Chapter 6. Water

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Solution 1:

The molecular formula of water is H_2O, this shows that water is not an element but it is a compound made up of two elements hydrogen and oxygen combined in a fixed ratio, i.e., 1:8 by mass. This also shows that the properties of water is totally different from those of hydrogen and oxygen as compounds have completely different properties than the elements of which it is made up of.

Solution 2:

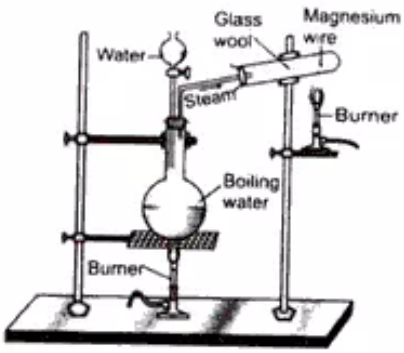
Two characteristics properties responsible for making water a good solvent are:

1. Water molecule can form hydrogen bonds with the molecules of other compounds.
2. Water molecule is polar in nature.

Solution 3:

Magnesium is least reactive with cold water but with hot water it burns with an intense white light, liberating hydrogen gas and a white ash, i.e., magnesium oxide

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{hot water}}{H_2O} \longrightarrow \underset{\text{Magnesium oxide}}{MgO} + \underset{\text{Hydrogen}}{H_2}\uparrow$$



Action of steam on magnesium

Solution 4:

1. **(a)** Physical properties of water:
    1. Pure water is colourless, transparent, odourless and tasteless liquid.
    2. Boiling and Freezing points: At normal atmospheric pressure water boils at 100^oC and freezes at 0^oC.
    3. Pure water being a covalent compound is a very poor conductor of heat and electricity.On addition of electrolytes it becomes a good conductor of heat and electricity.
    4. Solvent properties:Water is a remarkable solvent dissolves many substances forming aqueous solutions because of its high dielectric constant.

5. Anomalous behavior: On cooling water contracts in volume, as do other liquids, but at 4^{o} C, it starts expanding, and continues to do till the temperature reaches 0^{o}C,the point at which it converts to ice.

2. **(b)**
    1. Boiling point of water: It increases with the addition of salt in water.
    2. Freezing point of water: It decreases with the addition of salt in water.
    3. Density of water: It increases with the addition of salt in water.

Solution 5:

Due to its high specific heat capacity, water is used in cooling systems for e.g., as coolant in motor car radiators.

Solution 6:

In many chemical reactions water acts as a catalyst.

a. Hydrogen and oxygen when sparked together combines only if moisture is present.

$$4H_2 + O_2 \xrightarrow{\text{Moisture}} 2H_2O$$

b. Yellow phosphorus burns in air in the presence of moisture.

$$4P + 5O_2 \xrightarrow{\text{Moisture}} 2\,P_2O_5$$

c. Water also helps in rusting process

$$Fe + O_2 + H_2O \rightarrow Fe_2O_3.{}_xH_2O$$

Solution 7:

1. **(a)** Water reacts with metals oxides: corresponding hydroxides are formed which act as alkalis.
2. **(b)** Water reacts with non metals oxides: corresponding acids are formed.

Solution 8:

a. Calcium oxide reacts with water:

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

b. Sulphur trioxide reacts with water:

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

c. Phosphorous pentoxide reacts with water:

$$2P_2O_5 + 6\,H_2O \rightarrow 4\,H_3PO_4$$

d. Sulphur dioxide reacts with water:

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

e. Sodium reacts with water:

$$2Na + H_2O \longrightarrow 2\,NaOH + H_2$$

Solution 9:

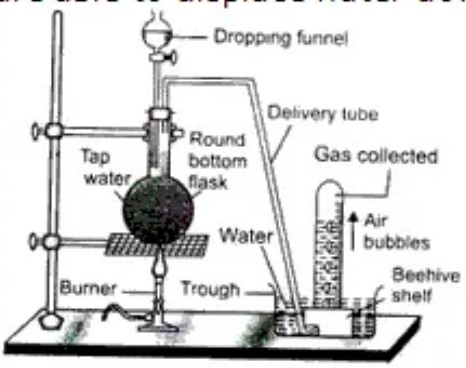
We can test the odourless, colourless liquid by:

1. Measuring its boiling point, if comes out to be 100 ^{o}C then it confirms the liquid to be water.

2. Measuring its melting point, if comes out to be 0 ^{o}C then it confirms the liquid to be water.

Solution 10:

a. Principle underlying the removal of dissolved gases from water is the downward displacement of water .This explains that the gases dissolved in water i.e., hydrogen and oxygen are less dense then water due to which they are able to displace water downwards and gases are collected upwards.



b. Importance of dissolved gases in water:

i. Oxygen gas is dissolved in water which is used by aquatic organism to respire.

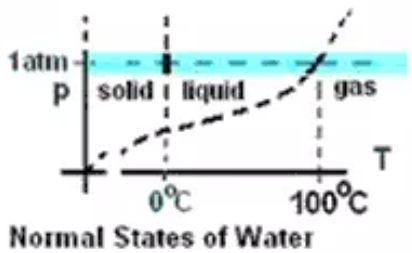
ii. Carbon dioxide is also dissolved in water, which is consumed by aquatic plants to prepare food in the form of carbohydrates by photosynthesis. Also carbon dioxide dissolved in water reacts with calcium carbonate present in rocks to form soluble calcium bicarbonate, which is absorbed by the marine animals.

Solution 11:

1. **(a)** Water being the universal solvent ,acts as an important mode of transport in plants,also water taken from natural source contains dissolved salts in them which is essential for the growth and development of plants
2. **(b)** Water constitutes 3/4th of our human body and it is necessary for the survival of human beings and being the universal solvent helps in transportation and also regulates the body temperature.It also contains dissolved salts which supply essential minerals which are necessary for our body.

Solution 12:

Normally water exist in liquid state but when heated under normal pressure (760mm Hg) water boils at 100°C and changes rapidly into gaseous state (steam) . Water freezes at 0°C and changes into solid state (ice).



Normal States of Water

Solution 13:

We can test the presence of water by performing these two tests:

1. On adding few drops of water to white anhydrous copper sulphate, the latter turns blue.($CuSO_4.5H_2O$)

$$CuSO_4 + 5H_2O \longrightarrow CuSO_4.5H_2O$$

Copper sulphate (anhydrous white) → Copper sulphate pentahydrate (blue)

2. On adding water to blue cobalt chloride the latter turns pink due to the formation of $CoCl_2.6H_2O$

$$CoCl_2 + H_2O \longrightarrow CoCl_2.6H_2O$$

Cobalt chloride (Blue) → Hydrated cobalt chloride (pink)

Solution 14:

Density of water is 0.997 gcm^{-3} at 4°C . The density of water decreases when the temperature increases above 4°C or decreases below 4°C.

At 4^0C, water has its maximum density and minimum volume. At any temperatur above or below 4 C, the density of water decreases. This property is called anomalous expansion of water. The significance of this unique property of water is that it enables marine life to exist in the colder regions of the world, because even when water freezes on the top, it is still liquid below the ice layer.

Solution 15:

At 4^0C, water has its maximum density and minimum volume. The property of anomalous expansion of water enables marine life to exist in the colder regions of the world because even when water freezes on the top, it is still liquid below the ice layer.

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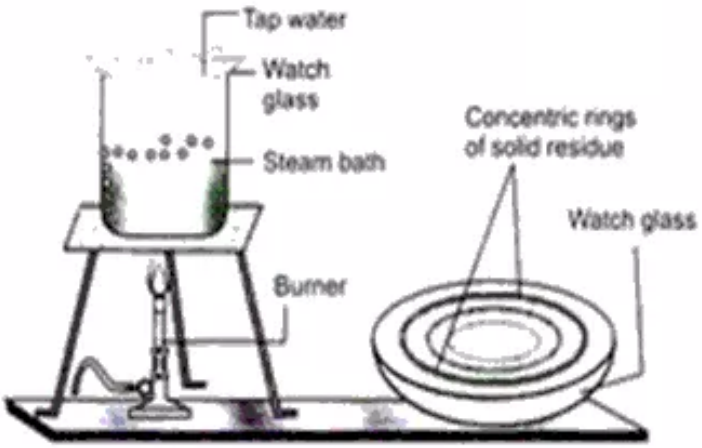
Solution 16:

Procedure: Put some tap water on a clean watch glass and place it over a beaker containing water as shown in Fig .Boil the water in the beaker. When all the water has evaporated from the watch glass, remove it from over the burner and let it cool.



Observation:

Hold the watch glass against the light, a no. of concentric rings of solid matter are observed. These rings are deposits of the dissolved solids left behind after evaporation.

Solution 17:

(a) A piece of Na is added to cold water:
It melts forming silvery globule is formed which floats on the surface of water, after the completion of the reaction a cololurless soapy and warm solution is left.

$$\underset{\text{Sodium}}{2Na} + H_2O \longrightarrow \underset{\text{Sodium hydroxide}}{2\,NaOH} + \underset{\text{hydrogen}}{H_2}$$

(b) A piece of Ca is added to cold water:
Calcium being heavier sinks in water and due to the formation calcium hydroxide in the reaction, the area around the metal turns milky.

$$\underset{\text{Calcium}}{Ca} + H_2O \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + H_2$$

(c) A coil of Mg is heated in steam:
It burns with an intense white ligh liberating hydrogen gas, and forms some white ash, i.e., magnesium oxide when steam is passed over heated magnesium wire.

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{steam}}{H_2O} \longrightarrow \underset{\text{Magnesium oxide}}{MgO} + H_2\uparrow$$

Solution 18:

1. **(a) Liquids:** alcohols, acids
2. **(b) Solids:** Sugar, urea
3. **(c) Gases:** Oxygen, carbon dioxide

Solution 19:

Rain water is the purest form of natural water.

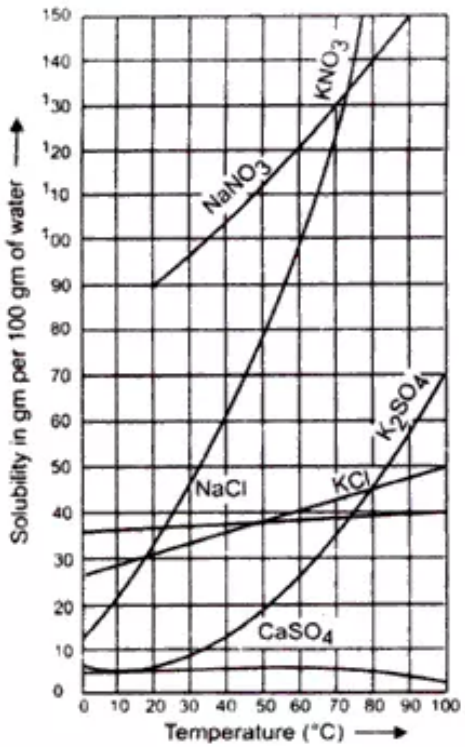
Solution 20:

1. **(a) Solid in a liquid:** Solubility decreases with rise in temperature in an exothermic process, for example, calcium sulphate($CaSO_4$), sodium sulphate($NaSO_4$), and in an endothermic reaction solubility increases with rise in temperature,for example potassium nitrte(KNO_3) and sodium nitrate($NaNO_3$).
2. **(b) A gas in a liquid:** Solubility decreases with rise in temperature.Thus, gases dissolves readily in cold water than in hot water.

Solution 21:

The advantages of solubility curve are:

1. It helps in the determination of solubility of a solute at a particular temperature.
2. It helps in comparing the solubilities of different solutes in a solvent at a particular temperature.
3. In separation and purification of solutes.
4. It also help to know the transition temperature i.e. there is a sharp break observed.



Variation in the solubility of some solids with changing temperature.

Solution 22:

1. **(a)** Density of water is 0.997 gcm^{-3} at 4^oC .The density of water decreases when the temperature decreases below 4^oC. So ice has less density of 0.92 and is lighter then that of water hence it floats on water.
2. **(b)** A solution is said to be saturated if at a particular temperature if no more of the solute can be dissolved in it at that temperature, when the temperature is increased more solute particles can be dissolved in that saturated solution as the solubility of most of the substances generally increases with rise in temperature and thereby making it unsaturated.
3. **(c)** Solubility of gases decreases with increase in temperature hence hot water contains less dissolved air than cold water.

Solution 23:

1. **(a) Solute:** The substance which dissolves in a medium to produce a solution is called the solute.
2. **(b) Solvent:** It is the medium in which the solute dissolves.
3. **(c) Solution:** A homogeneous mixture that has a uniform composition throughout the volume of the mixture. It is the medium in which the solute dissolves.

Solution 24:

1. **(a)** When we heat a saturated solution more solute can be dissolved in it, it as mostly solubility increases on raising the temperature and the solution then becomes an unsaturated solution.
2. **(b)** When a hot saturated solution is cooled slowly and is kept undisturbed the excess salt does not separates out . Thus the solution becomes a supersaturated solution which contains more solute in it than it can hold at room temperature.
3. **(c)** When the quantity of solvent increases,greater amount of solute can be dissolved.

Solution 25:

The solubility curve of sodium sulphate decahydrate ($Na_2SO_4.10H_2O$) shows sudden change in direction at 32.8°c .Its solubility increases sharply upto 32.8°c and then falls suddenly.Anomalous solubility of Glauber's salt ($Na_2SO_4.10H_2O$) in water is due to the reason that sodium decahydrate change to anhydrous sodium sulphate at 32.8°C. Due to this, a sharp increase occurs in solubility curve at 32.8°C and then falls suddenly.

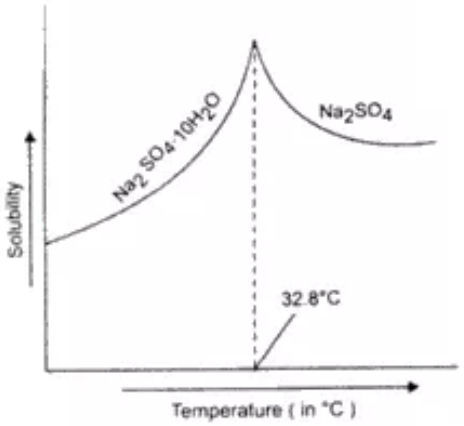


Fig. 6.10: Solubility curve for $Na_2SO_4.10H_2O$ (Glauber's salt)

$$Na_2SO_4.10H_2O \underset{\text{Below } 32.8^\circ C}{\overset{\text{Above } 32.8^\circ C}{\rightleftharpoons}} Na_2SO_4 + 10\ H_2O$$

Solution 26:

Solution	Mixture	Compound
1. In it solute is not present in any fixed proportion but its composition is uniform.	1. In it the composition is not uniform. The component may be present in any proportion.	1. In it the constituents are combined in a fixed proportion.
2. In it the solute can be recovered by evaporating the solvent, i.e., by physical means.	2. In it the components can be separated by ordinary physical means.	2. In it the constituents can be separated by chemical means only.

Solution 27:

Solubility of a solid depends on:

1. **Size of particles:** Smaller the size of particles of the solute, greater is the solubility.
2. **Contact between solute and the solvent:** Increased contact between the solute and the solvent increases the solubility.

3. **Temperature:** The variation of solubility with temperature depends on its nature i.e. whether the reaction is exothermic or endothermic.
   For exothermic reactions-The solubility decreases on increasing the temperature.
   For endothermic reaction-The solubility increases on increasing the temperature.

Solution 28:

Henry's law states that:

At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.

Solution 29:

1. Z is least reactive so it will be found free in nature.
2. X is more reactive so it will react with oxygen more readily and with ease.
3. Z
4. Y is iron whose oxide is brown coloured Fe_2O_3.
5. X
6. The piece of Y i.e., iron is more reactive then copper so it will displace copper from copper nitrate and a brown layer of copper will be developed on the iron piece.

Solution 30:

Drop in, a crystal of the solute that is in the solution. If the crystal dissolves its unsaturated, if it stays the same size then its saturated and if it gets bigger than its supersaturated.

1. This is because an unsaturated solution will be able to take in more solute, so it dissolves the crystal.
2. A saturated solution will not take in more solute but will also not deposit any solute so the crystal stays the same size.
3. A supersaturated solution wants to deposit its excess solute and become saturated, it just needs something to start it along.

The crystal starts it up and it will deposit its excess solute onto the crystal making the crystal bigger.

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Solution 31:

1. **(a) Increase in weight:** when sodium chloride when exposed in air it gains moisture and its weight increases.
2. **(b) Decrease in weight:** iron when exposed to air gets rusted due to the presence of moisture in the air it gets corroded, and hence its weight is reduced.
3. **(c) No effect on weight:** when conc. Sulphuric acid when exposed to air does not react and no change occurs in weight.

Solution 32:

Water pollution may be defined as the contamination of water by foreign substances which make it harmful for health of animals or plants or aquatic life, make it unfit for drinking and for domestic, industrial and agriculture use.

Solution 33:

Major pollutants of water are:

Ground water pollutants: Septic tanks, industry by products like pesticides, fertilizers, tanneries, mining wastes.

Surface water pollutants: No. of gases present in atmosphere like SO_2, CO_2, H_2S, NOx, CO, etc., pollute surface water.

Lake water pollutant: organic wastes from hills, toxic effluents from urban areas, industrial effluents, dumping of huge amounts of sediments etc.,

River water pollutants: Industrial discharge, sewage discharges, detergents, discharges from drug, paper, and textile industries

Marine water pollutant: major pollutant is oil spills.

Solution 34:

Various sources of water pollution are:

1. **Natural process:** Washing away of decomposed and animal wastes into main stream of water.
2. **Human activity:**
    1. **(a)Discharge of Household detergents:** detergents used as a cleaning agent produce foam and pollute water. They do not undergo bio-degradation.
    2. **(b) Discharge of industrial effluents:** Industrial activities generate a variety of waste products which are generally discharged into water streams.The pollutants associated with the industrial effluents are organic matter, inorganic dissolved salts, suspended solids. They inhibit oxidation or organic compounds; stabilize the colloidal impurities which do not aggregate to settle down.
    3. **(c) Sewage:** Sewage is cloudy dilute aqueous solution containing minerals and organic matter.Sewage from homes and industries contains decomposable organic matter ,inorganic cations and anions,toxic metals etc.Pouring the drains and sewers in fresh water bodies causes water pollution.
    Water pollution due to sewage creates the following problems:

        1. Self purifying ability of water is lost and it becomes unfit for domestic purpose.
        2. Self regulatory capabilities of aquatic organism is retarded.
        3. Sewages produce pathogens which are diseases causing bacteria and result in water born gastro-intestinal diseases.

Solution 35:

Water treated for safe effluents involves sequential treatment:

1. **Primary treatment:** The primary treatment involves physico-chemical processes to reduce settle able suspended solids of the wastes water and smoothened out individual effluent flow variations.It involves physic-chemical processes such as sedimentation,aeration,adsorption,oxidation etc.
2. **Secondary treatment:** In this, the dissolved and colloidal organic matter present in waste is removed by biological processes involving bacteria and other micro organisms.
    These process may be aerobic or anaerobic.
    Aerobic treatment: Purification is carried out by aerobes in the presence of molecular

oxygen.
Anaerobic treatment: Purification of waste is achieved by anaerobes in complete absence of molecular oxygen.

3. **Tertiary treatment:** It is the final treatment for polishing the effluents from secondary treatment. By this process suspended solids are removed, bacteria are removed, and organic and inorganic solids are removed.

Solution 36:

Two water born diseases are:

1. Gastroenteritis
2. Bacterial dysentery