCl = 1 grain of CaCO3 eq. hardness per gallon of water.

(or)

1 oCl = 1 part of CaCO3 eq. hardness per 70,000 parts of water  
∴ 1 ppm = 0.07 oCl

(4) Degree Of French (oFr): It is the number of parts of CaCO3 equivalent hardness per 105 parts of water.  
1 oFr = 1 part of CaCO3 equivalent hardness per 105 parts of water  
∴ 0.1 oFr = 1 ppm  
Note: The hardness of water can be converted into all the four units by making use of the following interconversion formula-

1 ppm = 1mg/L = 0.07oCl = 0.1oFr  
1 oCl = 1.43oFr = 14.3 ppm = 14.3 mg/L

(5) Milliequivalent per Litre (meq/L): It is the number of milliequivalent of hardness present per litre of water.  
1 meq/L= 1 meq of CaCO3 per litre of water = 10-3 x 50 g of CaCO3 eq. of hardness per litre of water = 50 mg of CaCO3 eq. of hardness per litre of water  
= 50 mg/L of CaCO3 eq.  
= 50 ppm  
∴1 meq/L= 50 ppm

Q7) How is hardness of water determined using EDTA Method?

Ans: DETERMINATION OF HARDNESS OF WATER BY EDTA method :-  
1. This is a Complexometric titration method where Ethylenediamine tetra acetic acid (EDTA) is used.  
2. EDTA forms complexes with different metal ions at different pH.  
3. Calcium & Magnesium ions form complexes with EDTA at pH 9 - 10. To maintain the pH 9 - 10 NH4Cl, NH4OH buffer solution is used.

4. The disodium salt of EDTA is used for complexation.  
5. An alcoholic solution of Eriochrome Black-T (EBT) is used as an indicator.

Q8) What is EDTA? What are the steps involved in determination of hardness of water by EDTA Method?

OR

Q9) Explain the calculations involved in the determination of hardness of water by EDTA Method.

Ans: The hardness of water is determined using the EDTA method through a complexometric titration. The steps involved in this method are:

1. Take a water sample of known volume and add a buffer solution to maintain the pH at 9 - 10.

2. Add a few drops of indicator solution, such as Eriochrome Black T, to the water sample. The indicator forms a complex with the metal ions in the water and changes colour depending on the concentration of metal ions.

3. Titrate the water sample with a standard solution of EDTA until the colour of the indicator changes from wine red to blue. The EDTA forms a complex with the metal ions in the water, which removes them from the solution.

4. Note the volume of EDTA solution required to reach the endpoint of the titration.

5. Repeat the titration with a blank water sample to determine the amount of EDTA required to neutralize the indicator and buffer solution.

6. Calculate the hardness of the water sample using the formula:

Hardness (in mg/L or PPM) = (Volume of EDTA solution used x Normality of EDTA solution x 1000) / Volume of water sample

The hardness of water is expressed in terms of CaCO3 equivalent hardness, which is the amount of CaCO3 required to produce the same effect as the metal ions in the water.

Q10) What are the advantages of EDTA method?

Ans: The advantages of the EDTA method for determining the hardness of water are:

1. High accuracy: The EDTA method is highly accurate and precise, and it can detect even small amounts of metal ions in the water.

2. Wide applicability: The EDTA method can be used to determine the hardness of water containing a wide range of metal ions, including calcium, magnesium, iron, and zinc.

3. Simple procedure: The EDTA method is relatively simple and straightforward, and it does not require any specialized equipment or complex procedures.

4. Fast results: The EDTA method provides fast and reliable results, and it can be used to analyze a large number of water samples in a short period of time.

5. Low cost: The EDTA method is relatively inexpensive, and the reagents and equipment required for the analysis are readily available and affordable.

Q11) What is Softening of Water? Explain Lime-Soda method of Softening of Water.

Ans: The removal of hardness causing salts from water is called “Softening of water”.

Lime-Soda Process:

This process is based on converting the soluble calcium and magnesium salts into Insoluble calcium carbonate and magnesium hydroxide precipitates by addition of calculated amount of lime (Ca(OH)2) and Soda (Na2CO3). The precipitate is removed by filtration. Any free dissolved CO2 and acids are also removed by this process.

Q12) What are different types of Lime-Soda Process?

Ans:

Cold Lime-Soda Process: In this method the lime & soda are mixed with hard water at room temperature with constant stirring.  
• Generally the precipitates formed by this process are finely divided and in order to settle the precipitates, coagulants like alum, ferrous sulphate, etc. are added.  
• The hard water to be softened is mixed with calculated quantity of chemicals (Lime + Soda + Coagulant) from the top into the inner chamber on vigorous stirring. The chemical reactions takes place and the hardness producing salts get converted into insoluble precipitates.  
• The sludge is removed from the bottom of the outer chamber while the softened water passes through a wood fibre filter to ensure the complete removal of any residual sludge particles.  
• The clear softened water is withdrawn from the top of the outer chamber.  
• The softened water from this process contains a residual hardness of 50-60ppm

Hot Lime-Soda Process:

• This process is similar to the cold lime-soda process, but no coagulant is needed.

• Here the process is carried at a temperature of 80o to 150oC. Since the reaction carried out at high temperature.  
(a) The reaction takes place faster  
(b) The sludge settles rapidly  
(c) Viscosity of soft water is lower, hence filtered easily  
(d) The dissolved gases such as CO2, air, etc. driven out of the water  
(e) The residual hardness is low, compared to cold lime- soda process.  
Hot lime soda process consists of three parts-  
• “REACTION TANK” in which complete mixing of water, chemicals and steam takes place and water gets softened.  
• “Conical Sedimentation Vessel” where the sludge settle down.  
• “SAND FILTER” where sludge is completely removed.

The softened water from this process contains a residual hardness of 15-30 ppm

Q13) What are the advantages and disadvantages of Lime-Soda Process?

Ans:

ADVANTAGES OF LIME-SODA PROCESS:  
I. This process is economical.  
II. Mineral content of the water is reduced.  
III. The process increases the pH value of water, which reduces the content of pathogenic bacteria.  
IV. Manganese and Iron salts are also removed by this process.  
V. The process improves the corrosion resistance of the water.

DISADVANTAGES OF LIME-SODA PROCESS:  
1) Due to residual hardness, water is not useful for high pressure boilers.  
2) Large amount of sludge is formed which create disposal problem.

Q14) Explain Zeolite Process for softening of water.

Ans: Zeolite is “Hydrated sodium alumino silicate”. Its general formula is: Na2O.Al2O3.xSiO2.yH2O; x= 2 - 10 y= 2 - 6.

Eg: Natrolite: Na2O.Al2O3.3SiO2.2H2O. Natural zeolites are generally non-porous.

The artificial zeolite is called Permutit. These are prepared by heating together with chain clay, feldspar and soda ash. These are porous and have greater softening capacity than natural zeolite.

Working:  
They exchange Na+ ions with the hardness, producing ions (Ca2+, Mg2+, etc.) in water.  
Sodium Zeolite is denoted as Na2Ze.

PROCESS: In this process hard water is passed through a bed of zeolite at ordinary temperature. The hard water percolates (filtered), Ca+2, Mg2+ present in hard water are exchanged with Na+ ions. The following reactions taking place:  
MgCl2 + Na2Ze ◊ MgZe + 2NaCl  
MgSO4 + Na2Ze ◊ MgZe + Na2SO4  
CaCl2 + Na2Ze ◊ CaZe + 2NaCl

CaSO4 + Na2Ze ◊ CaZe + Na2SO4  
Mg(HCO3)2 + Na2Ze ◊ MgZe + 2NaHCO3  
Ca(HCO3)2 + Na2Ze ◊ CaZe + 2NaHCO3

Regeneration Of Zeolite: On continuous passing of hard water through sodium zeolite bed it is converted to calcium and magnesium zeolite which is known as ‘Exhausted Bed’. Hence, it must be regenerated. This can be done by washing zeolite bed with 10% sodium chloride solution.  
CaZe + 2NaCl ◊ Na2Ze + CaCl2  
MgZe + 2NaCl ◊ Na2Ze + MgCl2

Q15) What are the limitations of Zeolite Process?

Ans: Limitations of Zeolite :-

1. If the supply of water is turbid, the suspended matter must be removed before the water is admitted to the zeolite bed. Otherwise the turbidity will clog the pores of zeolite bed thereby making it inactive.
2. water contain large quantities of coloured ions such as Mn2+ and Fe2+ , they must be removed first because these ions produce manganese and iron zeolites, which cannot be easily regenerated.
3. Mineral acids, if present in water destroy the zeolite bed and therefore they must be neutralised with soda before admitting the water to the zeolite softening plant.

Q16) What are the advantages and disadvantages of Zeolite process?

Ans:

ADVANTAGES:

1) The equipment is small and easy to handle.

2) It requires less time for softening.

3) Water obtained from this process contains a residual hardness upto 10 ppm.

4) Easy to regenerate.

5) No sludge is formed in this process.

DISADVANTAGES:

1) Highly turbid water cannot be treated by this process.

2) The process exchanges only Ca+2 & Mg2+ ions by sodium ions and hence the softened water contains more sodium salts.

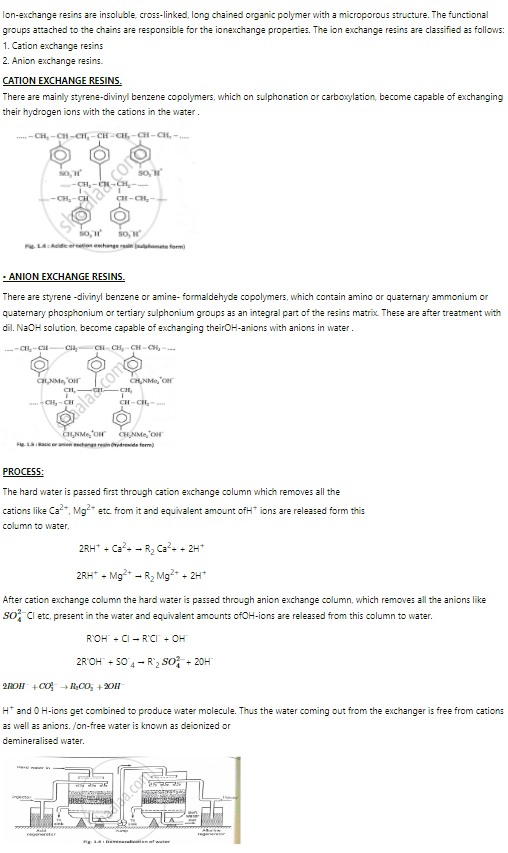
3) All the acidic ions like HCO3- , CO32-, etc. are not removed by this process.

4) Sodium bicarbonate decomposes in the boiler releasing CO2 which leads to corrosion.

5) While Na2CO3 is hydrolysed to NaOH which creates caustic embrittlement of boiler.

Q17) Explain Ion-Exchange process. What is ion-exchange resins? How are they classified?

Ans:



REGENERATION OF RESINS:

The resin bed gets exhausted, when used for a long period and can be regenerated:

(a) The exhausted cation exchange resin can be regenerated by passing dil. HCl (H+)

R2Mg2+ + 2H+  2RH+ + Mg2+

R2Ca2+ + 2H+  2RH+ + Ca2+

(b) The exhausted anion exchange resin can be regenerated by passing dil. NaOH (OH-)

RCl + OH-  ROH + Cl-

R2SO4 + 2OH-  2ROH + SO42-

Q22) Advantages and Disadvantages of Ion-Exchange process?

Ans:

ADVANTAGES:  
1) The softened water by this method is completely free from all salts and fit for use in boilers.  
2) It produces very low hardness nearly 2 ppm.  
3) Highly acidic or alkaline water can be treated by this process.  
DISADVANTAGES:  
1) The equipment is costly.  
2) More expensive chemicals are required for regeneration.  
3) Turbid water cannot be treated by this method.

Q23) What is Mixed-bed deionizer?

Ans: Mixed Bed Deionizer  
It is actually a single cylinder containing and intimate mixture of cation exchanger and strongly basic anion exchanger. Hence, water while passing through the column comes in contact with the two exchangers for a large number of times and the hardness is reduced to a very low level (1 ppm). Thus, it is actually equivalent to a series of cation and anion exchangers

Q24) What are the requirements of drinking water?

Ans:

1. The water should be clear, colourless, and odourless.

2. The water must be free from pathogenic bacteria and dissolved gases like H2S.

3. The optimum hardness of water must be 125 ppm, and the pH must be 7.0 to 8.5.

4. The turbidity in drinking water should not exceed 25 ppm.

5. The recommended maximum concentration of total dissolved solids in potable water must not exceed 500 ppm.

Q25) How is water for domestic use purified?

Ans:

1. Screening: The first stage in the treatment of water for domestic use is screening, where large debris, such as leaves, twigs, and other large particles, are removed from the water by passing it through screens.

2. Coagulation and Flocculation: The next stage is coagulation and flocculation, where chemicals, such as alum, are added to the water to form flocs, which attract and trap suspended impurities and colloidal particles.

3. Sedimentation: The water is then allowed to settle in a sedimentation tank, where the flocs settle to the bottom of the tank, and the clear water is removed from the top.

4. Filtration: The water is then passed through a sand filter to remove any remaining suspended impurities and colloidal particles.

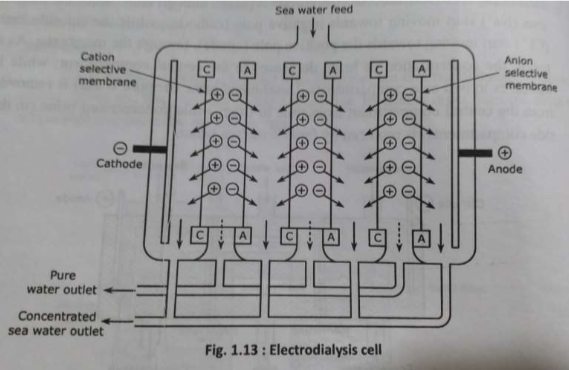
5. Disinfection: The final stage in the treatment of water for domestic use is disinfection, where the water is treated with a disinfectant, such as chlorine, to kill any harmful pathogenic bacteria that may be present in the water.

Q30) What is Desalination of Brackish Water?

Ans: Water containing high concentrations of dissolved solids with a peculiar salty or brackish  
taste is called ‘brackish water’. Sea water is an example of brackish water containing about 3.5% of dissolved salts. This water cannot be used for domestic and industrial applications unless the dissolved salts are removed by desalination.  
Commonly used methods are: 1) Electrodialysis 2) Reverse Osmosis

Q31) Explain Electrodialysis.

Ans: Electrodialysis is based on the principle that the ions present in saline water migrate towards their respective electrodes through ion selective membranes under the influence of applied e.m.f.  
The unit consists of a chamber with two electrodes, the cathode and anode. The chamber is divided to 3-compartments with the help of thin, rigid, ion-selective membranes which are permeable to either cation or anion. The anode is placed near anion selective membrane while the cathode placed near cation selective membrane. The anion selective membrane is containing positively charged functional groups such as R4N+ and is permeable to anions only. The cation selective membrane consists of negatively charged functional groups such as RSO3- and is permeable to cations only Under the influence of applied e.m.f. across the electrodes the cations move towards cathode through the membrane and the anions move towards anode through the membrane. The net result is depletion of ions in the central compartment, while it increases in the cathodic and anodic compartments. Desalinated water is periodically drawn from the central compartment while concentrated brackish water is replaced with fresh sample.



Q32) Explain Reverse Osmosis:

Ans: When two solutions of unequal concentration are separated by a semi-permeable membrane which does not permit the passage of dissolved solute particles, i.e., molecules and ions, flow of solvent takes place from the dilute solution to concentrated solution this is called as “OSMOSIS”.  
If a hydrostatic pressure in excess of osmotic pressure is applied on the concentrated side the solvent is forced to move from higher concentration to lower concentrated side across. Thus, solvent flow is reversed hence this method is called “Reverse Osmosis”  
Thus, in reverse osmosis pure water is separated from the contaminated water. This membrane filtration is also called “Super Filtration” or “Hyper-Filtration”.

METHOD OF PURIFICATION:  
The reverse osmosis cell consists of a chamber fitted with a semi- permeable membrane, above which sea water/ impure water is taken and a pressure of 15 to 40 kg/cm2 is applied on the sea water/ impure water. The pure water is forced through the semi permeable membrane which is made of very thin films of cellulose acetate. However superior membrane made of Polymethacrylate and Polyamide polymers have come to use.

Q33) What is BOD and COD?

Ans: BOD stands for Biochemical Oxygen Demand, which is a measure of the amount of oxygen required by microorganisms to break down organic matter in water. BOD is used to determine the level of biodegradable organic pollutants in water, such as sewage and other organic waste. The BOD test involves measuring the amount of oxygen consumed by microorganisms over a period of five days.

COD stands for Chemical Oxygen Demand, which is a measure of the amount of oxygen required to oxidize both biodegradable and non-biodegradable organic pollutants in water. COD is used to determine the level of both biodegradable and non-biodegradable organic pollutants in water, such as industrial waste and other chemicals. The COD test involves measuring the amount of oxygen required to oxidize the organic matter in water using a strong oxidizing agent.

Q34) What is difference between BOD and COD?

Ans:

