

# Chapter 15

## Environmental Chemistry II:

# WATER

**Question No. 1:** Write down the significance of water.

**Answer:**

### Significance of Water:

Throughout history, importance and significance of water has been recognized by mankind. Its importance is because of two reasons. Firstly, it is an essential and major component of each and every living cell. For example, human body consists of about 70% water. Secondly, it provides an environment for animals and plants that live in water. So, all living organisms owe their life because of water.

### Use in Daily Life:

We use water in daily life for drinking, cooking and washing purposes.

### Quality of Water:

Quality of drinking water has remained a major factor in determining human health and welfare since ages. Since World War II, there has been a rapid production and use of synthetic chemicals. Many of these chemicals (fertilizers and pesticides run off from agriculture and industrial lands discharge from industrial units) have polluted water supplies.

Besides this, there is also a threat to ground water from waste chemical dumps and landfills.

### Water Borne Diseases:

Currently, water borne toxic chemicals pose the greatest threat to the supplies of water especially in urban areas. Use of this water is causing water borne diseases. So use of polluted water is a concern of every citizen.

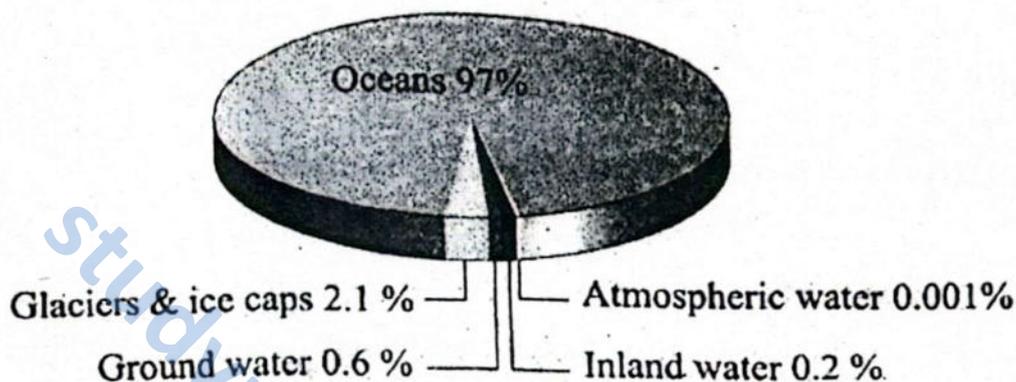


**Question No. 2:** Describe the occurrence of water.

**Answer:**

### Occurrence of Water:

The oceans contain about 97% of world water. The rest of the water is in the form of glaciers, ice caps, ground water and inland water (river, lakes, streams) and soil moisture. It is also present in atmosphere in the form of water vapours.



Distribution of water

Sea water is unfit for drinking and agricultural purposes due to high percentage of dissolved salts.

Only 0.2% of the total water on the Earth is potable, i.e., fit for drinking purposes.

**Question No. 3:** Write a note on properties of water.

**Answer:**

### Properties of Water:

Water is composed of two elements; oxygen and hydrogen. One atom of oxygen combines with two atoms of hydrogen to form one molecule of water.

Pure water is clear, colourless, odourless and tasteless liquid with following properties:

#### Effect on Litmus:

It is neutral to litmus.

#### Freezing & Boiling Points:

Its freezing point is  $0^{\circ}\text{C}$  and boiling point is  $100^{\circ}\text{C}$  at sea level.

**Density:**

Its maximum density is  $1 \text{ g.cm}^{-3}$  at  $4^\circ\text{C}$ .

**Excellent Solvent:**

It is excellent solvent for ionic as well as molecular compounds.

**Heat Capacity:**

It has unusually high that of heat capacity about  $4.2 \text{ Jg}^{-1}\text{K}^{-1}$ , which is about six times greater than that of rocks. This specific property of water is responsible for keeping the Earth's temperature within limits. Otherwise, day time temperature would have been too high to bear and night time temperature would have been too low to freeze everything.

**Capillary Action:**

It has high surface tension. This unique property of water is responsible for its high capillary action.

“Capillary action is the process by which water rises up from the roots of plants to leaves. This process is vital for the survival of land plants.”

**Question No. 4:** Which two unique properties of water make it a universal solvent?

**Answer:****Water as Universal Solvent:**

Water is the universal solvent because it can dissolve almost all the minerals.

Its ability to dissolve substances is because of two unique properties of water.

- (i) Polarity of water molecule.
- (ii) Exceptional hydrogen bonding ability.

**(i) Polarity Nature of Water:**

Water molecule has a “Polar structure” i.e., one end of the molecule is partially positive while the other end is partially negative because of electronegativity difference between oxygen and hydrogen atoms.

**Solubility of Polar Substances:**

All other polar substances are soluble in water, because of positive  $\text{H}^{\delta+}$  end of the substance is attracted by the negative end ( $\text{O}^{\delta-}$ ) of the water and negative end of the substance is attracted by the positive end ( $\text{H}^{\delta+}$ ) of the water.



The electrostatic attraction among the ions are overcome by the "ion-dipole forces" of attraction between ion and water molecules. In this way, positive and negative ions of the compounds are pulled apart as shown in fig.

Ultimately, these oppositely charged ions are surrounded by water molecules, thus separated and kept in solution. For example, most of the salts like  $\text{NaCl}$ ,  $\text{KCl}$ ,  $\text{Na}_2\text{SO}_4$  are soluble in water.

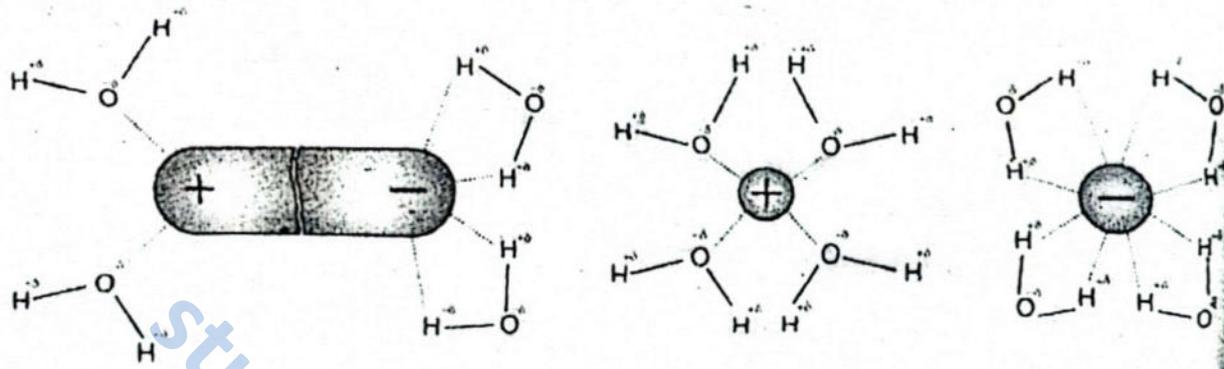


Fig: Dissolving Process of a Polar Substance in Water

### Non-Polar Compounds:

On the other hand, many covalent substances like benzene, ether, octane etc., which do not have polar ends or bonds are not attracted by water molecules. Therefore, non-polar compounds do not dissolve in water.

### (ii) Hydrogen Bonding Ability:

Water molecule is composed of oxygen and hydrogen atoms. Oxygen is bonded with two hydrogen atoms by sharing electrons in two single covalent bonds. Water molecule attains an "Angular Structure" due to two lone pairs of electrons of oxygen atom as shown in the fig.

Because of two O-H bonds and two lone pairs, one  $\text{H}_2\text{O}$  molecule can form hydrogen bonding with four other  $\text{H}_2\text{O}$  molecules, which are arranged tetrahedrally around the  $\text{H}_2\text{O}$  molecule as shown in the fig.

This unique behaviour of water enables it to dissolve many polar non-ionic compounds having hydroxyl group ( $-\text{OH}$ ), like alcohols, organic acids, glucose, sugar etc. by forming hydrogen bonds with them.

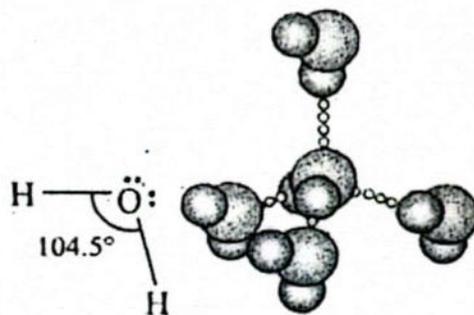


Fig: Hydrogen bonding of water molecule

### Interesting Information:

Besides dissolving solids and liquids, water can also dissolve all gases to some extent. **Ionizable gases** are those which react with water e.g., ammonia, hydrogen chloride and nitrogen dioxide are highly soluble in water. **Less ionizable gases** like sulphur dioxide, carbon dioxide and chlorine are fairly soluble in water. Water can even dissolve non-polar (un-ionizable) gases like oxygen, hydrogen, nitrogen etc. through “**Dipole induced dipole forces**”.

**Question No. 5:** Define soft and hard water. Also describe the causes and types of hardness in water.

**Answer:**

### Soft & Hard Water

#### Soft Water:

**Definition:** “Soft water is that which produces good lather with soap.”

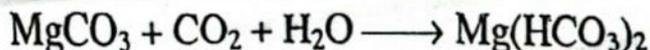
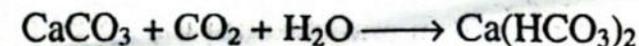
#### Hard Water:

**Definition:** “Hard water is that which does not produce lather with soap.”

#### Causes of Hardness in Water:

The rain water while coming down absorbs carbon dioxide from the atmosphere. The water mixed with carbon dioxide, when passes through the beds of the soil, converts insoluble carbonates of calcium and magnesium into soluble bicarbonates. It may also dissolve chlorides and sulphates of calcium and magnesium.

These salts make the water hard.



Thus, rain water dissolves many salts of divalent cations like  $Mg^{+2}$ ,  $Ca^{+2}$  and anions like  $Cl^{-1}$ ,  $SO_4^{-2}$ ,  $HCO_3^{-1}$  and  $CO_3^{-2}$ . For example, gypsum ( $CaSO_4 \cdot 2H_2O$ ) and lime stone ( $CaCO_3$ ). These salts make the water hard.

### Types of Hardness of Water:

Hardness is of two types:

- (i) Temporary Hardness
- (ii) Permanent Hardness

#### (i) Temporary Hardness:

Temporary hardness is because of presence of bicarbonates of calcium and magnesium.

#### (ii) Permanent Hardness:

Permanent hardness is because of presence of sulphates and chlorides of calcium and magnesium.

**Question No. 6:** Write a note on methods of removing hardness.

**Answer:**

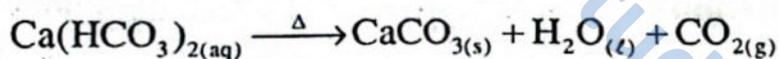
#### Methods of Removing Hardness:

The removal of  $Mg^{+2}$  and  $Ca^{+2}$  ions which are responsible for the hardness is called "water softening".

#### (i) Removal of Temporary Hardness:

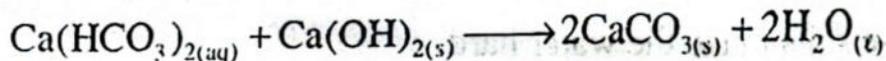
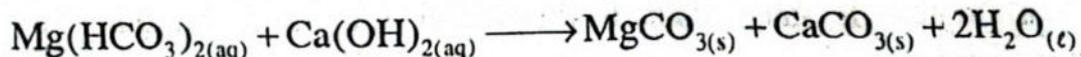
##### (a) By Boiling:

Temporary hardness of water is easily removed by boiling water. On boiling calcium bicarbonate  $Ca(HCO_3)_2$  decomposes to produce insoluble calcium carbonate, which precipitates out of the solutions.



##### (b) Clark's Method:

A chemical method to remove temporary hardness is by the addition of slaked lime ( $Ca(OH)_2$ ). A calculated amount of slaked lime is added to temporary hard water.



Thus, once the magnesium and calcium ions precipitate out water becomes soft.



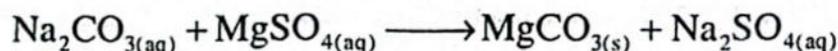
## (ii) Removal of Permanent Hardness:

Permanent hardness can only be removed by using chemicals.

These are two methods to remove permanent hardness of water.

### (a) By Using Washing Soda:

The addition of washing soda removes the calcium and magnesium ions as the insoluble calcium and magnesium carbonates respectively.



### (b) By Using Sodium Zeolite: (An ion exchanger)

Sodium zeolite is a naturally occurring resin of sodium aluminium silicate  $\text{NaAl}(\text{SiO}_3)_2$  which can also be prepared artificially. It is used for softening of water at domestic as well as on industrial scale. When water is passed through resin sodium ions of the resin are exchanged with the unwanted calcium and magnesium ions of the hard water as shown in the figure.

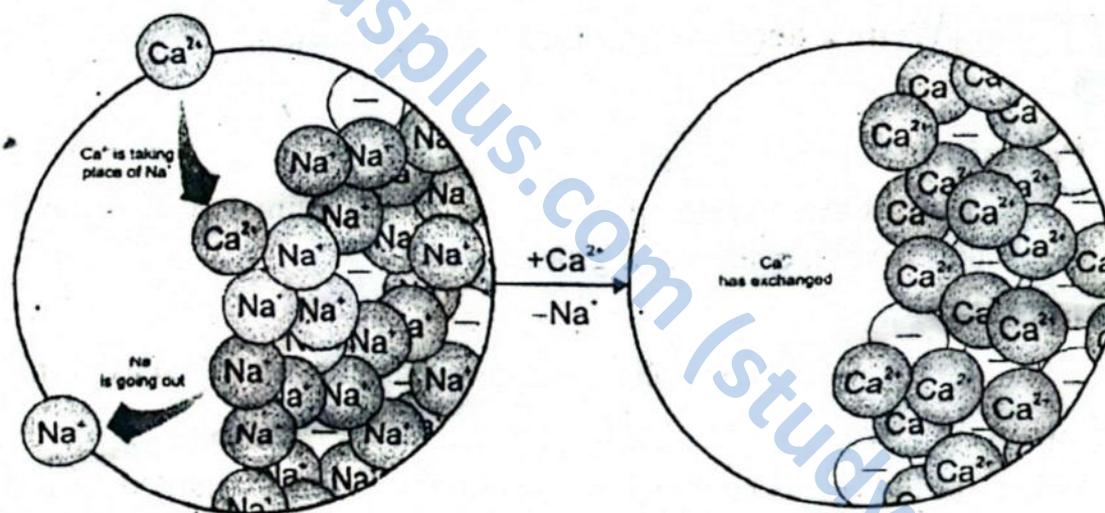
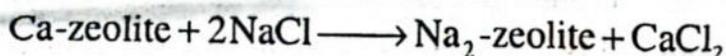


Fig: Ion exchange for removal of hard water ions

When resin is fully used up it can be regenerated by flushing it with concentrated solution of NaCl. The reverse process takes place because of high concentration of sodium ions.



**Question No. 7:** Write disadvantages of hard water.

**Answer:**

**Disadvantages of Hard Water:**

The disadvantages of hard water are given as follows:

**(i) Consumption of Soap:**

Hard water consumes large amount of soap with washing purposes.

**(ii) Stomach Disorder:**

Drinking hard water causes stomach disorders.

**(iii) Unfit for Industrial Use:**

Hard water is unfit for use in steam engines, boilers and turbines because insoluble calcium and magnesium salts are deposited inside. They are bad conductors of electricity and hence more fuel is used.

Insoluble calcium and magnesium sulphates not only reduce the efficiency of engine but also cause the boiler to burst.

This hard deposited layer of calcium and magnesium salts is called as "Boiler Scale".

**Question No. 8:** Write a detail account on water pollution.

**Answer:**

**Water Pollution:**

**Definition:** "Water pollution is a contamination of water bodies (e.g., lakes, rivers, oceans and ground water).

**Pollutants:**

**Definition:** "The pollution causing agents are called as pollutants."

**Explanation:**

Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.

**Industrial Effluents:**

Industrial units are installed to produce the desired substances (cloth, leather goods, paper) on commercial scale to meet the needs of society.

But unfortunately all the industrial units discharge their wastes (chemicals and solid wastes) either to open ground or to water channels. This is called "Industrial effluents".



The industrial effluent may be highly toxic organic chemicals, inorganic salts, heavy metals, mineral acids, oil and greases etc. on the other hand, water used as cleaning agent in industries is directly discharged out. This water contains all kinds of toxic chemicals and detergents.

When these effluents or used water enter lakes, streams, rivers or oceans, they either get dissolved or float suspended in water. Even they get deposited on the bed.

### Results:

This results in the pollution of water i.e.,

- They deteriorate the quality of water.
- They reduce the quantity of dissolved oxygen, ultimately affects aquatic life and ecosystem.
- They can also seep down and affect the ground water deposits. They contaminate the water deposits. When this water is used by human beings it causes serious diseases like cancer and gastro. This polluted water damages soil, crops, plants and animals.
- Heavy metals like cadmium, lead and mercury and toxic and health hazards for human beings. "Acute cadmium poisoning causes" high blood pressure, kidney damage and destruction of red blood cells. "Acute lead poisoning" causes dysfunction of kidney, liver, brain, central nervous system and reproductive system.  
"Mercury poisoning" causes neurological damage.

### Domestic Effluents:

Use of **detergents** is increasing day by day for cleaning purposes in houses and industries. It is because, detergents have strong cleaning action than that of soap even in hard water. They can work even in acidic solutions. But they have a major disadvantage over the soap, as some of the detergents are non-biodegradable (cannot be decomposed by micro-organisms like bacteria). When house hold water containing these detergents is discharged in streams, ponds, lakes and rivers, it causes water pollution.

The detergent remains in the water for a long time and makes the water unfit for aquatic life. The phosphate salts present in detergents cause rapid growth of algae in water bodies, which floats over the surface of water. These plants ultimately die and decay. Decaying plants being bio-degradable consume  $O_2$  present in water. Thus, depletion of  $O_2$  results in death of aquatic life.



Domestic sewage contains a wide variety of dissolved and suspended impurities. They include food and vegetable waste, garbage, cans, bottles, chemical soaps, washing powder etc.

### **Agricultural Effluents:**

Water pollution due to agricultural waste is because of use of fertilizer and pesticides. Fertilizers are used to make up the deficiency of nitrogen, phosphorous etc. of the soil because of intensive cultivation of crops in the recent years.

On the other hand, pesticides are used either directly to kill or control the growth of pests. Pests may be weeds, herbs, insects, fungi, viruses etc. They all damage crops and transmit diseases both to human beings and animals.

### **Dual Effects:**

Agricultural effluents have dual effects:

- (i) Intensive cultivation of crops causes these chemicals from fertilizer and pesticides to seep into the ground water commonly called leaching process. The high nitrate contents in ground water is mainly because of irrigation run-off from agricultural fields.
- (ii) Run-off from the agricultural land (where fertilizer and pesticides have been used) enters into ponds, streams or rivers. This water contains nitrate ( $\text{NO}_3^-$ ) and phosphate ( $\text{PO}_4^{3-}$ ) salts. These substances results in a rapid growth of algae, floating over the surface of water. They prevent the sunlight and air (oxygen) to reach upto aquatic life. When algae dies and decompose (bacteria consume oxygen of the water for decomposition). As a result, oxygen depletes in the water. Aquatic animals feel suffocation and ultimately die due to insufficient supply of oxygen.

**Question No. 9: What are the effects of water pollution?**

**Answer:**

### **Effects of Water Pollution:**

Water pollution has the following effects:

#### **(i) Diseases in Humans:**

It is hazardous to human health. Drinking polluted water can cause cholera, typhoid and diarrhea.

#### **(ii) Harmful for Animals & Birds:**

The use of polluted water is not only devastating people but also for animals and birds.

#### **(iii) Rapid Growth of Algae:**



It causes rapid growth of algae. Death and decomposition of algae cause deficiency of oxygen in water that affects other organism living in water.

**(iv) Danger for Aquatic Life:**

It is damaging aquatic life, thus breaking a link in food chain.

**(v) Aesthetic Quality:**

It reduces the aesthetic quality of lakes and rivers.

**(vi) Unfit for Domestic Use:**

It is unfit for cleaning or washing purposes.

**Question No. 10:** Write note on modern water treatment plant.

**Answer:**

**Modern Water Treatment Plant:**

We draw our water supply from surface water for example river, lakes and reservoirs and from ground water.

Water from these sources is never completely pure. The water may contain.

- (a) Bacteria.
- (b) Dissolved substances salts from the soil and rocks and gases from the air.
- (c) Solid substances and debris mud, sand, twigs, refuse and litter.

Before water is safe to drink, the bacteria and solid substances must be removed. Concern over the levels of pesticides in river water has led to an improved form of Advanced Water Treatment (AWT) plant. This system uses ozone to disinfect the water and for efficient removal of the trace chemicals like pesticides from the water. This is an extra purification compared to the previous methods. The ozone is converted into harmless oxygen. AWT also has the advantage that less chlorine is used in the later stages of treatment.

**Interesting Information:**

In some parts of the world, the water supply contains small amounts of fluorine compounds. It was found that in these areas, people did not suffer much from tooth decay. This is because compounds of fluorine protect teeth from decay. This is why many tooth-pastes contain fluorine compounds.



**Question No. 11:** Write a detail account on water borne diseases.

**Answer:**

### **Water Borne Diseases:**

**Definition:** "Diseases that spread because of drinking polluted water or eating food prepared with polluted water are called water borne diseases."

### **Causes:**

Water pollution may be due to the following two reasons:

- (i) Toxins
- (ii) Micro organisms
- (iii) Sanitation Facilities

#### **(i) Toxins:**

Toxins are arsenic, mercury, lead and many organic chemicals.

#### **(ii) Micro organisms:**

Micro organisms are viruses, bacteria, protozoa and worms.

#### **(iii) Sanitation Facilities:**

Lack of sanitation facilities is the main cause of rapidly spreading water borne diseases.

A few common diseases are mentioned here:

#### **(1) Diarrheal Diseases:**

Intestinal diseases, such as cholera, that may cause dangerous dehydration. Diarrhea may be caused by viruses, bacteria or parasites.

#### **(2) Dysentery:**

Dysentery is an intestinal disease which is typically caused by certain bacteria or parasites. It is characterized by "severe diarrhea" that may be accompanied by blood or mucous.

#### **(3) Cholera:**

Cholera is an acute infection caused by the bacteria "**Vibrios Cholerae**", which may be found in water contaminated by human faces. Cholera causes severe diarrhea and can be fatal.



#### **(4) Cryptosporidium:**

Water borne micro-organism (protozoa) that causes gastrointestinal illness (cryptosporidiosis) including diarrhoea and vomiting. These tiny pathogens are found in surface water sources like reservoirs, lakes and rivers.

#### **(5) Fluorosis:**

Fluorosis is a disease caused by the consumption of excess fluoride. Fluorosis can cause bones and teeth damage.

#### **(6) Hepatitis:**

It is liver inflammation commonly caused by one of five viruses called hepatitis A, B, C, D and E. Hepatitis A and E can be transmitted by contaminated water.

#### **(7) Hookworm:**

Hookworm is a parasitic worm that infects the small intestine. Severe cases can result in anemia and stunted growth in children. Hookworm larvae enter the body through the skin, often via the feet. Spread by poor sanitary conditions, hookworms infect about one billion people worldwide per ann.

#### **(8) Jaundice:**

Jaundice is caused by an excess of bile pigments in the blood. Liver ceases to function and eyes turn to yellow. Patient feels weakness and fatigue.

#### **(9) Typhoid:**

A dangerous bacterial disease often spread by contaminated water or by food prepared with contaminated water.

**Question No. 12:** How can we prevent from water borne diseases?

**Answer:**

#### **Prevention of Water Borne Diseases:**

Water borne diseases can be prevented by taking the following measures:

##### **(i) Provision of Safe Water:**

*Drinking water* must be properly treated and purified.

##### **(ii) Disposal of Sewage:**

There must be adequate sanitary disposal of sewage. Any type of waste must *not be* thrown or discharged directly in water supplies or reservoirs.



### (iii) Control of Toxic Chemicals:

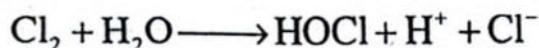
Chemical contamination can cause acute illness, but often toxic contaminants are slow poisons and carcinogens. There must be a strict control over the use of pesticides and other chemicals.

**Question No. 13:** What is the chemistry of swimming pool cleanliness?

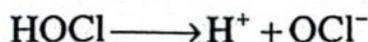
**Answer:**

#### Chemistry of Swimming Pool Cleanliness:

Swimming pools are cleaned by chlorination process. It is the addition of chlorine solution in swimming pools. Chlorine kills bacteria and other microorganisms,  $\text{Cl}_2$  itself does not kill rather it dissociate in water to form hypochlorous acid ( $\text{HOCl}$ ) and hydrochloric acid.



$\text{HOCl}$  further ionizes to produce hypochlorite and proton.



Both the products  $\text{HOCl}$  and  $\text{OCl}^-$  kill bacteria and microorganisms. The difference between their actions is: hypochlorous acid can kill the organisms in several seconds, while hypochlorite ions may kill in upto 30 seconds.

No doubt chlorination is very useful method for cleaning of pools, yet it has side effects also. Smell of chlorine is very unpleasant so people feel annoying. It can cause itching and irritation to skin and especially eyes. Too much chlorine can be hazardous to breathing. On the whole, chlorination is cheaper and gives effective cleanliness than other methods.

**Question No. 14:** Describe the various ways to determine the quality of water.

**Answer:**

#### Quality of Water:

Good quality water is colourless, odourless and tasteless. Hardness of water can be checked by washing. Soft water produces lather with water. Pure water has least conductivity.

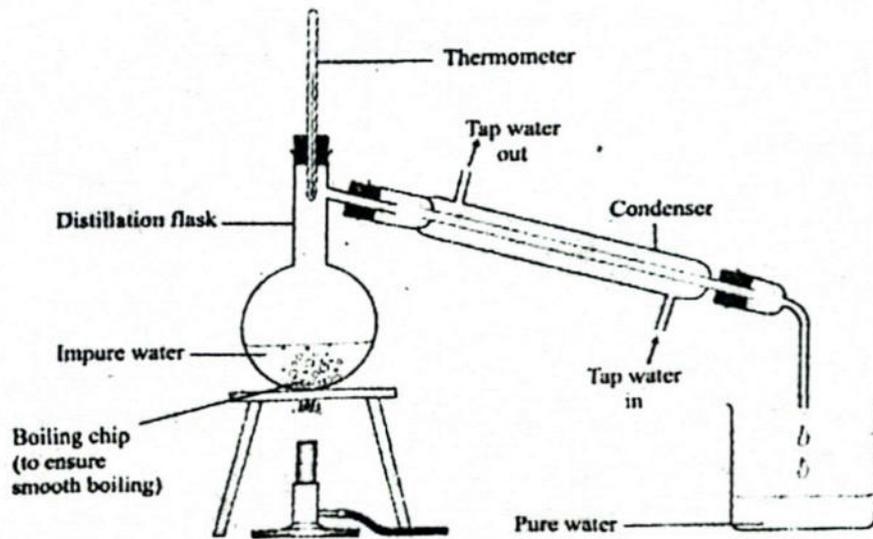
#### Boiling Point of Water:

Water boils at  $100^\circ\text{C}$ .

#### Distillation of Impure Water:

Impure water can be purified by simple distillation apparatus as shown in figure. Distillation process involves boiling of a liquid and then condensing the vapours.

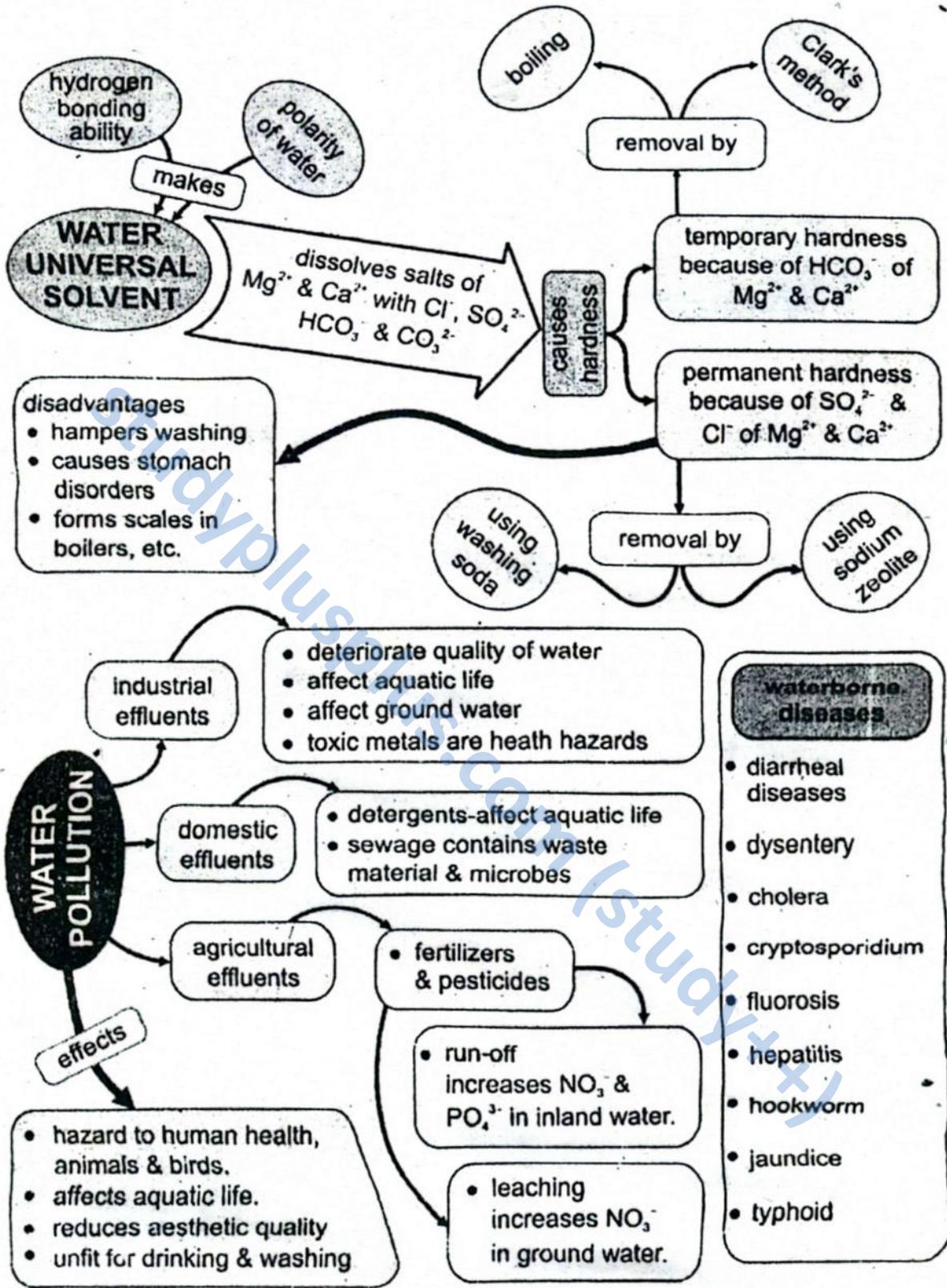




Impure water is taken in a distillation flask. It is boiled. Water vapours rise and enter the condenser. The vapours condense while passing through condenser. Thus, they are changed back into pure water, which is called distillate (distilled water). The distillate is collected in a beaker.

The impurities remains behind in the distillation flask.

# CONCEPT DIAGRAM



# KEY POINTS

**Q. What you know about water?**

**Ans.** Water is an excellent solvent, has high specific heat capacity, high surface tension and high capillary action.

**Q. Why water is consider as a universal solvent?**

**Ans.** Water is universal solvent because of its polarity, and hydrogen bonding ability.

**Q. What is action of soap with soft water?**

**Ans.** Soft water produces lather with soap.

**Q. What is the action of soap with hard water?**

**Ans.** Hard water does not produce lather with soap.

**Q. How many types of hardness appear in water?**

**Ans.** Hardness is of two types: temporary and permanent.

**Q. What is temporary hardness?**

**Ans.** Temporary hardness is because of bicarbonates of calcium and magnesium. This hardness can be removed by boiling or by addition of slacked lime ( $\text{Ca(OH)}_2$ ) in water.

**Q. What is permanent hardness?**

**Ans.** Permanent hardness is because of presence of carbonates and sulphates of calcium and magnesium. This hardness can be removed by treating water with washing soda and sodium zeolite.

**Q. What is another name of used water?**

**Ans.** Used water is called waste water or sewage.

**Q. How water pollution is caused?**

**Ans.** Water pollution is caused by affecting water quality by pollutants.

**Q. What are industrial effluents?**

**Ans.** Industrial effluents are one of the main causes of water pollution. It includes high toxic organic chemicals, inorganic salts, heavy metals, mineral acids, oil and greases etc.

**Q. What are the effects of household sewage on aquatic life?**

**Ans.** Household water in the sewage from toilets, baths, kitchens, etc. consists of detergents used for cleaning purposes. Detergent being non-biodegradable causes rapid growth of aquatic plants. When these plants



die and decay, they consume  $O_2$  present in the water. Thus, aquatic life is badly affected because of scarcity of  $O_2$ .

**Q. What are agricultural effluents and describe its effects?**

**Ans.** Agricultural effluents consist of fertilizers and pesticides. These substances provide nitrate and phosphate ions for rapid growth of aquatic plants. When these plants die and decay, their decomposition process consumes  $O_2$  of water. Thus, depletion of  $O_2$  causes damage to the aquatic life.

**Q. What is meant water borne diseases?**

**Ans.** Water borne diseases are those diseases that spread because of drinking polluted water.

**Q. How water borne diseases are spread out?**

**Ans.** These diseases spread because of lack of proper sanitation arrangements.

**Q. How can we prevent water borne diseases?**

**Ans.** These diseases can be prevented by using safe water, properly disposing sewage and controlled use of toxic chemicals.



# SOLVED EXERCISE

## MULTIPLE CHOICE QUESTIONS (MCQs)

Put a (✓) on the correct answer.

- Which one of the following properties of water is responsible for rising of water in plants?  
(a) specific heat capacity (b) surface tension  
(c) excellent solvent action (d) capillary action
- Specific heat capacity of water is:  
(a)  $4.2 \text{ kJg}^{-1} \text{ K}^{-1}$  (b)  $4.2 \text{ Jg}^{-1} \text{ K}^{-1}$   
(c)  $2.4 \text{ kJg}^{-1} \text{ K}^{-1}$  (d)  $2.4 \text{ Jg}^{-1} \text{ K}^{-1}$
- Water dissolves non-ionic compound by:  
(a) ion-ion forces (b) ion-dipole forces  
(c) dipole-dipole forces (d) hydrogen bonding
- Temporary hardness is because of:  
(a)  $\text{Ca}(\text{HCO}_3)_2$  (b)  $\text{CaCO}_3$   
(c)  $\text{MgCO}_3$  (d)  $\text{MgSO}_4$
- Temporary hardness is removed by adding:  
(a) quick lime (b) slaked lime  
(c) lime stone (d) lime water
- Permanent hardness is removed by adding:  
(a)  $\text{Na}_2$  zeolite (b) soda lime  
(c) lime water (d) quick lime
- Which one of the following salts makes the water permanently hard?  
(a)  $\text{Na}_2\text{CO}_3$  (b)  $\text{NaHCO}_3$   
(c)  $\text{Ca}(\text{HCO}_3)_2$  (d)  $\text{CaSO}_4$
- Rapid growth of algae in water bodies is because of detergent having:  
(a) carbonate salts (b) sulphonic acid salts



- (c) sulphate salts                      (d) phosphate salts
9. Which one of the followings is not a reason of depletion of  $O_2$  from water?
- (a) decaying of aquatic plants  
(b) biodegradation of aquatic plants  
(c) rapid growth of aquatic plants  
(d) decomposition of aquatic plants
10. Which one of the following diseases causes liver inflammation?
- (a) typhoid                                      (b) jaundice  
(c) cholera                                      (d) hepatitis
11. Which one of the following diseases causes severe diarrhea and can be fatal?
- (a) jaundice                                      (b) dysentery  
(c) cholera                                      (d) typhoid
12. Which one of the following gases is used to destroy harmful bacteria in water?
- (a) iodine                                      (b) chlorine  
(c) fluorine                                      (d) bromine
13. Which one of the following ions does not cause hardness in water?
- (a)  $Ca^{2+}$                                       (b)  $Mg^{2+}$   
(c)  $Fe^{2+}$                                       (d)  $Na^+$
14. A disease that causes bone and tooth damage is:
- (a) flourosis                                      (b) hepatitis  
(c) cholera                                      (d) jaundice
15. Ionic compounds are soluble in water due to:
- (a) hydrogen bonding                      (b) ion-dipole forces  
(c) dipole-dipole forces                      (d) dipole-induced dipole forces

16. The chemicals used to kill or control pests are called pesticides. They are:

- (a) dangerous inorganic chemicals
- (b) dangerous organic chemicals
- (c) beneficial inorganic chemicals
- (d) beneficial organic chemicals

**ANSWERS**

1.	(d)	2.	(b)	3.	(d)	4.	(a)	5.	(b)
6.	(a)	7.	(d)	8.	(d)	9.	(c)	10.	(d)
11.	(b)	12.	(b)	13.	(c)	14.	(a)	15.	(b)
16.	(a)								



## SHORT ANSWER QUESTIONS

**Q1. How water rise in plants?**

**Ans.** Capillary action is the process by which water rises up from the roots of plants to leaves. This property is vital for the survival of the land plants.

**Q2. Which forces are responsible for dissolving polar substances in water?**

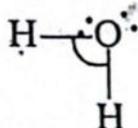
**Ans.** Hydrogen bonding is responsible for dissolving polar substances in water.

**Q3. Why non-polar compounds are insoluble in water?**

**Ans.** The non-polar compounds do not have polar ends or bonds and are not attracted by water molecules. Therefore, non-polar compounds do not dissolve in water.

**Q4. How water dissolves sugar and alcohols?**

**Ans.** Because of two O-H bonds and two lone pairs, one H<sub>2</sub>O molecule can form hydrogen bonding with four other H<sub>2</sub>O molecules, which are arranged tetrahedrally around the H<sub>2</sub>O molecule.



This unique behaviour of water enables it to dissolve many polar non-ionic compounds having hydroxyl group (-OH) like alcohol and sugar by forming hydrogen bonds with them.

**Q5. How lime stone dissolves in water?**

**Ans.** The water which have carbon dioxide dissolved in it, convert the insoluble lime stone (calcium carbonate) into soluble calcium bicarbonate. In this way, lime stone dissolves in water.

**Q6. Differentiate between soft and hard water.**

**Ans.** See Q. No. 5.

**Q7. What are the causes of hardness in water?**

**Ans.** See Q. No. 5.

**Q8. What are the effects of temporary hardness in water?**

**Ans.** Temporary hard water consumes a large amount of soap and also causes stomach disorder.

**Q9. Mention the disadvantages of detergents.**

**Ans.** Detergents have a major disadvantage over the soap as some of the detergents are non-biodegradable (cannot be decomposed by micro-



organisms like bacteria). When house hold water containing these detergents is discharged in streams, ponds, lakes and rivers, it causes water pollution.

**Q10. What is difference between biodegradable and non-biodegradable substances?**

Ans.	Biodegradable Substances	Non-biodegradable Substances
	<p>“The substance which can be decomposed by micro-organisms like bacteria are called as the biodegradable substances.”</p> <p>e.g., Dead bodies of living organisms like plants and animals.</p>	<p>“The substances which cannot be decomposed by microorganism like bacteria are called as non-biodegradable substances.”</p> <p>e.g., plastics, rubber etc.</p>

**Q11. How detergents make the water unfit for aquatic life?**

**Ans.** Because the detergents are non-biodegradable, so they remains in the water for a long time and makes the water unfit for aquatic life. The phosphate salts present in detergents cause rapid growth of algae in water bodies, which floats over the surface of water. These plants ultimately die and decay. Decaying plants being biodegradable consumes  $O_2$  present in water. Thus, depletion of  $O_2$  results in death of aquatic life.

**Q12. Why pesticides are used?**

**Ans.** Pesticides are used either directly to kill or control the growth of pests. Pests may be weeds, herbs, insects, fungi, viruses etc. They all damage crops and transmit diseases both to human beings and animals.

**Q13. What are the reason of water borne diseases?**

**Ans.** Water borne diseases may be due to “Toxins” or “Microorganisms” and lake of proper “Sanitation facilities”.

**Q14. How water borne diseases can be prevented?**

**Ans.** The water borne diseases can be prevented by the following three methods:

- (i) Provision of safe water
- (ii) Disposal of sewage
- (iii) Control of toxic chemicals



## LONG ANSWER QUESTIONS

**Q1. How polarity of water molecule plays its role to dissolve the substances?**

**Ans.** See Q. No. 4

**Q2. Explain the methods of removing permanent hardness.**

**Ans.** See Q. No. 6

**Q3. Explain the water pollution because of industrial waste.**

**Ans.** See Q. No. 8

**Q4. Justify the statement: household water is the reason of water pollution.**

**Ans.** See Q. No. 8 "Domestic Effluent"

**Q5. Explain agricultural effluents are fatal for aquatic life.**

**Ans.** See Q. No. 8

**Q6. Explain five important water borne diseases. How can these be prevented?**

**Ans.** See Q. No. 11 and 12.

**Q7. Give some disadvantages of hard water.**

**Ans.** See Q. No. 7

**Q8. What is water pollution? Describe the effects of using polluted water.**

**Ans.** See Q. No. 8 and 9

**Q9. Explain the reasons, water is considered a universal solvent.**

**Ans.** See Q. No. 4

**Q10. Write a note on the treatment of sewage water.**

**Ans.** See Q. No. 10



# TEST YOURSELF

## Exercise No. 15.1

(i) What is capillary action?

**Ans.** **Definition:** "Capillary action is the process by which water rises up from the roots of plants to leaves."

- This process is vital for survival of land plants.

(ii) Point out two properties of water that make it an excellent solvent.

**Ans.** The ability of water to dissolve substances is because of two unique properties which are given below:

- (1) Polarity of water molecule
- (2) Exceptional hydrogen bonding ability

(iii) Why the water molecule is polar?

**Ans.** **Polar Nature of Water:** Water molecule has a polar structure i.e., one end of the molecule is partially positive while the other end is partially negative because of electronegativity difference between oxygen and hydrogen atoms.

(iv) Explain why non-polar gases are soluble in water?

**Ans.** Water can even dissolve non-polar (un-ionizable) gases like oxygen, hydrogen and nitrogen etc. through dipole-induced dipole forces.

## Exercise No. 15.2

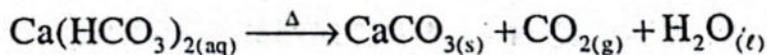
(i) Which salts are responsible for hardness of water?

**Ans.** **Causes of Hardness:** Rain water dissolves many salts of divalent cations like  $Mg^{+2}$ ,  $Ca^{+2}$  and anions like  $Cl^{-1}$ ,  $SO_4^{-2}$ ,  $HCO_3^-$  and  $CO_3^{-2}$ . For example, gypsum ( $CaSO_4 \cdot 2H_2O$ ) and lime stone ( $CaCO_3$ ). These salts make the water hard.

(ii) Explain the chemistry of removing the temporary hardness by boiling water.

**Ans.** **Removal of Temporary Hardness:** On boiling, calcium bicarbonate  $Ca(HCO_3)_2$  decomposes to produce insoluble calcium carbonate, which precipitates out of the solution.



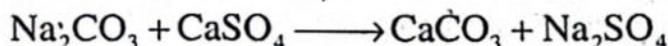


(iii) **What is the principle of removing permanent hardness of water?**

**Ans. Removal of Permanent Hardness:** The permanent hardness can only be removed by using chemicals calcium ( $\text{Ca}^{+2}$ ) and magnesium ( $\text{Mg}^{+2}$ ) are removed as "Insoluble salts" by adding washing soda ( $\text{Na}_2\text{CO}_3$ ) or sodium zeolite.

(iv) **How addition of  $\text{Na}_2\text{CO}_3$  removes permanent hardness of water?**

**Ans. By Using Washing Soda:** The addition of washing soda removes the calcium and magnesium ions as the insoluble calcium and magnesium carbonates respectively.



(v) **How sodium zeolite softens water?**

**Ans.** Sodium zeolite is a naturally occurring resin of sodium aluminium silicate  $\text{NaAl}(\text{SiO}_3)_2$ , which can also be prepared artificially. When water is passed through resin sodium ions of the resin are exchanged with the unwanted calcium and magnesium ions of the hard water.



(vi) **What do you mean by boiler scales? How are they removed?**

**Ans.** Hard water is unfit for use in steam engines, boilers and turbines because insoluble calcium and magnesium salts are deposited inside. This hard deposited layer of calcium and magnesium salts is called as boiler scale. They can be removed by washing the boilers with washing soda, slaked lime and sodium zeolite.

### Exercise No. 15.3

(i) **What is an industrial waste?**

**Ans. Industrial Waste:**

**Definition:** "All the industrial units discharge their wastes (chemicals and solid materials) either to open ground or to water channels. This is called industrial effluent."



(ii) **How water used as a cleaning agent in industries causes pollution?**

**Ans.** Water used as cleaning agent in industries is directly discharged out. This water contains all kinds of toxic chemicals and detergents.

When these effluents or used water enter lakes, streams, rivers or oceans, they either get dissolved or float suspended in water. Even they get deposited on the bed. This results in pollution of water.

(iii) **Why use of detergents is increasing day by day?**

**Ans.** The use of detergents is increasing in houses and industries because detergents have strong cleaning action that of soap even in hard water. They can even work in acidic solution.

(iv) **How decaying plants consume oxygen?**

**Ans.** Decaying plants consume oxygen for the biodegradable.

(v) **What is function of fertilizers?**

**Ans.** Fertilizers are used to make up the deficiency of nitrogen, phosphorous etc. of the soil because of intensive cultivation of crops in the recent years.

(vi) **How pesticides cause water pollution?**

**Ans.** Run-off from the agricultural land (where fertilizer and pesticides have been used) enters into ponds, streams or rivers. This water contains nitrate ( $\text{NO}_3^-$ ) and phosphate ( $\text{PO}_4^{3-}$ ) salts. These substances results in a rapid growth of algae, floating over the surface of water. They prevent the sunlight and air to reach the aquatic life. When algae dies and decompose, bacteria consume oxygen of the water for decomposition. As a result, oxygen depletes in water. Aquatic animals feel suffocation and ultimately die due to insufficient supply of oxygen.

In this way, pesticides play their role in water pollution.

#### Exercise No. 15.4

(i) **Define water borne diseases.**

**Ans. Water Borne Diseases:**

**Definition:** "Diseases that spread because of drinking polluted water or eating food prepared with polluted water are called water borne diseases."



**(ii) What is dysentery?**

**Ans.** **Dysentery:** Dysentery is an intestinal disease which is typically caused by certain bacteria or parasites. It is characterized by severe diarrhea that may be accompanied by blood or mucous.

**(iii) Which of the bacteria causes the cholera?**

**Ans.** Cholera is an acute infection caused by the bacteria "vibrios cholerae".

**(iv) What do you mean by fluorosis?**

**Ans.** Fluorosis is a disease caused by the consumption of excess fluoride. Fluorosis can cause bones and teeth damage.

**(v) What is hepatitis?**

**Ans.** It is liver inflammation commonly caused by one of five viruses called hepatitis A, B, C, D and E. Hepatitis A and E can be transmitted by contaminated water.



## ADDITIONAL MULTIPLE CHOICE QUESTIONS (MCQs)

- (1) Human body consist of \_\_\_\_\_ % water.  
(a) 50 (b) 60  
(c) 70 (d) 80
- (2) All living organisms owe their life because of:  
(a) air (b) light  
(c) soil (d) water
- (3) The ocean water contains about \_\_\_\_\_ % of world water.  
(a) 87 (b) 97  
(c) 57 (d) 77
- (4) Only \_\_\_\_\_ % of the total water on earth is potable.  
(a) 0.1 (b) 0.2  
(c) 0.3 (d) 0.4
- (5) Water has maximum density at:  
(a) 0°C (b) 4°C  
(c) 10°C (d) 100°C
- (6) Non-polar substances like benzene, ether are \_\_\_\_\_ in water.  
(a) soluble (b) insoluble  
(c) highly soluble (d) none
- (7) Gypsum is partially \_\_\_\_\_ in water.  
(a) lighter (b) dense  
(c) soluble (d) none
- (8) The removal of  $Mg^{+2}$  and  $Ca^{+2}$  ions which are responsible for the hardness is called:  
(a) Processing (b) Water softening

(c) Molecularity (d) Microorganism

(9) The chemical formula of sodium oleate is:

(a)  $C_{17}H_{35}COONa$  (b)  $C_{17}H_{33}COONa$

(c) both (a) and (b) (d) none

(10) Detergents can even work in \_\_\_\_\_ solutions.

(a) basic (b) acidic

(c) both (a) and (b) (d) none

(11) The phosphate salts present in detergents cause rapid growth of:

(a) bacteria (b) fungi

(c) algae (d) none

(12) Water pollution damage the aquatic life, thus breaking a link in:

(a) food web (b) food link

(c) food chain (d) none

(13) AWT shows the:

(a) advanced water treatment (b) avoid water treatment

(c) both (a) and (c) (d) none

(14) In Western Europe each person use about \_\_\_\_\_ of water per day.

(a)  $180 \text{ dm}^3$  (b)  $160 \text{ dm}^3$

(c)  $140 \text{ dm}^3$  (d)  $200 \text{ dm}^3$

(15) Which of the following gases is a good fuel?

(a) Methane gas (b) Ethane gas

(c) Carbon dioxide (d) None

(16) Diarrhea may be caused by:

(a) Viruses (b) Bacteria

(c) Parasites (d) All

(17) Which of the following is characterized by sewer diarrhea?





## ADDITIONAL SHORT ANSWER QUESTIONS

(1) **What is the significance of water?**

**Ans.** Throughout history, importance and significance of water has been recognized by mankind. It is an essential and major component of each living cell. It provides an environment for animals and plants that lives in water.

(2) **What is the effect of water on litmus?**

**Ans.** It is neutral to litmus.

(3) **Define soft and hard water.**

**Ans. Soft Water:**

**Definition:** "Soft water is that which produces good lather with soap."

**Hard Water:**

**Definition:** "Hard water is that which do not produce lather with soap."

(4) **What do you mean by temporary hardness?**

**Ans.** Temporary hardness is because of bicarbonates of calcium and magnesium.

(5) **What do you mean by permanent hardness?**

**Ans.** Permanent hardness is because of present of sulphates and chlorides of calcium and magnesium.

(6) **What is water softening?**

**Ans.** The removal of  $Mg^{+2}$  and  $Ca^{+2}$  ions which are responsible for the hardness is called water softening.

(7) **Define water pollution.**

**Ans. Water Pollution:**

**Definition:** "Water pollution is a contamination of water bodies (e.g., lakes, rivers, oceans and ground water.)"

Water pollution occurs when pollutants are discharged directly or indirectly into water bodies.

(8) **Give two effects of water pollution.**

**Ans.** (i) It reduces the aesthetic quality of lakes and rivers.



(ii) It is unfit for cleaning or washing purposes.

**(9) What are diarrheal diseases?**

**Ans.** Intestinal diseases, such as cholera, that may cause dangerous dehydration. Diarrhea may be caused by viruses, bacteria or parasites.

**(10) What is typhoid?**

**Ans.** A dangerous bacterial disease often spread by contaminated water or by food prepared with contaminated water.

**(11) By which methods we can be prevented from water borne diseases?**

**Ans.** Water borne diseases can be prevented by taking the following measures:

- (i) Provision of safe water.
- (ii) Disposal of sewage.
- (iii) Control of toxic chemicals.

**(12) Write short note on fluorosis.**

**Ans.** Fluorosis is a disease caused by the consumption of excess fluoride. Fluorosis can cause bones and teeth damage.

**(13) What do you mean by quality of water?**

**Ans.** Good quality water is colourless, odourless and tasteless. Hardness of water can be checked by washing. Soft water produces lather with water. Pure water has least conductivity.

**(14) Name the methods used to remove the temporary hardness of water.**

**Ans.** The following methods are used:

- (i) By Boiling
- (ii) By Clark's Method

**(15) Name the methods used to remove permanent hardness of water.**

**Ans.** The following methods are used to remove permanent hardness of water:

- (i) By using washing soda.
- (ii) Using sodium zeolite.

**(16) Define capillary action.**

**Ans. Capillary Action:**

**Definition:** "Capillary action is the process by which water rises up from the roots of plants to leaves."

This process is vital for survival of the land plant.



(17) Give the density of water at 4°C.

Ans. Water has maximum density at 4°C is  $1 \text{ g cm}^{-3}$ .

(18) What is sodium zeolite?

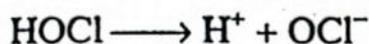
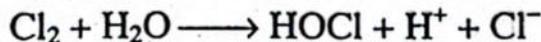
Ans. Sodium zeolite is a naturally occurring resin of sodium aluminium silicate  $\text{NaAl}(\text{SiO}_3)_2$ .

(19) What is cryptosporidium?

Ans. Water borne micro-organism that causes gastrointestinal illness including diarrhea and vomiting. These tiny pathogens are found in surface water sources like lakes, reservoirs and rivers.

(20) How chlorine cleans the water? Write equations only.

Ans.



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