

# Environmental Chemistry

## II Water

### Long Answer Questions

**Q.1 Write the physical properties of water.**

**Ans. Physical 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 a clear, colourless, odourless and tasteless liquid with following properties:

- (i) It is neutral to litmus.
- (ii) Its freezing point is  $0^{\circ}\text{C}$  and boiling point is  $100^{\circ}\text{C}$  at sea level.
- (iii) Its maximum density is  $1\text{ gcm}^{-3}$  at  $40^{\circ}\text{C}$ .
- (iv) It is excellent solvent for ionic as well as molecular compounds.
- (v) 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.
- (vi) 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 the land plants.

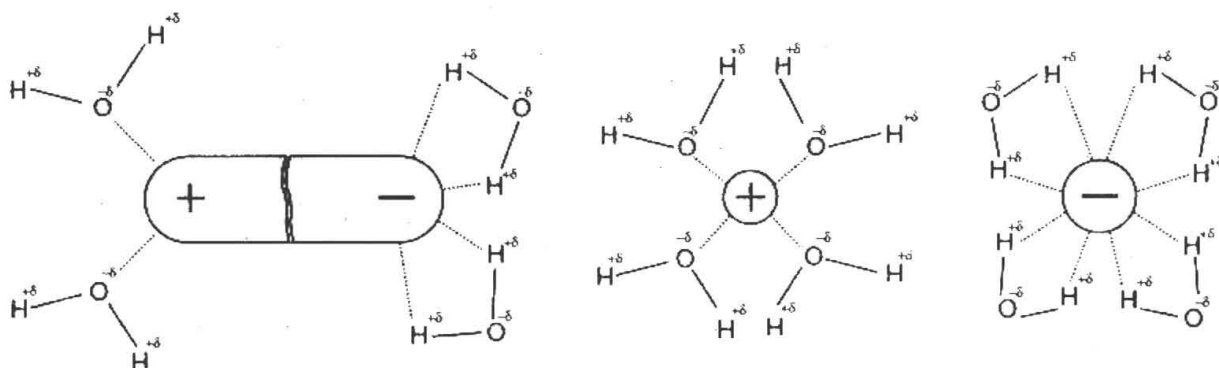
**Q.2 How polarity of water molecule plays its role to dissolve the substance?**

**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.

All other polar substances are soluble in water, because the 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 figure 15.1. Ultimately, these oppositely charged ions are most of the salts like NaCl, KCl, Na<sub>2</sub>SO<sub>4</sub>, etc., are soluble in water.



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.

### Q.3 Explain the water pollution because of industrial waste.

**Ans.** Industrial units are installed to produce the desired substances (chemicals, cloth, leather goods, paper, plastic items, petrochemicals and rubber items) on commercial scale to meet the needs of the society. But unfortunately all the industrial units discharge their wastes (chemicals and solid materials) either to open ground or to water channels. This is called industrial effluent. The industrial effluent may be highly toxic organic chemicals, inorganic salts, heavy metals, mineral acids, oil and grease, 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. This results in the pollution of water, i.e.,

- (i) They deteriorate the quality of water.
- (ii) They reduce the quantity of dissolved oxygen, ultimately affects aquatic life and ecosystem.
- (iii) 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 damage soil, plants and animals.
- (iv) Heavy metals like cadmium, lead and mercury are 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 reproduction system. Mercury poisoning causes neurological damage.

**Q.4 Justify the statement house hold water is the reason of water pollution.**

**Ans.** 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 soaps, as some of the detergents are non-biodegradable (cannot be decomposed by micro-organisms like bacteria). When household 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. It also contains disease causing microbes. All these substances add to water pollution.

**Q.5 Explain agricultural effluents are fatal for aquatic life.**

**Ans.** Water pollution due to agricultural waste is because of use of fertilizers and pesticides. Fertilizers are used to make up the deficiency of nitrogen, phosphorus, 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.

Run-off from the agricultural land (where fertilizer and pesticides have been used) enters into ponds, streams or rivers. This water contains nitrate  $NO_3^-$  and phosphate  $PO_4^{3-}$  salts. These substances result in a rapid growth of algae, floating over the surface of water. They prevent the sunlight and air (oxygen) to reach up to 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.

**Q.6 What are waterborne infectious diseases? Explain any four waterborne diseases**

**Ans.** Diseases that spread because of drinking polluted water or eating food prepared with polluted water are called water borne diseases. Water pollution may be due to toxins or

microorganisms. Toxins are arsenic, mercury, arsenic, lead and many organic chemicals. Microorganisms are viruses, bacteria, protozoa and worms.

Lack of proper sanitation facilities is the main cause of rapidly spreading waterborne diseases. A few common diseases are mentioned here:

### **Diarrheal disease**

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

### **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.

### **Cholera**

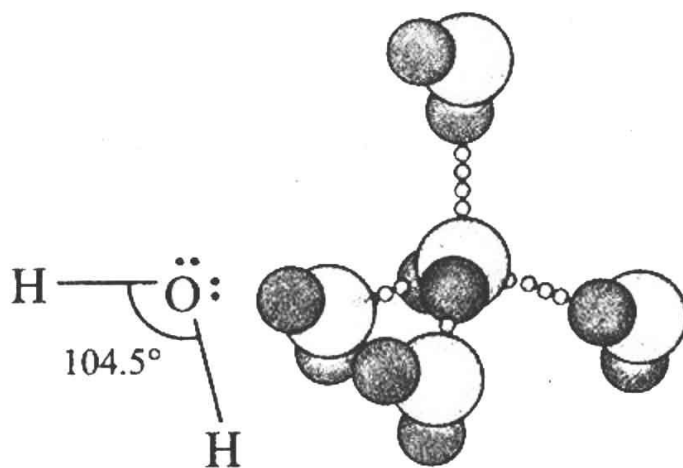
Cholera is an acute infection caused by the bacteria *Vibrios cholera*, which may be found in water contaminated by human feces. Cholera causes severe diarrhea and can be fatal.

### **Cryptosporidium**

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

### **Q.7 Explain hydrogen bonding in water molecule?**

**Ans.** Water molecule is composed of oxygen and hydrogen atoms. Because of two O-H bonds and two lone pairs, one  $H_2O$  molecule can form hydrogen bonding with four other  $H_2O$  molecules, which are arranged like tetrahedral around the  $H_2O$  molecule as shown in Figure. This unique behaviour of water enables it to dissolve many polar non-ionic compounds having hydroxyl group (-OH), like alcohols, organic acids, glucose, sugar, etc. by forming hydrogen bonds with them.



**Hydrogen bonding of water molecule**

### Q.8 Write disadvantages of hard water?

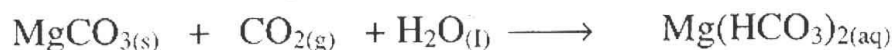
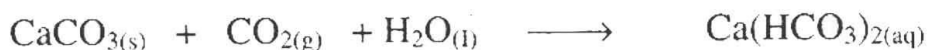
**Ans.** Following are some of the disadvantages of hard water:

- Hard water consumes large amount of soap in washing purposes.
- Drinking hard water causes stomach disorders.
- Hard water is unfit for use in steam engines, boilers and turbines because insoluble calcium and magnesium salts are deposited inside. Which is called scales. They are bad conductors of heat and hence more fuel is used. Insoluble calcium and magnesium sulphates not only reduce the efficiency of the engine but also cause the boiler to burst.

### Q.9 How hardness in water is caused? Explain

**Ans.** 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  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ , and anions like  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{HCO}_3^-$  and  $\text{CO}_3^{2-}$  for example, gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) and limestone ( $\text{CaCO}_3$ ).

These salts make the water hard.

Gypsum is sparingly soluble in water, while limestone is insoluble in water. However, in the presence of carbon dioxide small quantity of limestone is soluble in water according to the above chemical reaction.

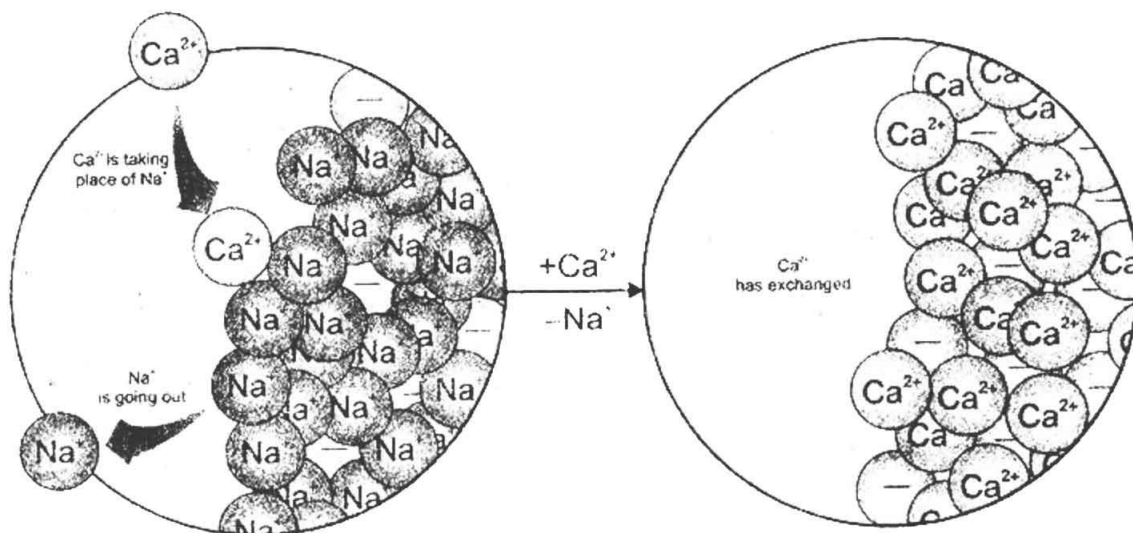
### Q.10 How permanent hardness is removed by using sodium zeolite?

**Ans.** 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 figure



When resin is fully used up it can be regenerated by flushing it with concentrated solution of  $\text{NaCl}$ . The reverse process take place because of high concentration of sodium ions.

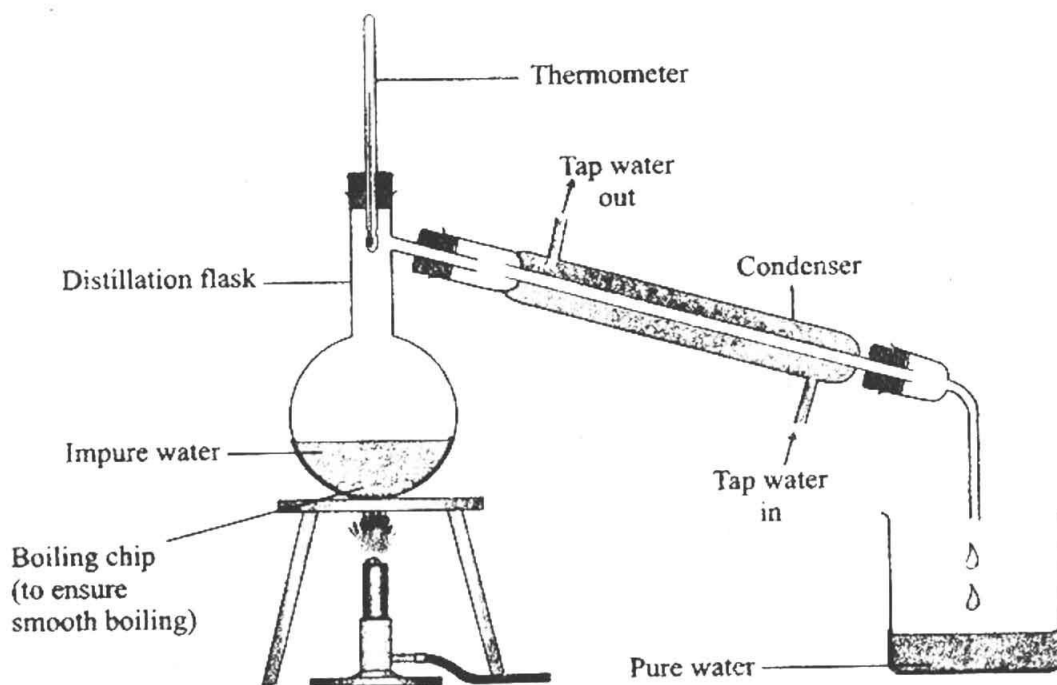




### Ion exchange for removal of hard water ions

#### Q.12 How impure water is purified by distillation process?

**Ans.** 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.



#### Q.13 What are the effects of water pollution explain?

**Ans.** Following are some of the effects of water pollution:

- It is hazardous to human health. Drinking polluted water can cause cholera, typhoid and diarrhea.
- The use of polluted water is not only devastating for people but also for animals and birds.



- iii. It causes It cause rapid growth of algae. Death and decomposition of algae cause deficiency of oxygen in water that affects other organism living in water.
- iv. It is damaging aquatic life, thus breaking a link in food chain.
- v. It reduces the aesthetic quality of lakes and rivers.
- vi. It is unfit for cleaning or washing purposes.

**Q.14 How waterborne diseases can be prevented?**

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

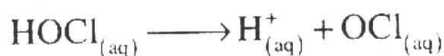
- i. Provision of safe water: Drinking water must be properly treated and purified.
- ii. Disposal of sewage: There must be adequate sanitary disposal of sewage. Any type of waste must not be thrown or discharged directly in water supplies or reservoirs.
- iii. Control of toxic chemicals: Chemical contamination 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.

**Q.15 Explain the chemistry of swimming pool cleanliness?**

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



HOCl further ionizes to produce hypochlorite and proton



Both the products HOCl and OCl kill bacteria and micro-organisms.

## Short Answer Questions

**Q.1 Why water is considered to be universal solvent?**

**Ans.** 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.

**Q.2 Write occurrence of water?**

**Ans.** 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, and streams), It is also present