# CHAPTER 6

# Water

*LATEST SYLLABUS – SCOPE OF SYLLABUS – WATER*

**Water**

Water as a compound and as a universal solvent; its physical and chemical properties;

*Why is water considered a compound? Chief physical properties should include: density, b.p, m.p. Experiment to show that the water we drink, contains dissolved solids & dissolved gases [air]; their significance. Solutions as 'mixtures' of solids in water; saturated solutions; qualitative effect of temperature on solubility [e.g. solutions of calcium sulphate, potassium nitrate, sodium chloride in water].*

*Chemical Properties: The action of cold water on sodium and calcium; the action of hot water on magnesium and steam on iron; reversibility of reaction between iron and steam.*

*Students can be shown the action of sodium and calcium on water in the laboratory; they must be asked to make observations [equations for the above reactions] and form reactivity series based on reactions.*

**Water pollution – Causes** – household detergents, sewage, industrial waste, offshore oil drilling.
**Treatment of Water Pollution** – Proper collection and disposal of domestic sewage, treatment of industrial waste to yield safe effluents.

## A. INTRODUCTION

**Next to air, water is one of the most – common substances on the earth's surface.**

- *W. Ostwald* stated that 'almost all the chemical processes which occur in nature, takes place – *among solutions in water*'. Water is thus the – *elixir of life*.
- Water which is found in the natural state is called – ***'natural water'*** while – water which has received some form of treatment is known as – ***'treated water'***.
- ***Importance of water*** –
  Water is important for natural processes & is vital for the – *growth of plant & animal life.*
  *The human body* – needs water for almost every function carried out by each & every cell.
  *Industrial processes* – dependent on water are – the agriculture, transportation and the power generation plants both hydro & thermoelectric.

**OCCURRENCE – Of Water**

*IN THE FREE STATE*

| | |
|---|---|
| SOLID STATE | In the form of – Ice, snow, frost. |
| LIQUID STATE | |
| • On the earth's surface | As – river water, lake water, sea water, spring water. |
| • Below the earth's surface | In – well water and moisture accumulation in the soil. |
| • Above the earth's crust | As – dew |
| GASEOUS STATE [vapour] | As – Water vapour, clouds, mist, fog. |

*IN THE COMBINED STATE* :

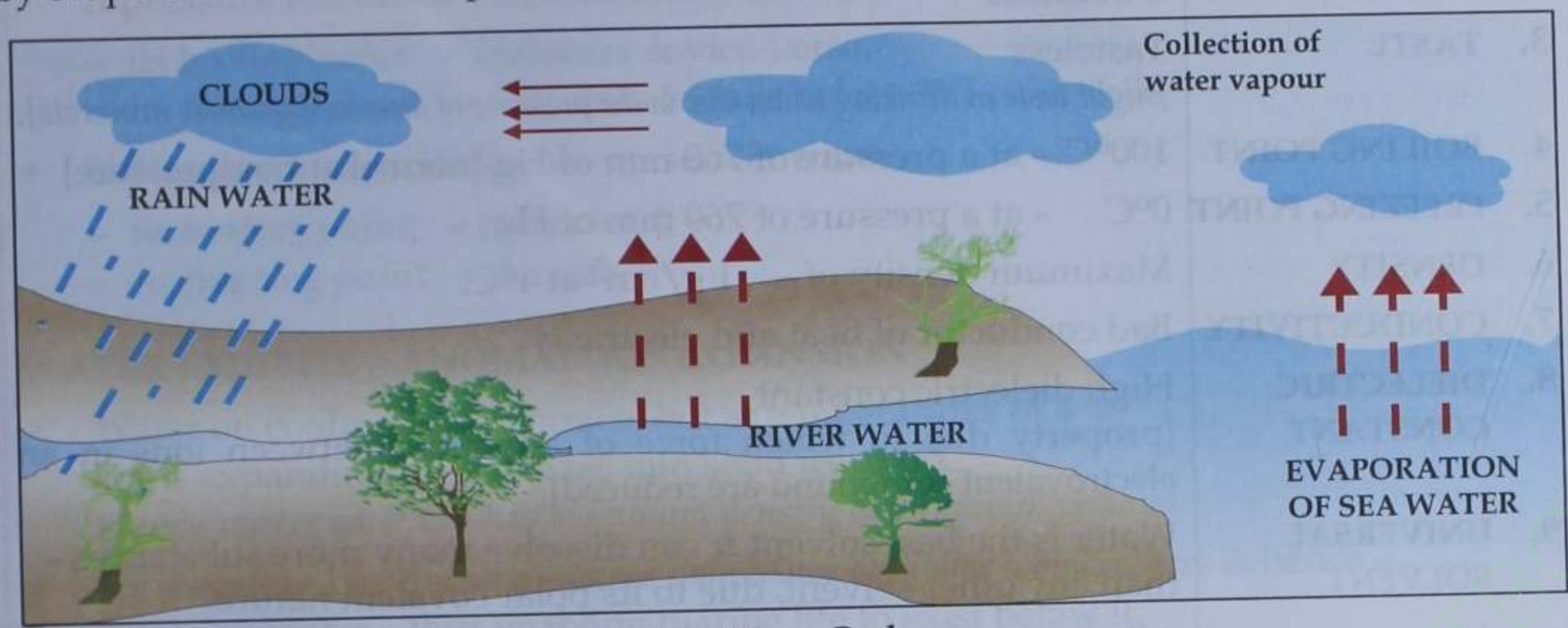
- Water occurs in the combined form in all living matter i.e. plants & animals.
- Water is present in hydrated salts eg. $MgCl_2.6H_2O$ and in certain minerals.

| | |
|---|---|
| EARTH'S SURFACE | Covers approximately 75% of the earth's surface. |
| HUMAN BODY | Nearly 70% of the body weight. |
| FOOD PRODUCTS | Green vegetables [80-90%], Milk [80-85%], Dry cereals [3-5%] |

# B. WATER – As a Compound

## THE WATER CYCLE

Nature maintains the water cycle by – *circulation of water from the earth's surface* – by evaporation to the atmosphere and – *back to the earth's surface as – rain water.*




The Water Cycle

## WATER – Is Considered a Compound and not an element.

- ***Henry Cavendish*** - *synthesized water* from its elements – [*2 vols. of hydrogen & 1 vol. of oxygen*] by *igniting the elements* in their respective ratios, thereby leading to the conclusion that– Water is not an element but a compound of – *hydrogen & oxygen* – combined in the *ratio 2:1.*
- ***A. Lavoisier*** - further confirmed that water is a compound of two elements – 'H' & 'O' & that a molecule of water is comprised of – *two atoms of hydrogen & one atom of oxygen.*

| PROPERTIES OF COMPOUNDS | WATER |
|---|---|
| 1. Compounds have a – fixed composition & the elements, combined in a – ***fixed proportion by weight.*** | 1. In water the elements – hydrogen and oxygen are combined in a – ***fixed proportion by weight.*** |
| 2. Compounds have ***new properties*** – & the original components lose their – individual properties. | 2. Properties of water – ***differ*** from the properties of its individual elements – hydrogen and oxygen. |
| 3. Components of a compound – ***can be separated by chemical means*** only and not by physical means. | 3. The components hydrogen and oxygen – ***can be separated by chemical means*** – [eg. electrolysis] but not by physical means. |

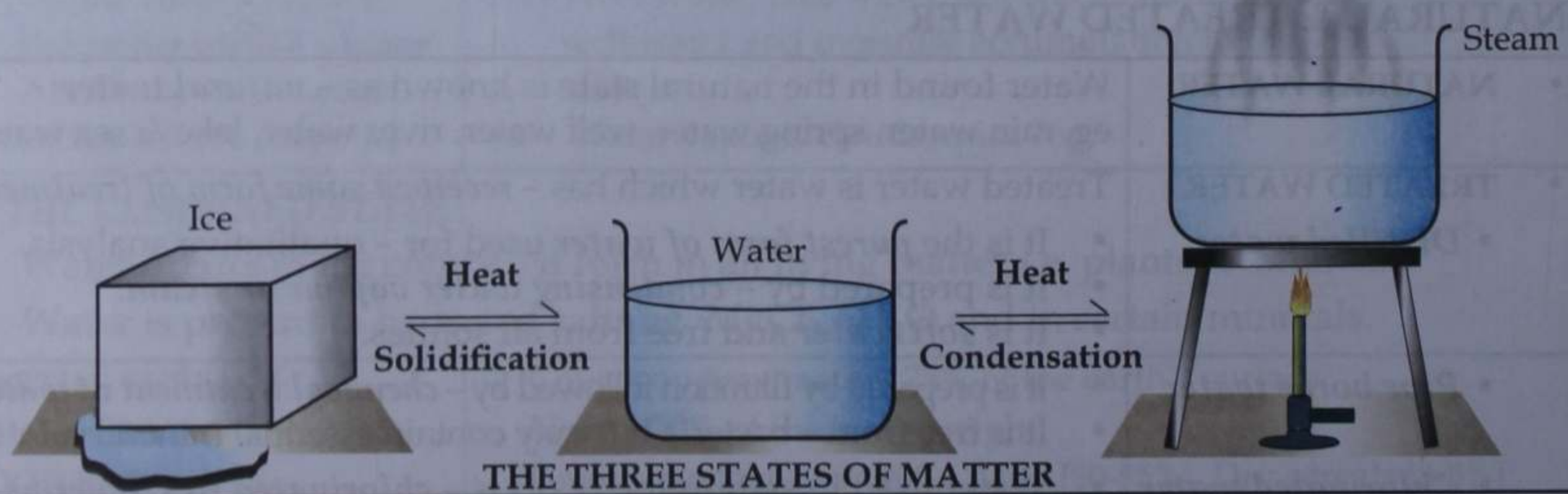
## NATURAL & TREATED WATER

| | |
|---|---|
| • NATURAL WATER | Water found in the natural state is known as – ***natural water*** eg. rain water, spring water, well water, river water, lake & sea water. |
| • TREATED WATER | Treated water is water which has – ***received some form of treatment.*** |
| • *Distilled water* | • It is the ***purest form of water*** used for – qualitative analysis.<br>• It is prepared by – ***condensing water vapour or steam.***<br>• It is ***soft water*** and free from all solutes. |
| • *Pipe borne water* | • It is prepared by filtration followed by – ***chemical treatment of water.***<br>• It is free from – bacteria but may contain essential mineral solutes. |
| • *Chlorinated water* | • Water used in swimming pools is – ***chlorinated to kill germs.*** |

| PHYSICAL PROPERTIES | |
|---|---|
| 1. COLOUR | Colourless, transparent clear liquid. |
| 2. ODOUR | Odourless |
| 3. TASTE | Tasteless<br>*[slight taste in drinking water due to the presence of dissolved gases & minerals].* |
| 4. BOILING POINT | 100°C – at a pressure of 760 mm of Hg [normal atmos. pressure] |
| 5. FREEZING POINT | 0°C – at a pressure of 760 mm of Hg |
| 6. DENSITY | Maximum density of – 1 g/cm$^3$ at 4°C. |
| 7. CONDUCTIVITY | Bad conductor of heat and electricity. |
| 8. DIELECTRIC CONSTANT | High dielectric constant<br>[property due to which force of attraction between ions in an electrovalent compound are reduced]. |
| 9. UNIVERSAL SOLVENT | Water is the best solvent & can dissolve many more substances – than any other solvent, due to its polar covalent nature.<br>All electrovalent compounds eg. mineral acids, bases and salts – dissolve in water.<br>All covalent compounds which contain the hydroxyl group [–OH]– also dissolve easily in water eg. alcohol.<br>Gases which ionize to a great extent in solution or react with water– are *highly soluble in water* e.g. $NH_3$, HCl.<br>Gases which ionize slightly are found to be – *fairly soluble in water* e.g. $CO_2$, $SO_2$, $Cl_2$<br>Gases which do no not ionize at all in water – are only sparingly i.e. *very slightly soluble in water*. e.g. $O_2$, $H_2$, $N_2$, CO. |

**WATER – Exists in all three states i.e. liquid, solid & gas**

- Water exists in *liquid state* at ordinary temperatures.
  When cooled below 0°C – it freezes into brittle ice crystals [*solid state*] which on – warming are again – converted to water [*liquid state*].
- On heating under normal pressure [760 mm], water boils at 100°C – & changes rapidly into steam [a gaseous state] which on condensation gives water.




THE THREE STATES OF MATTER

**BOILING AND FREEZING POINTS OF WATER ARE AFFECTED BY – CHANGE IN PRESSURE AND BY ADDITION OF SOLUTES**

- If **pressure increases** – on the surface of water –
  - its *boiling point* – *increases* & vice-versa.
  - its *freezing point* – *decreases* ie. falls below 0°C.
- If **dissolved impurities** – are present in water –
  - its *boiling point* – *increases* & –
  - its *freezing point* – *decreases*.

**WATER EXHIBITS – ANOMALOUS EXPANSION**

- Water on cooling first contracts but at temperatures of 4°C – starts expanding till it freezes into solid ice at 0°C. Hence *water at 4°C – has maximum density & minimum volume.*
- *Ice* therefore has density – *lower than water at higher temperatures* & hence – ***floats on water*** – thus enabling marine life to exist below it.

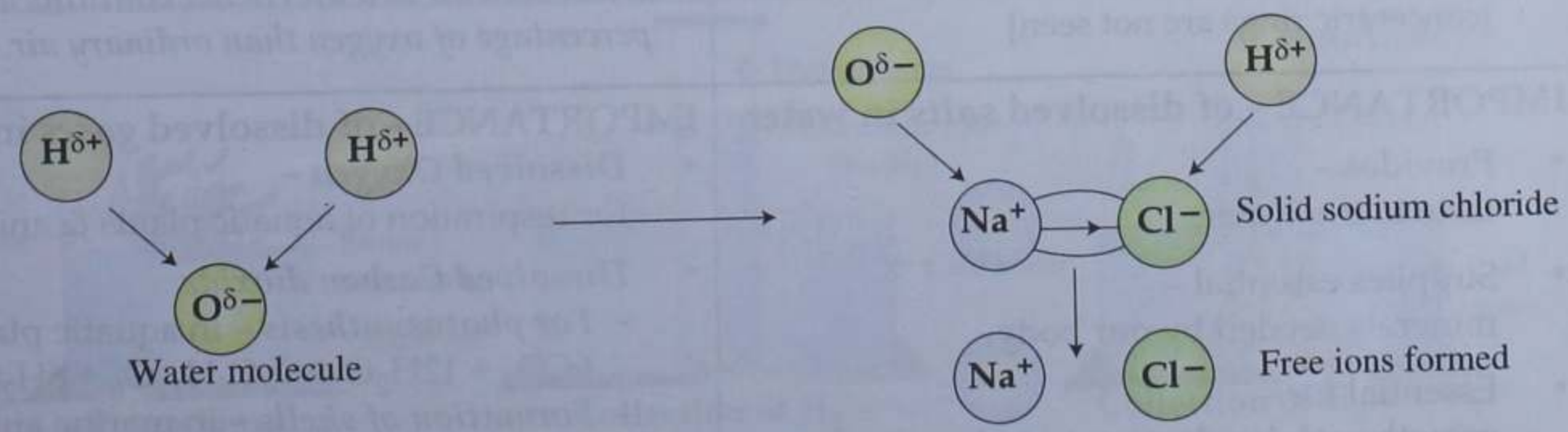
**WATER IN – CONTROLLING OR MODIFYING THE CLIMATE**

- Water finds application in cooling systems and – in controlling or modifying the climate of the nearby land adjacent to large areas of water thereby making them – warmer or cooler depending on the seasonal conditions.

  Specific heat capacity of water [i.e. the amount of heat absorbed by 1 g of water when heated through 1°C] is high. Hence water requires – more heat to raise its temperature by 1°C than an equal mass of any other specific substance in the solid or liquid state.

**WATER IS – A UNIVERSAL SOLVENT**

- Water is a ***polar covalent compound*** [covalent compound exhibiting charge separation] and has a – ***high dielectric constant*** due to which it has a unique ability to – break or reduce the electrostatic force of attraction holding the positively & negatively charged ions of an ionic [electrovalent] compound. Thus ions of an – ***electrovalent compound*** become mobile & the compound ***rapidly dissolves in water.***
- Thus water dissolves – ***inorganic*** [usually electrovalent] compounds, certain – ***organic compounds*** [carbohydrates, proteins] and a large number of ***gases*** and – hence is called a ***'universal solvent'***.




**Dissociation of sodium chloride in water**

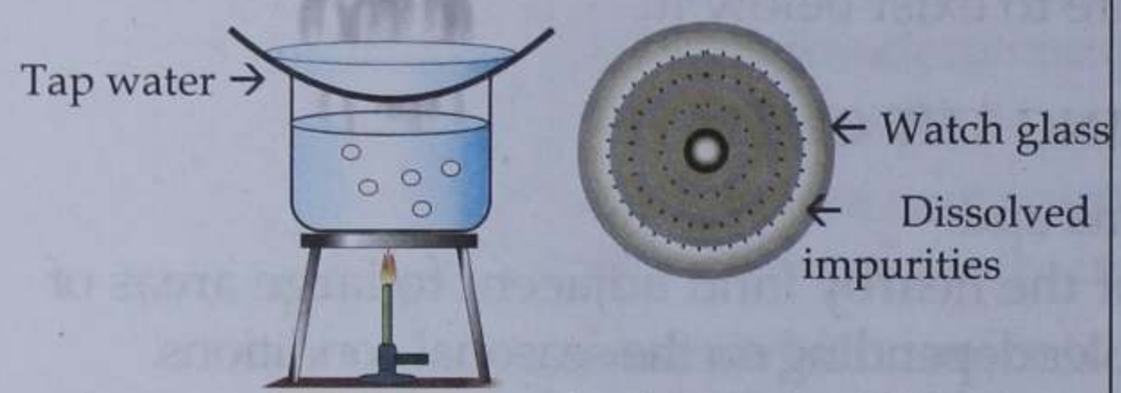
## TAP WATER CONTAINS – Dissolved Solids

**PROCEDURE :**

- A beaker half-filled with water is taken & – ***slowly heated*** with the help of a burner.
- A large watch glass containing tap water – is carefully placed over the beaker, as shown.

**OBSERVATIONS :**

- The ***boiling water*** in the beaker produces – steam whose heat evaporates all the water in the watch glass. The watch glass is then seen against light when – ***concentric rings*** of ***solid material*** are seen to be present.
- The experiment is repeated with river water, well water, rain water and distilled water.




**Experiment to show presence of – *dissolved solids in water***

**COMPOSITION OF – Dissolved Solids in Water**

- The concentric rings in the watch glass contain solid matter which are dissolved solids left behind after evaporation of water.
- The dissolved solids are **salts, minerals** and **impurities** which remain dissolved in water.

**CONCLUSIONS :**

**Tap or drinking water, river water, well water**

- ***contains*** – dissolved solids [concentric rings are seen]

**Rain water, distilled water**

- ***does not contain*** – dissolved solids [concentric rings are not seen]

**IMPORTANCE – of dissolved *salts* in water**

- Provides – taste to the water.
- Supplies essential – minerals needed by our body.
- Essential for – growth and development of plants.

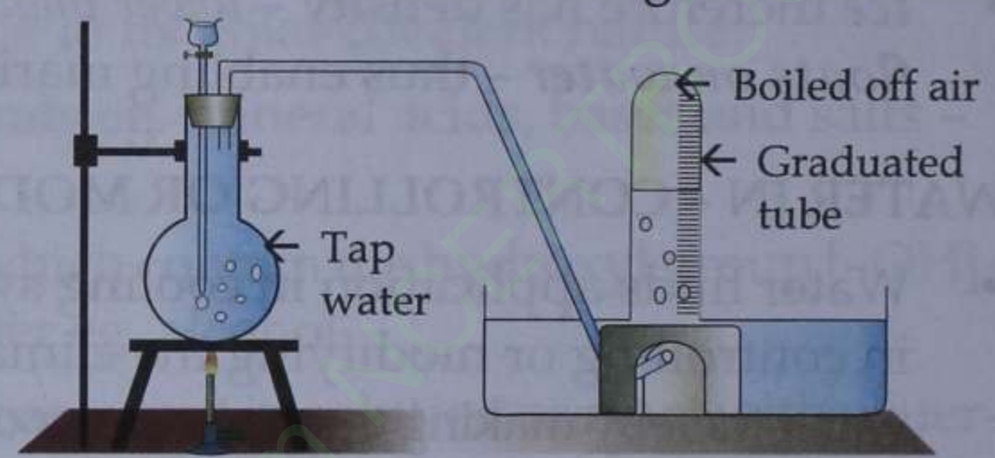
## TAP WATER CONTAINS – Dissolved Gases

**PROCEDURE :**

- Fill a round bottom flask completely with tap water and a graduated tube completely filled with water is inverted over the delivery tube in the trough.

**OBSERVATIONS :**

- When the water is boiled – ***bubbles of gas*** [air] are formed in the flask which rise up the delivery tube & collect in the graduated tube. The heating is continued till – no more bubbles are evolved.
- The ***dissolved gases*** are evolved out on boiling & its volume is noted in the graduated tube.




**Experiment to show presence of – *air dissolved in water***

**COMPOSITION OF – Dissolved Gases in Water**

| Percentage by – *volume of dissolved gases.* | | | |
|---|---|---|---|
| *IN ORDINARY AIR* | | *IN BOILED OFF AIR* | |
| *Oxygen* | 21% | *Oxygen* | 30-35% |
| *Nitrogen* | 78-79% | *Nitrogen* | 65-66% |
| *Carbon dioxide* | 0.03% | *Carbon dioxide* | 0.6% |

**CONCLUSIONS :**

**Tap or drinking water contains dissolved air**

- The % of $O_2$ & $N_2$ in boiled off air [air dissolved in water] differs from that in ordinary air since $O_2$ is more soluble in water than $N_2$,
- ***Dissolved air in water hence contains a – higher percentage of oxygen than ordinary air.***

**IMPORTANCE – of dissolved *gases* in water**

- ***Dissolved Oxygen*** – for respiration of aquatic plants & animals.
- ***Dissolved Carbon dioxide***
  - ***For photosynthesis*** – in aquatic plants.
    $6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6H_20 + 6O_2$
  - ***Formation of shells*** – in marine animals.
    $\underset{\text{[insoluble]}}{CaCO_3} + H_2O + CO_2 \rightarrow \underset{\text{[soluble layer]}}{Ca(HCO_3)_2}$

# D. CHEMICAL PROPERTIES – Of Water

**NATURE OF WATER :**

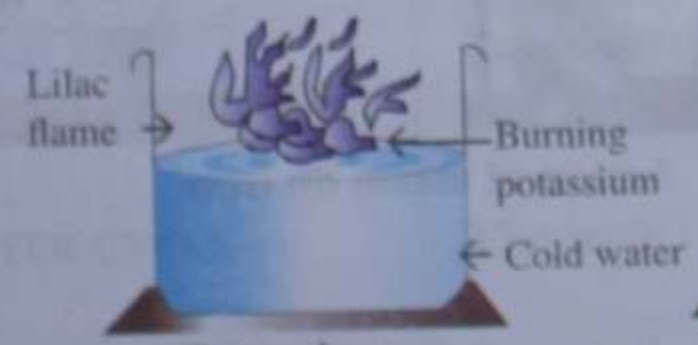
- Water in the pure state is – ***neutral to litmus*** & – ***stable in nature*** & decomposes slightly at temperatures above 2000°C.
- Certain reactions take place in pure water where it acts as a – ***catalyst***. eg.
  - ***Synthesis of*** – *hydrogen chloride in presence of moisture* : $H_2 + Cl_2 \rightarrow 2HCl$
  - ***Combustion of*** – *white phosphorus to phosphorus pentoxide* : $4P + 5O_2 \rightarrow 2P_2O_5$

## 1. REACTIONS OF COLD WATER WITH METALS - *Potassium, Sodium, Calcium*

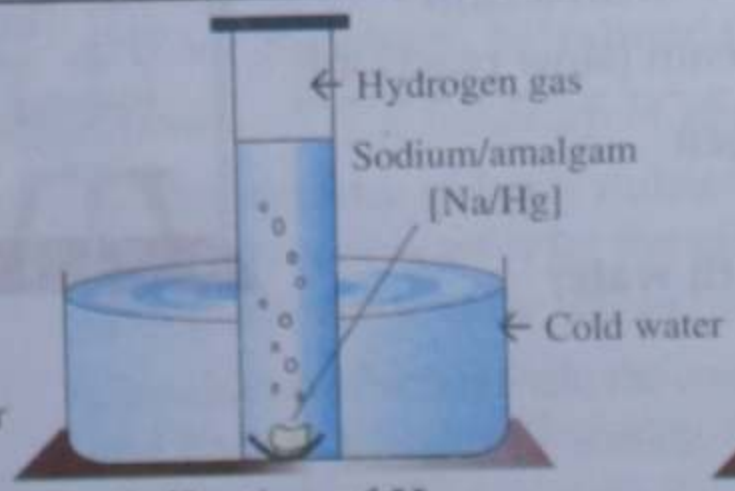
**PROCEDURE** – Cut a piece of potassium, sodium or calcium with a knife – pick it up with a pair of forceps – & gently drop it on the surface of – ***cold water***.

**OBSERVATION** – The following observations are seen :

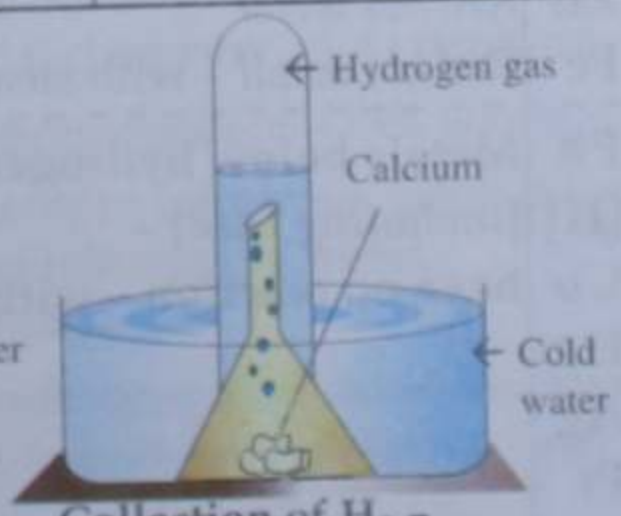
| | POTASSIUM | SODIUM | CALCIUM |
|---|---|---|---|
| • DENSITY & M.P. | 0.86 g/cc – 62°C | 0.97 g/cc – 97°C | 1.55 g/cc – 810°C |
| • OBSERVATION | • ***Floats*** – on water.<br>• ***Melts*** – forming a silver grey globule which ***darts*** – about on the surface of water haphazardly. | • ***Floats*** – on water.<br>• ***Melts*** – forming a silvery globule which ***revolves*** & ***darts*** – about on the surface of water. | • ***Sinks*** – in water.<br>• ***Sinks*** – down, the area around the metal turns milky. ***Smooth reaction*** – with water. |
| • NATURE OF REACTION | • Reaction is – ***highly exothermic*** & vigorous. | • Reaction is ***comparatively less exothermic*** & vigorous. | • Reaction is ***much less*** vigorous comparatively smooth. |
| • COLOUR OF FLAME | • Catches fire & – burns with a – ***lilac flame***. | • Catches fire & – burns with a – ***golden yellow flame***. | • Sinks - ***does not catch fire in water***. |
| • NATURE OF SOLUTION | • Bubbles of – ***hydrogen evolved***.<br>• Residual solution – ***colourless, soapy & warm***.<br>• ***Soln. alkali*** – in nature [red litmus turns blue.] | • Bubbles of – ***hydrogen evolved***.<br>• Residual solution – ***colourless, soapy, & slightly warm***.<br>• ***Soln. alkali*** – in nature. [red litmus turns blue] | • Bubbles of – ***hydrogen evolved***.<br>• Residual solution – ***milky, turbid & warm***.<br>• ***Soln. alkali*** – in nature [red litmus turns blue] |
| • EQUATION | $2K + 2H_2O \rightarrow 2KOH + H_2$ | $2Na + 2H_2O \rightarrow 2NaOH + H_2$ | $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ |




**Potassium – added to cold water**




**Collection of $H_2$ – using Na/Hg & water**




**Collection of $H_2$ – using Ca & cold water**

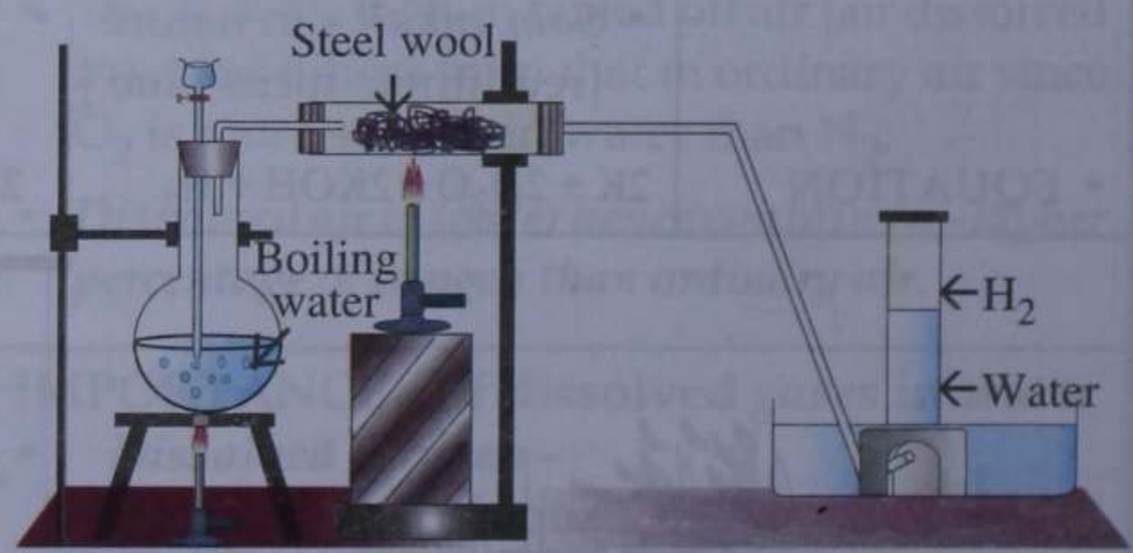
## 2. REACTIONS OF BOILING WATER & STEAM WITH METALS - *Mg, Al, Zn, Fe*

| | |
|---|---|
| • MAGNESIUM | • **No reaction** with – *cold water,* **slow reaction** with – *boiling water.*<br>• *Burning* magnesium burns with a *dazzling white light* and reacts – with *steam* forming a coating of white *magnesium oxide* on its surface.<br>• The coating later crumbles down due to heat – exposing the magnesium further to steam resulting in – *liberation of hydrogen.*<br>[The gas liberated gives a 'pop' sound when a lighted taper is brought near it.]<br>$Mg + H_2O \rightarrow MgO + H_2$ [g] |
| • ALUMINIUM | • Aluminium **does not react** with – *cold* or *boiling water.*<br>• A compact coating of – **aluminium oxide** renders the – *metal inactive.*<br>• The coating breaks at high temp. & Al reacts with steam – liberating $H_2$<br>$2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2$ |
| • ZINC | • Zinc in the *red hot state* reacts with – steam when it is – passed over it forming – **zinc oxide** and – *liberating hydrogen.*<br>$Zn + H_2O \rightarrow ZnO + H_2$ |
| • IRON | • Iron in the *red hot state* reacts with – steam forming – *triferric tetroxide* & hydrogen.<br>The above reaction of iron with steam is – **reversible**<br>[ie. the products interact under the same conditions to give back the reactants].<br>$3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$ [g] |

- The reaction of –
  **K** with **cold water** is – *very vigorous,* of **Na** is – *less vigorous* & of **Ca** – *least vigorous.*
  **Mg** & **Al** with **steam** is – *fastest,* of **Zn** with **steam** is – *slow* & of **Fe** with **steam** is – *slowest.*
- Thus metals can be arranged in order of their – *increasing reactivity with water.*
- **A series of metals arranged according to their decreasing reactivity is called – *Activity Series.***

### REACTIVITY SERIES OF METALS

| | |
|---|---|
| **K** | *Vigorous reaction* – with cold water |
| **Na** | *Less vigorous reaction* – with cold water |
| **Ca** | *Mild reaction* – with cold water |
| **Mg** | *Heated metal* – with boiling water or steam |
| **Al** | *Heated metal* – with steam |
| **Zn** | *Red hot metal* – with steam |
| **Fe** | *Red hot metal* – with steam [slow reaction] |
| **Pb** | **Metals below hydrogen** |
| **[H]** | **[*including lead*] –** |
| **Cu** | **have no reaction – with water** |
| **Hg** | |
| **Ag** | |
| **Pt** | |
| **Au** | |




**Action of steam on iron**

## D. CHEMICAL PROPERTIES – Of Water [Contd.]

| 3. REACTIONS OF WATER WITH – Non-metals, Non-metallic & Metallic Oxides | | |
|---|---|---|
| NON-METAL | | |
| • Carbon | *Steam is passed over red hot coke –* • Water gas [$CO : H_2$] is formed | $C + H_2O \rightarrow \underbrace{CO + H_2}_{\text{water gas}}$ (coke, steam) |
| • Chlorine | *Chlorine gas is bubbled through water –* • Chlorine water [HCl:HClO] is formed | $Cl_2 + H_2O \rightarrow HCl + HClO$ |
| NON-METALLIC OXIDES | *Dissolves in cold water forming –* | |
| • Sulphur dioxide | • Sulphurous acid [$H_2SO_3$] | $SO_2 + H_2O \rightarrow H_2SO_3$ |
| • Sulphur trioxide | • Sulphuric acid [$H_2SO_4$] | $SO_3 + H_2O \rightarrow H_2SO_4$ |
| • Carbon dioxide | • Carbonic acid [$H_2CO_3$] | $CO_2 + H_2O \rightarrow H_2CO_3$ |
| • Nitrogen dioxide | • Nitrous [$HNO_2$] & nitric acid [$HNO_3$] | $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$ |
| METALLIC OXIDES | *Reacts with water forming –* | |
| • Potassium oxide | • Potassium hydroxide [KOH] | $K_2O + H_2O \rightarrow 2KOH$ |
| • Calcium oxide | • Calcium hydroxide [$Ca(OH)_2$] | $CaO + H_2O \rightarrow Ca(OH)_2$ |

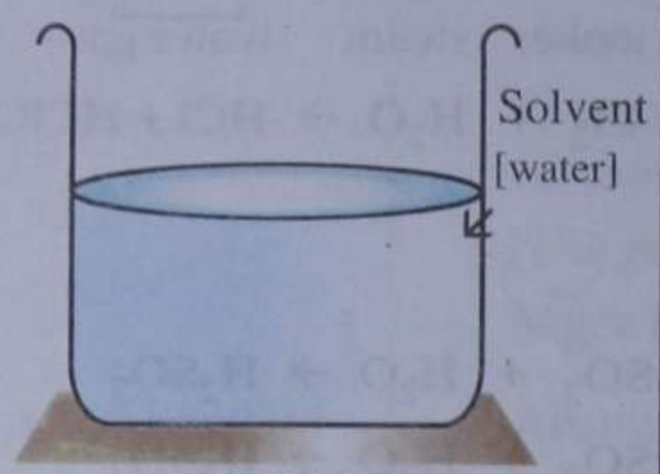
## E. TESTS FOR WATER

| TEST | OBSERVATION | | | |
|---|---|---|---|---|
| • PHYSICAL TESTS | • **Boiling Point** - 100°C at a pressure of 760 mm of Hg. • **Freezing Point** - 0°C at a pressure of 760 mm of Hg. | | | |
| • CHEMICAL TESTS | • Addition of water to certain anhydrous salts may result in – formation of hydrated salts which may be accompanied by ***change in colour.*** | | | |
| | SALT | ANHYDROUS | HYDRATED | EQUATION |
| | **Copper sulphate** | White | Blue | $CuSO_4 + 5H_2O \rightarrow CuSO_4.5H_2O$ [*white*] [*blue*] |
| | **Cobalt chloride** | Blue | Pink | $CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$ [*blue*] [*pink*] |

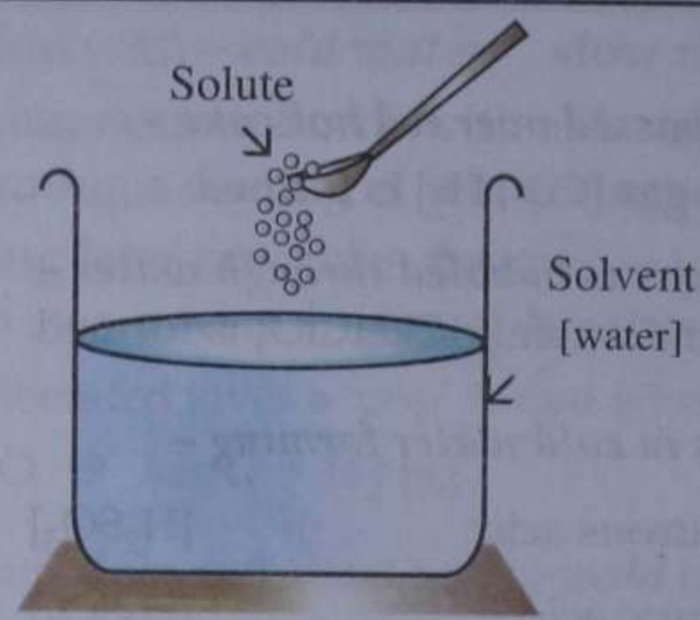
## F. USES OF WATER

| | | |
|---|---|---|
| UNIVERSAL SOLVENT | **Reason :** | Dissolves ***inorganic*** and ***organic*** compounds due to its – polar covalent nature and high dielectric constant. |
| | **Solvent in :** | a] Plant chemistry, b] Industrial chemistry, c] Agriculture. |
| HUMAN BODY | **Constituent :** | Human body is made up of approximately – 75% water. |
| | **Function :** | a] Transference of body nutrients in cells in aq. solutions. b] Removal of wastes by the elimination of water. c] Regulation of body temperature. |
| WATER CYCLE | **The term :** | Circulation of water from the earth's surface to the atmosphere and back to the earth's surface constitutes the – ***water cycle.*** |
| | **Function :** | The climate is greatly influenced by the water cycle. |
| INDUSTRY | **Industries :** | Metallurgical, fuel, pharmaceutical, etc. |

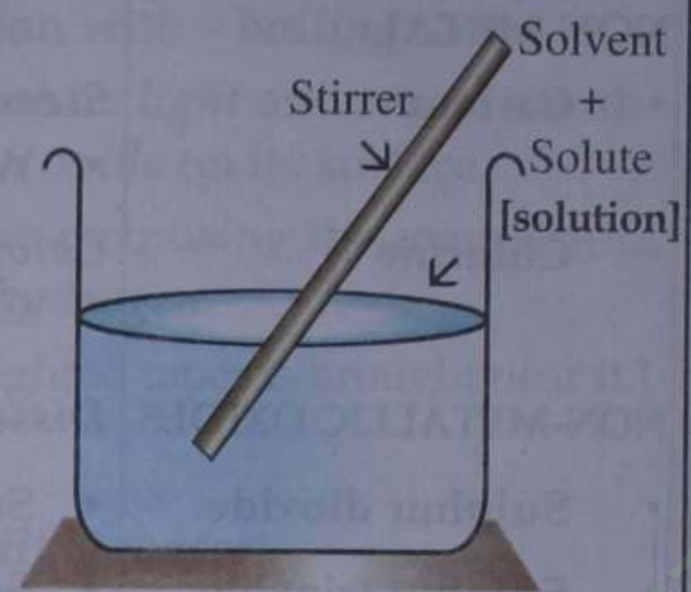
## THE TERMS - SOLVENT, SOLUTE, SOLUTION




**SOLVENT** +
[water]




**SOLUTE** →
[Sodium chloride]




**SOLUTION**
[Aqueous solution of NaCl]

### SOLVENT

**Liquid** [generally water] or – **medium of dissolution** – which allows the solute to dissolve in it so as to form – a solution is called a – **solvent**.

### SOLUTE

**Substance which dissolves** or – disappears in the solvent to form– a solution is called a – **solute.**

### SOLUTION

**A homogenous mixture of – a solute in a solvent** [i.e. a uniform mixture of two or more substances] whose composition maybe gradually changed by changing the – relative amount of components.

## DILUTE & CONCENTRATED SOLUTIONS.

**Amount of solute in a given weight of solvent determines the conc. of the solution.**

*DILUTE SOLUTION*

A solution in which the amount of – ***solute is relatively small*** – compared to the amount of solvent in – a given mass of it is called a ***dilute solution***.

*CONCENTRATED SOLUTION*

A solution in which the amount of – ***solute is relatively large*** – compared to the amount of solvent in– a given mass of it is called a ***concentrated solution***.

## TRUE SOLUTIONS

**A true solution has its – *own characteristic properties.***

- **NATURE** — It is clear, transparent and – ***homogenous in nature.***
- **PARTICLE SIZE** — Particle size is molecular and the particles -
  - ***Can pass*** – through the pores of filter paper.
  - ***Cannot be seen*** – under a microscope.
  - ***Do not*** – settle down.
- **SEPARATION** — Solute can be recovered from the solvent by – physical and not by chemical means.

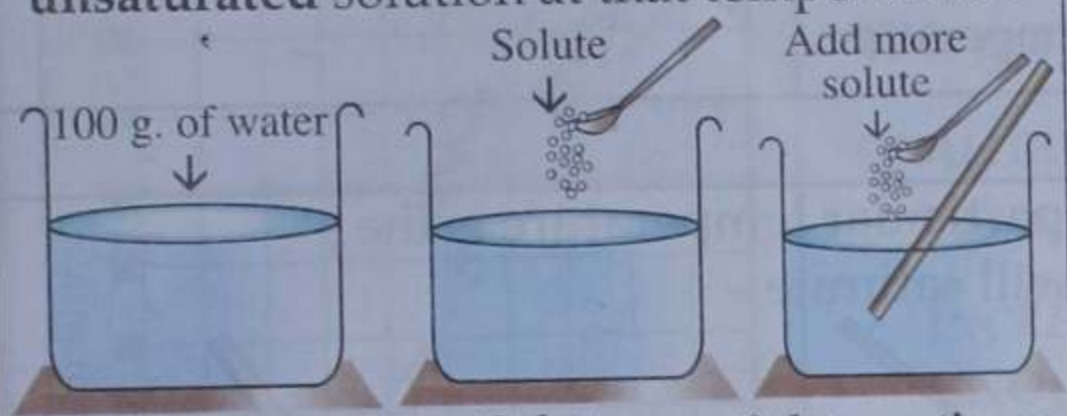
  ***A true solution is therefore – a mixture and not a compound.***

# H. SOLUTIONS – Saturated solutions.

## SATURATED SOLUTIONS

### *UNSATURATED SOLUTION*

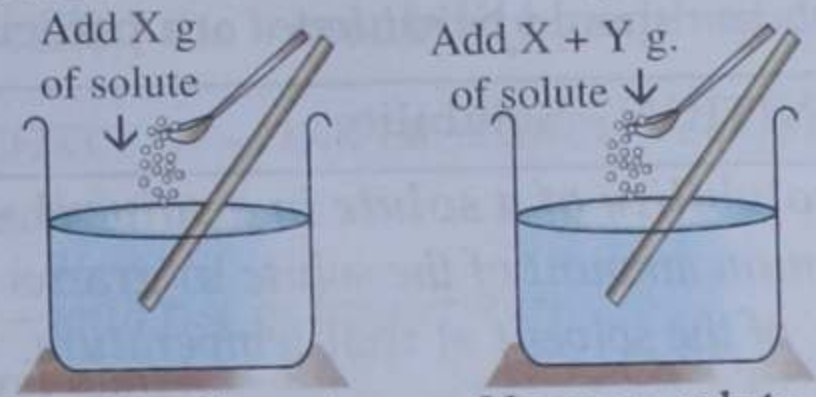
A solution which – ***can dissolve*** more of the solute at a given temperature is called an– **unsaturated** solution at that temperature.




Temp. t°C | Solute dissolves | Solute continues to dissolve

### *SATURATED SOLUTION*

A solution which – ***cannot dissolve*** more of the solute at a given temperature is called a– **saturated** solution at that temperature.




Solute dissolves at temp t°C. | No more solute dissolves at temp t°C.

A SATURATED SOLUTION – *Can be converted to an unsaturated solution –*

- ***By heating the saturated solution slowly.***
  A saturated solution can dissolve – more of the solute at a higher temperature.
- ***By adding more solvent to the saturated solution.***
  Increased amount of solvent can dissolve – more of the solute at that temperature.

A SUPERSATURATED SOLUTION – *Differs from a saturated solution –*

- **Super saturated solution -**
  It is one which can hold or contains –
  *more of the solute at a given temperature than that present in a saturated solution.*
- **Preparation -**
  A saturated solution of a solute [eg. nitre] is prepared in boiling water.
  If the above solution is cooled excess nitre separates out from the hot saturated solution
  The hot solution therefore contains more of the solute dissolved in than it can hold at that given temperature and is thus called a – ***supersaturated solution.***
- **Exceptions -**
  With certain substances eg. $Na_2SO_4.10H_2O$ it is possible to cool a saturated solution without excess solute crystallizing out provided – *no undissolved solids are present*

SOLVENTS - [Other than water]

| *Solvents* | *Solute it dissolves* | *Solvents in everyday life* |
|---|---|---|
| **Benzene** | Rubber | 1. **In laundries and dry cleaners**<br>• *Petrol, kerosene* or *ammonia solution* – for removing grease stains<br>• *Turpentine* – for removing paint stains<br>• *Borax solution* – for removing coffee or tea stains. |
| **Turpentine oil** | Paints, paraffin wax | |
| **Carbon disulphide** | Sulphur, phosphorus | |
| **Petrol** | Grease, chlorophyll, rubber | 2. **In manufacture of perfumes**<br>• Aromatic oils - dissolved in *alcohol.* |
| **Acetone** | Cellulose acetate [nail polish] | 3. **Extraction of chlorophyll in laboratory**<br>• By boiling the leaves in – *alcohol.* |
| **Alcohol** | Iodine, napthalene, chlorophyll | 4. **Dressing wounds in dispensary**<br>• Iodine dissolved in – *alcohol* is used as tincture of iodine. |
| **Oxalic acid** | Rust | |
| **Methylated spirit** | Chlorophyll | |

# I. SOLUBILITY

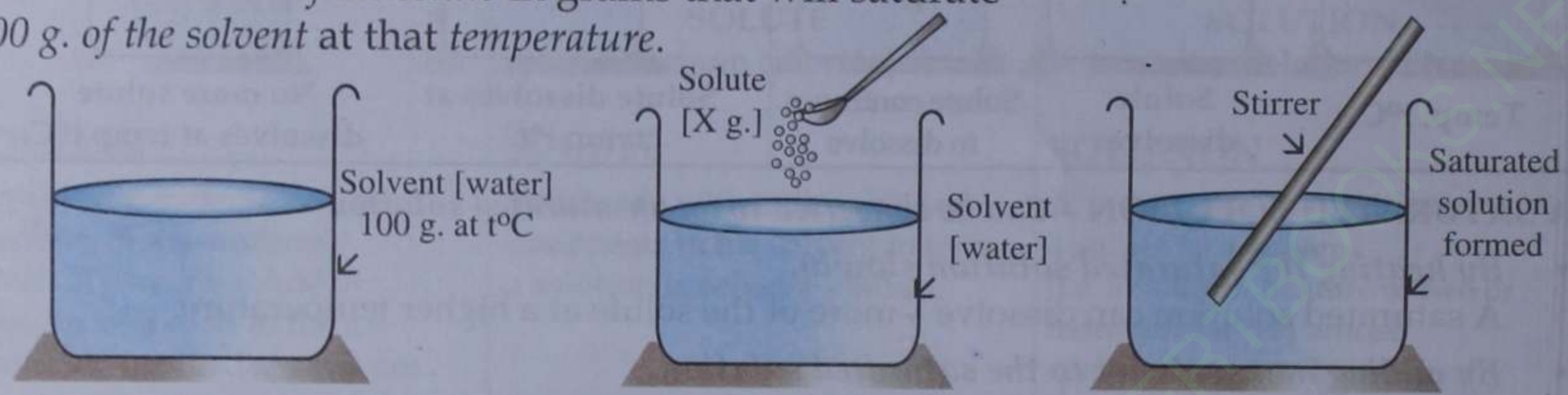
## INTRODUCTION

Different solutes dissolve to a different extent in the same mass of a solvent i.e. they have different – *solubilities*.

***Solubility*** – is the ability of a *solute* to dissolve in a particular *solvent*.
To obtain a uniform result, the amount of *solvent* is fixed [100 g.] & – the *solution* should be *saturated* at a particular temperature.

## DEFINITION – Solubility

***The solubility of a solute in a solvent*** – at a particular temperature is the – *maximum amount of the solute* in grams that will saturate – *100 g. of the solvent* at that *temperature*.




**SOLUBILITY – of a Solute *[at t°C]***

$$= \frac{\text{Weight of solute [g.]}}{\text{Weight of solvent [g.]}} \times 100 \quad \text{i.e.} \quad \frac{\text{Weight of solute [g.]}}{\text{Wt. of solution - Wt. of solute [g.]}} \times 100$$

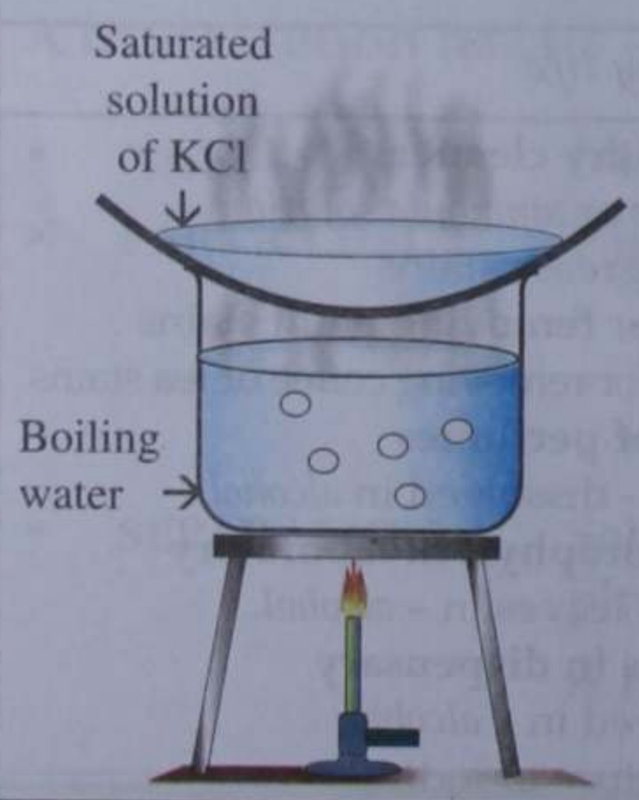
## DETERMINATION – Of Solubility

**To determine the solubility of a – *solute [KCl] at room temperature*.**

**STEP I : PREPARATION OF THE SATURATED SOLUTION OF POTASSIUM CHLORIDE [KCl].**

- Take a boiling tube half-filled with about – *100 ml. of distilled water.*
- Add crystals of potassium chloride – to the distilled water and stir slowly.
- Continue stirring till the crystals dissolve. Repeat the process till no more salt can dissolve.
- Pour the saturated solution – in a clean dry test-tube.

**STEP II : DETERMINATION OF THE SOLUBILITY OF THE SOLUTE**



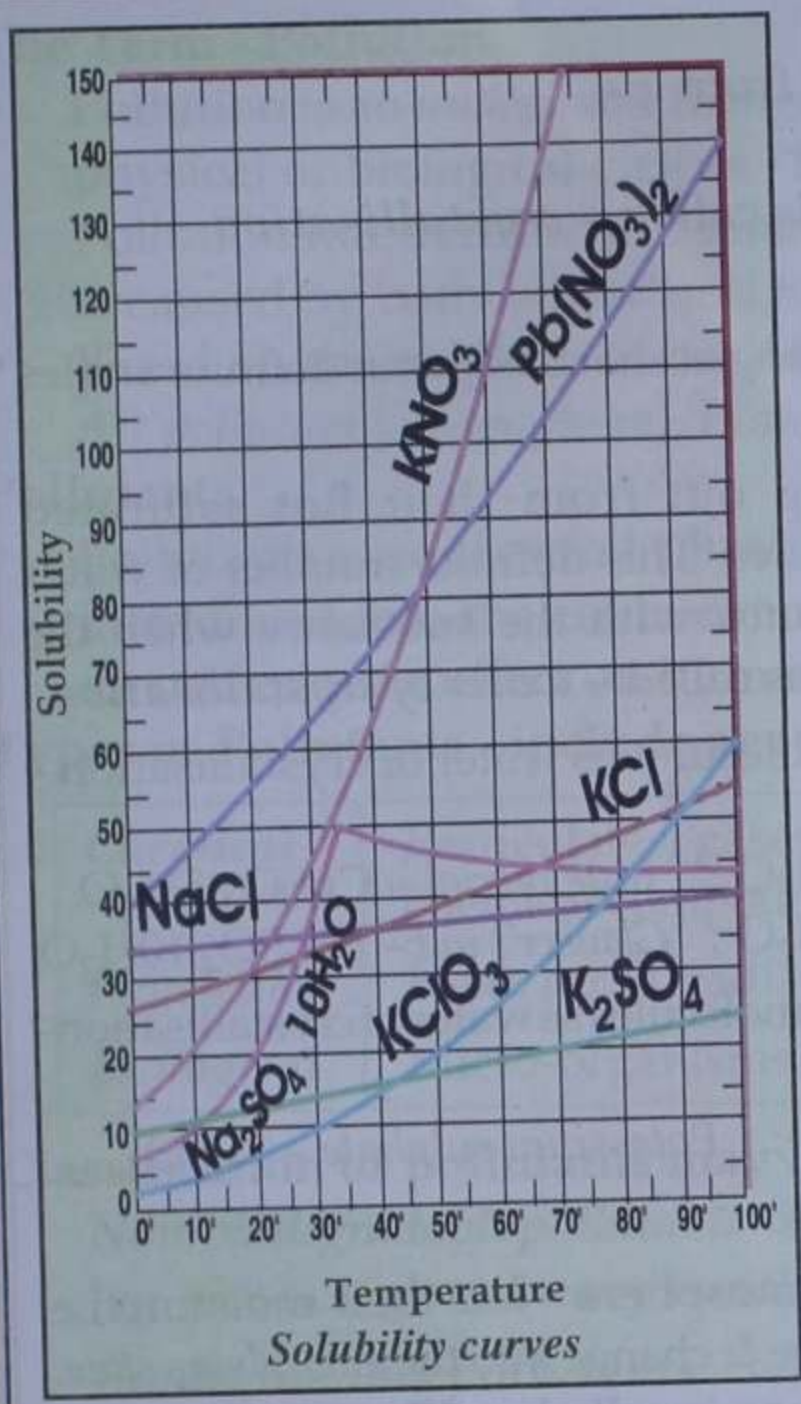

- Weigh a clean and dry evaporating dish = M g.
- Add the above saturated soln. to it and reweigh = $M_1$ g.
- Heat the solution to dryness as shown in the fig. and reweigh the dish with residue = $M_2$ g.
- Note the temperature of the saturated solution = t°C

$$\textbf{Solubility} = \frac{\text{Weight of solute}}{\text{Weight of solvent}} \times 100$$

$$= \frac{[M_2 - M]\ \text{g.}}{[M_1 - M_2]\ \text{g.}} \times 100 \text{ at } t^oC$$

# I. SOLUBILITY – Qualitative effect of temperature on solubility

## SOLUBILITY CURVE




*Solubility curves*

***If the solubility of a solute – in a given solvent –*** are plotted against their respective *temperatures* – a graph showing the effect of – temperature on solubility of the substance is obtained. This graph is called the – **solubility graph or curve**.

*QUALITATIVE EFFECT OF – TEMPERATURE ON SOLUBILITY*

***Solids whose solubility***

- *INCREASES – with rise in temperature.*
  **$KNO_3$** – other examples – $KClO_3$, $NaNO_3$, $CuSO_4$, $NH_4Cl$.
- *INCREASES SLIGHTLY – with rise in temperature.*
  **NaCl** – other examples – KCl, $Ca(OH)_2$ [below 70°C].
- *DECREASES – with rise in temperature.*
  **$CaSO_4$** – other examples – $Ca(OH)_2$ [above 70°C].

– **$Na_2SO_4.10H_2O$** shows a solubility curve with a – sharp break at 36°C. It is hydrous below 36°C & anhydrous above that temperature.

– **$KNO_3$** has the highest solubility at 100°C.

– Solubility of solids is – ***independent of change in pressure.***

***Solubility curves can be used –***

- *To determine –* Solubility of a given solute at a particular temperature.
- *To compare –* Solubilities of different solutes in a solvent at a given temperature.
- *To calculate –* Amount of substance which will crystallize out – when a hot saturated solution is cooled to a lower temperature.

**SOLUBILITY OF GASES –**

**An increase in pressure on the surface of water – causes**

– *Increase in solubility* – of gas in water.

– Soda contains carbon dioxide dissolved in water under pressure.

On opening the bottle the gas rapidly bubbles out since the – *pressure* on the surface of the water *suddenly decreases* and – so does the solubility of carbon dioxide gas in water.

**An *increase* in temperature of water – causes**

– *Decrease in solubility* – of gas in water.

– Gases are more soluble in cold water than in water at high temperatures.

– On boiling, water therefore loses its taste – since water contains soluble gases which contributes to the taste of water.

**COOLING – A hot saturated solution**

*Crystallisation*

The *process* by which *crystals* are separated or deposited from a – hot saturated solution of a substance on cooling slowly – followed by slow evaporation of the saturated solution is called – ***crystallisation***.

**Crystals –**

They are homogenous solids, arranged symmetrically, meeting at sharp edges at definite angles to one another and having a regular definite shape.

- Some substances while crystallising or separating out from their hot saturated solutions unite with a definite number of water molecules. This definite number of water molecules which enters into a – *loose chemical combination* with the substance when the substance is crystallised – from its hot saturated solution is called – ***water of crystallisation***.
- ***Hydrated substances*** – contain fixed number of water molecules as water of crystallisation – in loose chemical combination with the substance.
  eg. *Washing soda* – $Na_2CO_3.H_2O$ ; *Gypsum*– $CaSO_4.2H_2O$ ; *Blue vitriol* – $CuSO_4.5H_2O$ ; *Epsom salt* – $MgSO_4.7H_2O$ ; *Green vitriol* – $FeSO_4.7H_2O$ ; *Glauber's salt* – $Na_2SO_4.10H_2O$
- ***Anhydrous substances*** – do not contain any fixed number of molecules as water of crystallisation – in loose chemical combination with the substance.
  eg. *Potassium nitrate* – $KNO_3$ ; *Potassium chloride* – KCl ; *Potassium sulphate* – $K_2SO_4$

**Efflorescent crystals –**

- Crystalline hydrated salts – which on exposure to the atmosphere – *lose* their moisture i.e. water of crystallisation, partly or completely to the atmosphere & change into the *amorphous state*. The substance is called – **efflorescent** and the phenomenon is called – **efflorescence**.
  eg. *Washing soda* – $Na_2CO_3.H_2O$ ; *Blue vitriol* – $CuSO_4.5H_2O$ ; *Glauber's salt* – $Na_2SO_4.10H_2O$

**Deliquescent crystals –**

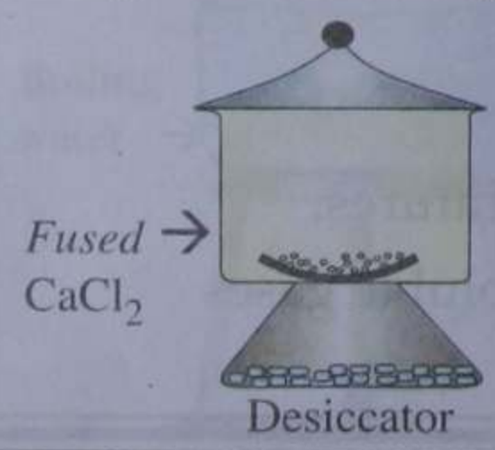
- Water soluble salts – which on exposure to the atmosphere – *absorb* moisture from the atmosphere, dissolve in the absorbed moisture & change into the *liquid state*. The substance is called – **deliquescent** and the phenomenon is called - **deliquescence**.
  eg. *Iron [III] chloride* – $FeCl_3$ ; *Calcium chloride* – $CaCl_2$ ; *Sodium hydroxide* – NaOH

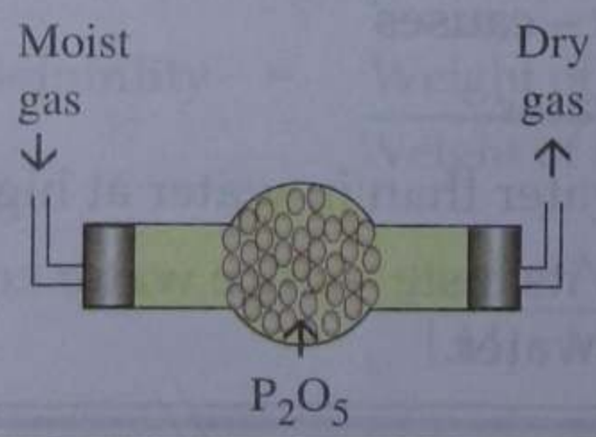
**Hygroscopic substances –**

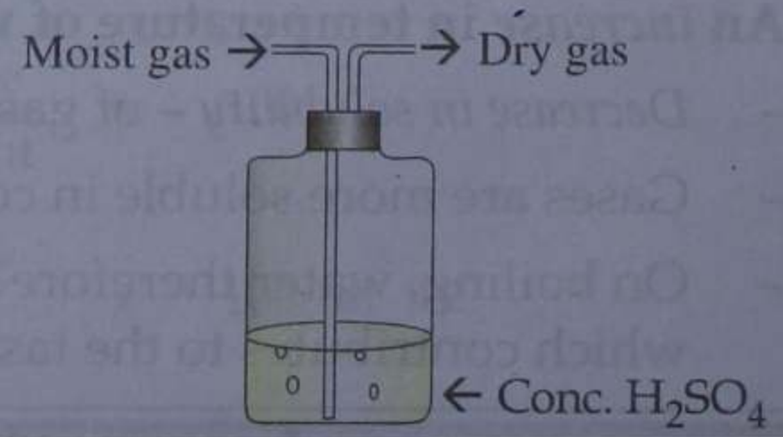
- *Hygroscopic substances* absorb moisture from the atmosphere when exposed to it but – unlike deliquescent substances *do not change their state* after absorption of moisture.
  eg. *Quicklime* – CaO ; *Anhydrous* – $CaCl_2$ ; $P_2O_5$ ; *Silica gel* ; *Conc.* $H_2SO_4$

**Drying or desiccating agents –**

- *Drying agents* are substances which can readily absorb or remove moisture from other substances. Most of the hygroscopic substances are drying agents.
  eg. *Fused* – $CaCl_2$ ; *Fused* – $P_2O_5$ ; *Conc.* $H_2SO_4$ ; *Quicklime* – CaO



# K. WATER POLLUTION

## 1. INTRODUCTION - Pollution

**The Term - Pollution**

- Pollution is an *undesirable change* in the *natural environment* brought about by - chemical, physical or biological factors - in air, water or land.
  Pollution interferes with human health and with ecosystem functioning and - is caused by both *natural* and *man-made sources*.
- Based on the medium of contamination of the earth's environment it is termed as - *Air pollution* [atmosphere], *Water pollution* [hydrosphere], *Soil pollution*.

**Pollutants**

- Pollutants - are *chemical, physical* or *biological agents* or foreign substances – introduced into the environment in quantities which have – an undesirable effect on human health and his environment.

**Types of Pollutants - include agents such as –**

| | |
|---|---|
| *Chemical* | Particulates, gases *[CO, $CO_2$, $SO_2$, $NO_2$ etc.]* heavy metals *[lead mercury]*, chemical compounds *[organic, inorganic]* solid & liquid wastes. |
| *Physical* | Heat, noise, radiation etc. |
| *Biological* | Micro-organisms |

**Classification of pollutants may include -**

***Non-biodegradable pollutants*** - which do not degrade by microbes or degrade very slowly. [eg. plastics, glass, heavy metal compounds, pesticides, etc.]

***Biodegradable pollutants*** - which can be decomposed by micro-organisms [their accumulation which may not degrade completely, causes pollution eg. sewage]

***Primary pollutants*** - emitted directly from their source into the environment eg. CO, $SO_2$, NO

***Secondary pollutants*** - formed from primary pollutants by secondary reactions eg. $CO_2$, $SO_3$, $NO_2$

## 2. WATER POLLUTION

**The Term - Water pollution**

- Water pollution - is an undesirable change in the *chemical, physical* and *biological* conditions of water due to the - presence of foreign substances in water.
  It leads to *degrade the quality of water* and makes it unsuitable for its designated use.
- **Contaminations of water through various sources** – deteriorates the ecosystem of water bodies.

| | |
|---|---|
| • *Household detergents* | • Chemical cleaning organic compounds - contains *phosphates* a major source of water pollution |
| • *Domestic sewage* | • Waste water from household activities - contains organic & inorganic materials - causing *water pollution* |
| • *Industrial waste* | • Waste from industrial sources - contains toxic chemicals - which pollutes water bodies |
| • *Offshore oil drilling* | • Exploring of oil & gas beneath ocean floors - releases drilling fluids & causes oil spills - *polluting water*. |
| • *Agricultural wastes* | • Residues of agricultural work i.e. pesticides, fertilizers, etc. - pollute water |
| • *Pathogens* | • Sewage discharge contains - bacteria viruses, etc. |

## 3. CAUSES *[SOURCES]* OF WATER POLLUTION

### A. HOUSEHOLD DETERGENTS

**Term**

- **Detergents are household chemical cleaning organic compounds –** used for laundering & dishwashing. They may contain -
  - *sodium hypochlorite* [NaClO] - an effective disinfectant, toxic in polluted water & *surfactants* - which are petroleum based non-biodegradable organic compounds. In addition detergents contain - ***phosphates*** - mainly *sodium triphosphate* [obtained by substituting hydrogen atoms of phosphoric acid [$H_3PO_4$] by a metal] ***Phosphates*** – soften water, stabilize alkalinity & hydrolyse grease and oil.

**Cause of pollution**

- **Phosphates are a major source of water pollution.**
  - Presence of *excessive plant nutrients* causes – pollution of water. Nutrients are supplied in the form of nitrogen, carbon & phosphorus generally from sewage. Sewage is an important source of phosphorus, when detergents containing large amounts of *phosphates* – enter from washing wastes.

**Impact of pollution**

- ***'Eutrophication'*** or *'increase in chemical nutrients in an ecosystem'* - occurs due to added *phosphates,* which increases *algal growth* [algal bloom]. This reduces – penetration of oxygen, light & heat into the water bodies. Algal bloom also leads to – *consumption of oxygen dissolved in water,* draining water of all its oxygen – resulting in death of marine organisms.

### B. SEWAGE

**Term**

- **Domestic sewage - is waste water generated from household activities.** [sewage also includes liquid waste from - *industry* & *commerce*]
  **Domestic sewage water contains -**
  - Organic materials & inorganic materials such as - *phosphates* & *nitrates.* *Organic* - from food & vegetables & *inorganic* - from soaps & detergents.

**Cause of pollution**

- **Improper handling of waste water** - is the main reason behind pollution.
- **Draining of sewage water without prior treatment** - also results in pollution

**Impact of pollution**

- **Careless disposal of sewage waste leads to –**
  - *Spreading of diseases* – Pathogenic micro-organisms enter the water system through sewage and the bacteria & viruses may cause - *malaria* & *typhoid.*
  - ***Eutrophication*** – Organic matter in sewage poured into water bodies generally results in excessive growth of algae - which *deoxygenates water.*
  **Increase in -**
  - ***Toxins*** - which when released through sewage are consumed by - fishes and other marine animals. Toxins may thus enter the food chain.
  - ***Chemical compounds*** - Nitrates, chlorides & sulphates which are already in water, increases in amounts through sewage waste. This leads to salinization *[salt concentration]* of soil & increase in soil erosion.
  - ***BOD*** – *[Biological oxygen demand]* increases through sewage water pollution. [BOD is a measure of oxygen utilized by micro-organisms during oxidation of organic matter. Higher the amount of BOD, more polluted is the water.]
  - **Control of water pollution** - hence can be done by proper handling of sewage waste.

## 3. CAUSES *[SOURCES]* OF WATER POLLUTION

### C. INDUSTRIAL WASTE

| | |
|---|---|
| **Term** | • **Industrial waste includes organic pollutants & toxic chemicals.** i.e. Heavy metals • Inorganic & organic compounds • Acids & alkalies • Oils, lubricants, grease & petroleum.<br>**Industrial water pollution** - is caused by emissions of industrial waste [effluent] into water bodies. It is the main source - of water pollution. |
| **Cause of pollution** | • **Industrial waste enters from -**<br>Iron & steel industry • Food industry • Mines •<br>Organic chemical industries - which include<br>paints, dyes, pesticides, detergents, plastic, paper, pharmaceutical, etc. |

POLLUTANTS FROM INDUSTRIES

| Pollutants | Industrial Sources | Impact of Industrial Waste |
|---|---|---|
| • **Heavy metals** | | |
| – *Lead* | Paint industry, smelting | – Lead inhibits action of bodily enzymes |
| – *Mercury* | Chemical industries | – Mercury transforms into water soluble *methylmercury* by bacterial action & thus contaminates fish. If fish is consumed it causes - *mercury poisoning*. |
| • **Inorganic compounds** | | |
| – *Nitrates & phosphates* | Fertilizer plants | Increased use of fertilizers, causes nitrates to be washed from the soil to rivers thus causing – *'eutrophication'* which is harmful for marine life. |
| • **Acids** | | |
| – Sulphuric acid | Mine drainage | – Acid causes corrosion of metals & concrete. |
| • **Alkalies** | Textile & paper industry | – Alkalies in industrial waste affects aquatic life. |
| • **Oil** | Oil refineries | – Oil waste is harmful for fish & marine birds. |
| • **Petrochemicals** | Petroleum plants | – Petrochemicals are toxic to marine life. |

- **Pollutants from – Food industry**
  The constituents of food & agricultural waste water are often complex to predict.
  – *Vegetable washing* - generates waste water with – increased particulate matter.
  – *Animal processing* - generates waste water with – added antibiotics, pesticides, etc.
  – *Processing foods* - produces wastes rich in – oil, flavouring & colouring matter.
- **Pollutants from – Organic chemical industry**
  These industries manufacture or use, complex organic chemicals which include - pesticides, paints, detergents, plastics etc. The organic chemicals contaminate - waste water with - *reactant materials, by products, cleaning agents* etc.
- **Pollutants from – Iron & steel industry**
  Conversion of iron to steel, contaminates waste water with - *hydraulic oils*.
  Treating iron & steel products for galvanizing [coating with zinc] or chromium plating - results in acidic rinse waters in waste waters.

## 3. CAUSES *[SOURCES]* OF WATER POLLUTION -

### D. OFFSHORE OIL DRILLING

**Term**

- ***Offshore oil drilling*** **- involves exploring for oil & gas beneath the ocean floor.** Before drilling an offshore oil-well, geologists first locate the wells using magnetic surveys. This is followed by drilling - *'exploratory wells'* to find out if there is a source of oil below. On discovery of oil or gas a - *'production well'* is drilled and an *'oil rig'* is built to replace the exploratory drilling rig.

**Cause of pollution**

- **The main sources of water pollution from offshore oil drilling are -**
  - ***Drilling fluid***
    Drilling mud or fluid is pumped into the well during drilling to - cool, lubricate & regulate the pressure while drilling.
    Residual drilling fluid is claimed to be toxic & contains - heavy metals & petroleum products of varying concentrations.
    *Impact of drilling fluid* - it affects the health & reproduction of marine animals.
  - ***Oil spills or leaks***
    It is the leakage of oil & petroleum products into sea water due to - accidents of ships & oil tankers or leakages of pipelines & storage tanks. They occur when oil is being *produced* – from offshore well & stored temporarily or may also happen during *transportation* – by pipes or tankers.
- **Other sources** - Oil refineries, petrochemical plants, automobile wastes, etc.

**Impact of pollution**

- **Damage caused by oil spills - on marine organisms**
  - Fish, reptiles, amphibians & birds, that live in or near the ocean - are badly affected by oil wastes which may contain - *volatile organic compounds.*
  - *Oil spills deteriorates* - thermal insulation & damages reproductive system. Gills of fish get coated with oil leading to their death. It interrupts the food chain, which may cause extinction of species. It penetrates birds feathers & affects its buoyancy. Oil spreads on water surface & thus reduces the amount of oxygen in water. On reaching coasts it harms *coastal marine life.*

**Control of pollution**

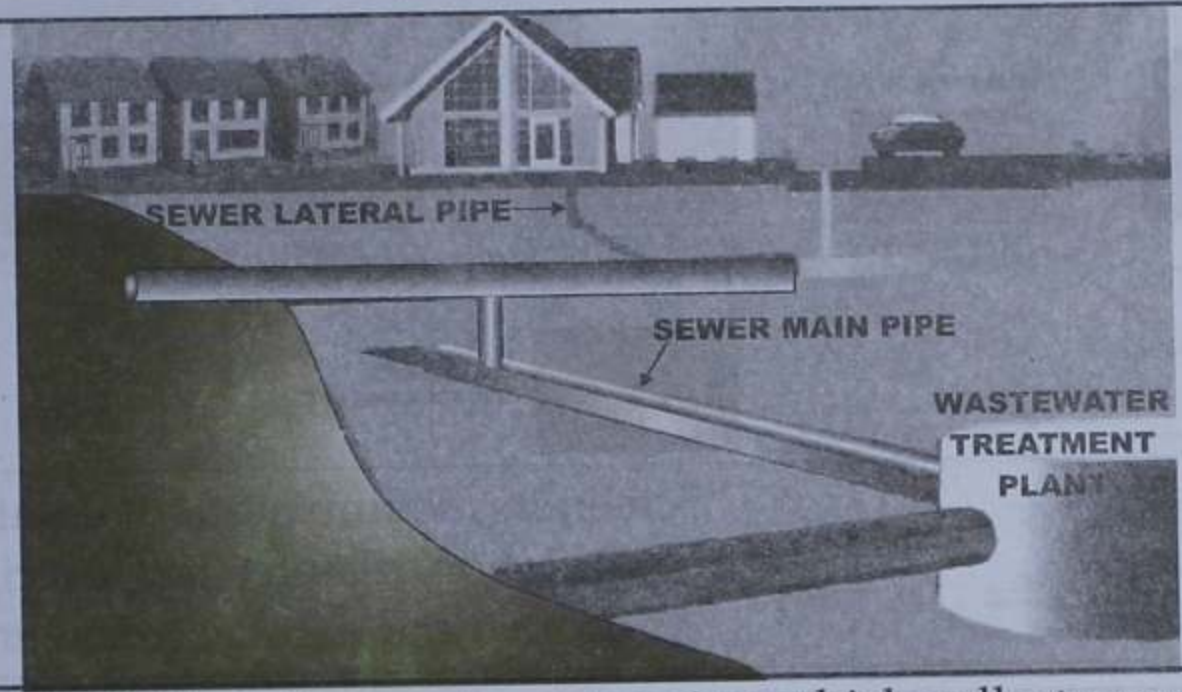
- **Methods to improve offshore oil drilling - to reduce water pollution**
  - Apply a complete *environmental assessment analysis* - before oil drilling.
  - Use *drilling fluids* which are - biodegradable & have low aquatic toxicity.
  - Develop better *pollution control measures* which include - *removal of oil* - by skimming or filtering, *dispersing oil* - into smaller droplets & *removing 'oil clumps'* – by using coagulating agents.

An oil rig

## 4. TREATMENT OF WATER POLLUTION - from Domestic Sewage & Industrial Waste

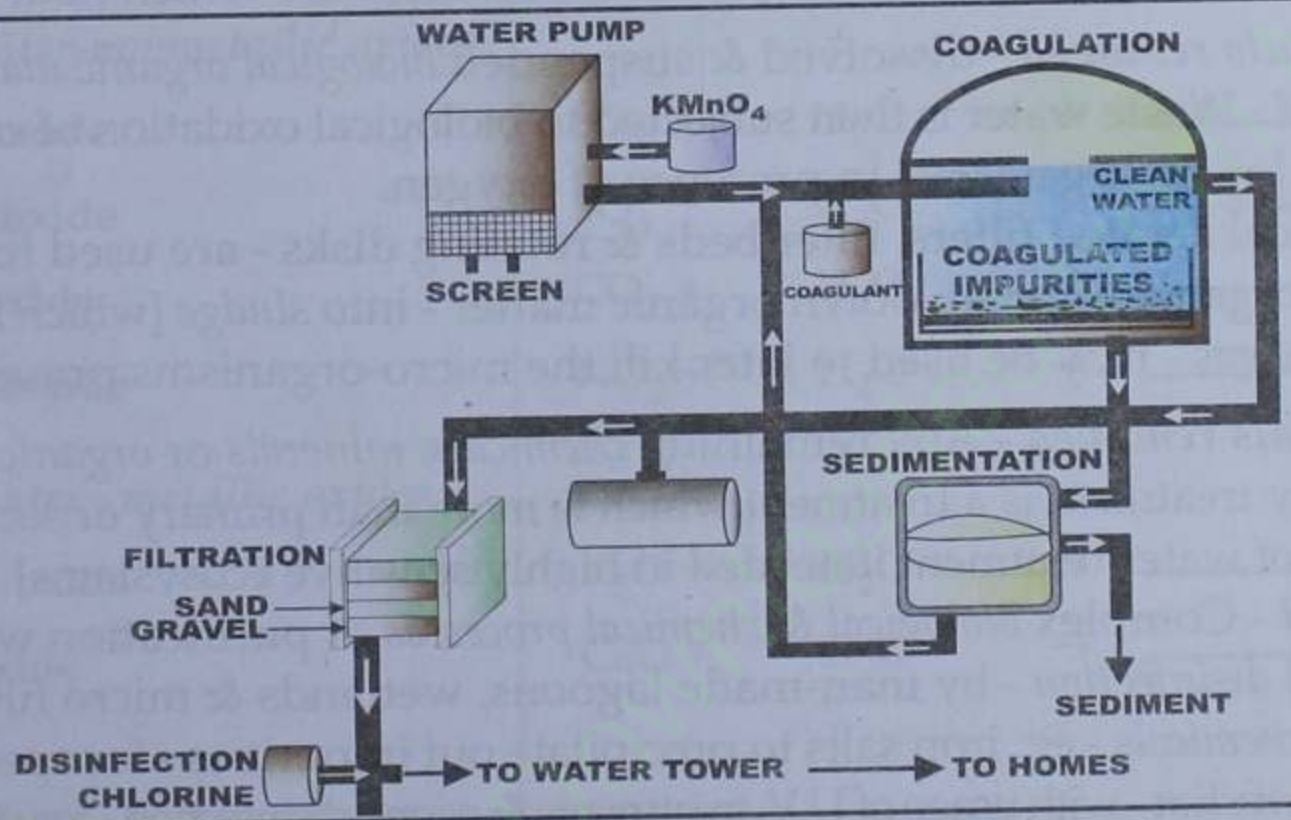
### A. COLLECTION & DISPOSAL OF DOMESTIC SEWAGE

- A typical waste water system for sewage i.e. waste water generated from household activity consists of a - *network of waste water pipes.*




*SEWER LATERAL PIPE* - is the waste water pipe which collects sewage from household.
*SEWER MAIN PIPE* – is the larger pipe on the main street which connects from sewer lateral pipe.
The waste water from sewer main pipe is then led to the - *Water treatment plant.*

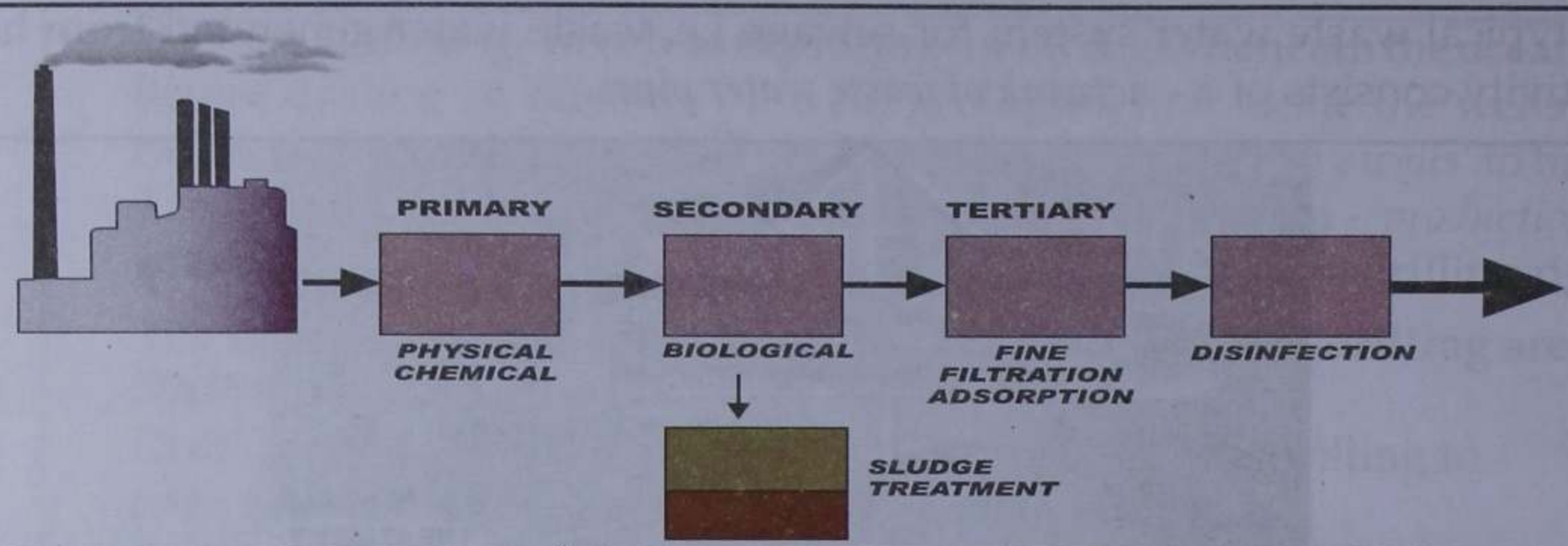
### B. TREATMENT OF WASTE WATER - Basic Water Treatment Plant




| PROCESS | WASTES REMOVED FROM WATER |
|---|---|
| 1. Screen | *Large waste materials* – such as leaves, rocks, twigs, etc. are easily removed [algal blooms maybe treated with $KMnO_4$ soln.] |
| 2. Coagulation | *Coagulated suspended impurities* – are removed by adding coagulants [eg. alum], which settle out and are - removed before filtration of water. |
| 3. Sedimentation | *Solid suspended particles* - settle down in the sedimentation tank. |
| 4. Biological Treatment | *Biodegradable wastes* i.e. dissolved and suspended biological matter - is treated with water-borne microbes [bacteria] which metabolize the organic matter in waste giving an easily removable solid mass & inorganic end products. [aerobic treatment is performed in presence of oxygen by aerobic micro-organisms and anaerobic treatment in absence of oxygen]. |
| 5. Filtration | *Remaining pollutants* - are removed by passing water through sand & gravel filters. |
| 6. Disinfection | *Remaining pathogens* - are killed by liquid chlorine [ozone or bleaching powder] |

## 4. TREATMENT OF WATER POLLUTION - from Domestic Sewage & Industrial Waste

### C. INDUSTRIAL WASTE WATER TREATMENT USING VARIOUS PROCESSES




| | |
|---|---|
| • *Physical processes* | • Screening, sedimentation, flotation, filtration |
| • *Chemical processes* | • Coagulation, disinfection, precipitation |
| • *Biological process* | • Anaerobic and aerobic treatments |

### MAIN THREE STAGES OF WATER TREATMENT

| | |
|---|---|
| **Primary treatment** | ***Materials removed*** - suspended *organic & inorganic solids.*<br>***Method*** - i] *Sedimentation* - for suspended solids -<br>ii] *Skimming* - for light solids, oil & grease which float at the top. |
| **Secondary treatment** | ***Materials removed*** - dissolved & suspended *biological organic matter.*<br>***Method*** - Waste water is then subjected to biological oxidation of organic matter by-*aerobes* [micro-organisms] in presence of oxygen.<br>Biological aerated filters, filter beds & rotating disks - are used for the process.<br>Micro-organisms break down organic matter - into *sludge* [which is easily removed]<br>*Chlorine gas* - may be used to later kill the micro-organisms present. |
| **Tertiary treatment** | ***Materials removed*** - Any remaining *chemicals, minerals* or *organic matter.*<br>[Tertiary treatment is a treatment which is more than primary or secondary - for use of water treatment if needed in highly sensitive ecosystems]<br>***Method*** - Complex *biological & chemical processes* of purification which involves -<br>*Physical disinfection* - by man-made lagoons, wetlands & micro filtration.<br>*Uses of chemicals* - eg. iron salts to precipitate out impurities - for specific applications.<br>*Final disinfection* - with usage of U.V. treatments & ozone disinfection - for varied applications. |

### SOME MODIFIED INDUSTRIAL EFFLUENT TREATMENT METHODS - for removal of

| | |
|---|---|
| • *Oil & Grease* | **Industry** - from oil refineries, petrochemicals, chemical plants, etc.<br>*Method* - Oil-water separator - which results in break up of suspended solids [*oil* - at the top, *cleansed waste water* - in the middle layer, *sludge* - at the bottom] |
| • *Acids & alkalies* | **Industry** - chemical , iron & steel , food and agricultural.<br>*Method* - neutralization under controlled conditions |
| • *Organic materials in waste water* | **Materials** - solvents, paints, pesticides - which are difficult to treat.<br>*Methods* - distillation, adsorption [specific methods for specific treatment] |
| • *Biodegradable organics* | **Industry** - Food & agricultural industry.<br>*Process* - i] *Activated sludge process* - an aerobic biochemical process<br>ii] *Biological trickling filter process* - involves adsorption of organic compounds in waste water by microbial slime layer. |

# EQUATION WORKSHEET

Complete and balance the equations

| | |
|---|---|
| **WATER** | |
| **a. Chemical properties of water** | |
| *Reactions of water with metals* | |
| **1. Potassium** | $K + H_2O \rightarrow$ _____ + _____ [g] |
| **2. Sodium** | $Na + H_2O \rightarrow$ _____ + _____ [g] |
| **3. Calcium** | $Ca + H_2O \rightarrow$ _____ + _____ [g] |
| **4. Magnesium** | $Mg + H_2O \rightarrow$ _____ + _____ [g] |
| **5. Aluminium** | $Al + H_2O \rightarrow$ _____ + _____ [g] |
| **6. Zinc** | $Zn + H_2O \rightarrow$ _____ + _____ [g] |
| **7. Iron** | $Fe + H_2O \rightleftharpoons$ _____ + _____ [g] |
| *Reactions of water with nonmetals* | |
| **8. Coke** | $C + H_2O \rightarrow$ _____ + _____ [g] |
| **9. Chlorine** | $Cl_2 + H_2O \rightarrow$ _____ + _____ |
| *Reactions of water-nonmetallic oxides* | |
| **10. Sulphur dioxide** | $SO_2 + H_2O \rightarrow$ _____ |
| **11. Sulphur trioxide** | $SO_3 + H_2O \rightarrow$ _____ |
| **12. Carbon dioxide** | $CO_2 + H_2O \rightarrow$ _____ |
| **13. Nitrogen dioxide** | $NO_2 + H_2O \rightarrow$ _____ + _____ |
| *Reactions of water - metallic oxides* | |
| **14. Potassium oxide** | $K_2O + H_2O \rightarrow$ _____ |
| **15. Calcium oxide** | $CaO + H_2O \rightarrow$ _____ |
| **b. Tests for water** | |
| **16. Anhydrous copper sulphate** | $CuSO_4 + 5H_2O \rightarrow$ _____ [white] [ ] |
| **17. Cobalt chloride** | $CoCl_2 + 6H_2O \rightarrow$ _____ [blue] [ ] |
| **c. Biological importance of dissolved gases in water** | |
| **18. Dissolved oxygen - respiration** | $C_6H_{12}O_6 + 6O_2 \rightarrow$ _____ + _____ |
| **19. Dissolved $CO_2$ - photosynthesis** | $6CO_2 + 12H_2O \rightarrow$ _____ + _____ + _____ |
| **20. Dissolved $CO_2$ - formation of shells** | $CaCO_3 + H_2O + CO_2 \rightarrow$ _____ |

For additional questions on **Chp. 6** - Refer
**'OBJECTIVE WORKBOOK FOR SIMPLIFIED I C S E CHEMISTRY' FOR STD. IX BY DR. VIRAF J. DALAL**
[A Supplementary work book for "Simplified I. C. S. E. Chemistry for Std. IX"]

# Questions

**1984**

1. Give two chemical tests for water.
2. How does an increase in temperature affect : i] the solubility of NaCl, ii] the solubility of $CaSO_4$ in water?

**1985**

1. Complete the following "word" equation : i] sodium + water → ii] calcium + water →

**1986**

1. Why is anhydrous $CaCl_2$ used in a desiccator. Name one substance which is *'efflorescent'*.

**1987**

1. Ordinary air from the atmosphere contains about 21% of oxygen whereas the dissolved air in river water contains about 30%. Give a reason for this.
2. State the biological importance of the presence of dissolved oxygen and $CO_2$ in river water.

**1988**

1. A sample of waterweed was placed in water and exposed to sunlight. Bubbles of a gas are seen to form on the surface of the leaves : i] Name the gas evolved, ii] Name the process taking place, iii) Give a balanced equation of the reaction which takes place during the process. [oxygen, photosynthesis]
2. Name a gas evolved and give a balanced equation in the following : *A small piece of calcium is dropped into a bowl of water.*
3. Complete the following : *The solubility of a gas at constant pressure may be increased by decreasing the ....*

**1990**

1. Complete the following : Calcium + water → calcium hydroxide + ..... . Define *'deliquescence'*.

**1991**

1. Explain why silver nitrate crystals are dissolved in distilled water and not in tap water to prepare silver nitrate solution as a laboratory reagent. [impurities in tap water]
2. What is the effect of temperature on the solubility of $KNO_3$ and calcium sulphate in water.
3. Write down the 'word' or 'balanced' equation for : *'a piece of calcium is dropped into cold water'*.

**1992**

1. What test would you do to find out whether a given solution is saturated or unsaturated.
2. How can you increase the solubility of a given volume of gas in water.

**1993 —, 1994 —, 1995** [discontinued]

**2007 - [from environmental education]**

1. Define 'eutrophication'.
2. What is meant by the term 'oil spill'.

**2008**

1. State any two sources of water pollution.
2. State the causes and consequences of 'eutrophication'.
3. What is meant by the term 'offshore drilling'. State the main environmental effects of offshore drilling.
4. Explain why oil spills have an adverse effect on marine life.

**2009**

1. Explain any two environmental impacts of an 'oil spill'.

**2010**

1. Explain the methods of controlling water pollution.

## Additional Questions

1. State the importance of water. How does it occur in the free state and in the combined state.
2. Water cycle maintains the circulation of water in nature. Explain.
3. Give three reasons to prove that water is a compound and not a element.
4. Differentiate between natural and treated water. State three different forms of treated water.
5. State the colour, odour, taste, boiling point, melting point and density of water.
6. 'Water is considered a universal solvent'. Give the reason for the same. State why electrovalent compounds rapidly dissolve in water.
7. State why ammonia is highly soluble, carbon dioxide is fairly soluble & oxygen is sparingly soluble in water.
8. From the gases hydrogen, hydrogen chloride, chlorine, nitrogen, sulphur dioxide and carbon monoxide – state which are highly soluble, fairly soluble and very slightly soluble in water.
9. Give reasons for the following : i] water at 4°C has maximum density and minimum volume, ii] water finds applications in cooling systems and in modifying the climate of the nearby land.
10. Describe a simple experiment to show that the water we drink contains dissolved solids & dissolved gases [air].
11. State the i] composition, ii] importance of dissolved solids and dissolved gases in water. Account for the difference in composition of atmospheric air and air dissolved in water.
12. Give two examples of reactions in which water acts as a catalyst.
13. State the i] observation, ii] nature of the reaction, iii] colour of the flame, iv] nature of solution – when each of the metals – potassium, sodium and calcium are individually dropped into cold water.
14. Give balanced equations for the reaction of i] potassium, ii] sodium, iii] calcium with cold water.
15. State the observation when magnesium reacts with hot or boiling water. Give a balanced equation for the same.
16. Give balanced equations for the liberation of hydrogen using water as the reactant with – i] a trivalent metal, ii] a metal which undergoes a reversible reaction with water.
17. State how the reactions of potassium, sodium, calcium, magnesium, aluminium, zinc and iron with water helps us to form the reactivity series of metals.
18. Name five metals which have no reaction with water.
19. State the products formed when each of the following reacts with water. Give a balanced equation for the same. i] Red hot coke, ii] Chlorine gas, iii] Sulphur dioxide, iv] Sulphur trioxide, v] Carbon dioxide, vi] Nitrogen dioxide, vii] Potassium oxide, viii] Calcium oxide
20. State the colour change when water is added to : i] anhydrous copper sulphate, ii] cobalt chloride.
21. State the functions of water in the human body. Give two industrial applications of water.
22. What is meant by the term – 'solution' Explain the meaning of the terms : i] solute, ii] solvent with reference to a solution. What are dilute and concentrated solutions. State the characteristics of a true solution.
23. Differentiate between unsaturated, saturated & supersaturated solutions. How would you convert a saturated solution to an unsaturated solution and vice versa.
24. State one solvent for each of the following – rubber, paint, sulphur, rust, iodine and grease stains.
25. Define solubility. Explain the effect of temperature on solubility of – i] $KNO_3$, ii] NaCl iii] $CaSO_4$ in water.
26. Give two examples each of efflorescent crystals and deliquescent crystals. How do they differ from each other. Give three examples of hygroscopic substances used as drying agents.
27. Explain the terms : i]Pollution ii] Pollutants iii] Water pollution.
28. 'Contamination of water through various sources deteriorates the ecosystem of water bodies'. State four chemical agents responsible for the same.
29. State what is meant by the term 'eutrophication'. Explain how use of household detergents leads to 'eutrophication', and resultant water pollution.
30. State the constituents of 'sewage waste'. State the impact of careless disposal of sewage waste on water pollution.
31. 'Industrial waste is an important source of water pollution'. Elaborate the statement with suitable examples.
32. State the main causes of water pollution from 'offshore oil drilling'. Enumerate the damage caused by 'oil spills' on marine organisms.
33. State the methods which may be used to control marine water pollution caused by offshore oil drilling.
34. Enlist the main processes involved in treatment of waste matter from domestic sewage, in a basic water treatment plant. State the role of water borne micro-organisms in the biological treatment.
35. Differentiate between the primary, secondary & tertiary - industrial effluent treatment methods.

# Unit Test Paper 6 — Water

30 marks

**Q.1 Select the correct word from the words in brackets to complete each sentence:** **[5]**

1. Water is considered a compound, since the elements hydrogen and oxygen can be separated by _____ [physical / chemical] means.
2. If pressure on the surface of water increases its boiling point _____ and freezing point _____ [increases / decreases].
3. A saturated solution can be converted to an unsaturated solution by _____ [increasing / decreasing] the amount of the solvent.
4. Dissolved air in water contains a _____ [higher / lower] percentage of oxygen than ordinary air.
5. Eutrophication is – _____ in chemical nutrients in an ecosystem. [decrease/increase]

**Q.2 Select the correct answer from the choice given in the brackets.** **[5]**

1. A metal which reacts with cold water, catches fire & burns with a lilac flame. [Na / K / Ca]
2. A metal which sinks in water, forming an alkali solution & does not catch fire. [K / Ca / Na / Mg]
3. A metal which reacts with boiling water forming a coating of the metallic oxide on its surface which later breaks down exposing the metal to steam, liberating hydrogen. [Na / Mg / K]
4. A metal other than lead which has no reaction with water. [Zn / Cu / Ca]
5. A heavy metal present in industrial waste water which contaminates fish & leads to poisoning – on human consumption. [lead / mercury / silver]

**Q.3 Give reasons for the following.** **[5]**

1. Ammonia is highly soluble in water while nitrogen is sparingly soluble in water.
2. Solubility curves find utility in separation and purification of solutes.
3. Pressure and temperature influence the solubility of gases in water.
4. Water has the unique ability to reduce the electrostatic force of attraction holding the ions of an electrovalent compound.
5. Higher the BOD [biological oxygen demand] the more the level of pollution in water.

**Q.4 Name or state the following.** **[5]**

1. A greenish yellow gas fairly soluble in water.
2. A chemical method or means by which the components – hydrogen & oxygen can be separated from water.
3. An acidic gas which reacts with water to give two acids.
4. A salt other than calcium hydroxide, whose solubility decreases with rise in temp. of the solvent water.
5. A disease caused by presence of pathogens in sewage waste water.

**Q.5 Differentiate between the following :** **[5]**

1. Natural water and treated water
2. Saturated solution and a super saturated solution
3. Solubility and solubility curve
4. Solute and solvent – forming a solution.
5. Non-biodegradable pollutant & biodegradable pollutant.

**Q.6 Give balanced equations for the following conversions involving water as one of the reactants.** **[5]**

1. Potassium → Potassium hydroxide ← Potassium oxide
2. $Cl_2$ | $SO_2$ | $SO_3$ | $CO_2$ | $NO_2$ → V, W, X, Y & Z respectively [V, W, X, Y & Z are different acids]
3. Iron → Hydrogen ← Aluminium
4. Coke → Water gas
5. Calcium oxide → Calcium hydroxide ← Calcium hydride