

## 10 Atmosphere and environment

### Content

10.1 Air

10.2 Water

### Learning outcomes

*Candidates should be able to:*

#### 10.1 Air

- (a) describe the volume composition of gases present in dry air as 78% nitrogen, 21% oxygen and the remainder being noble gases (with argon as the main constituent) and carbon dioxide
- (b) describe the separation of oxygen, nitrogen and the noble gases from liquid air by fractional distillation
- (c) state the uses of oxygen (e.g. in making steel; oxygen tents in hospitals; in welding)
- (d) name some common atmospheric pollutants (e.g. carbon monoxide; methane; nitrogen oxides (NO and NO<sub>2</sub>); ozone; sulfur dioxide; unburned hydrocarbons)
- (e) state the sources of these pollutants as
  - (i) carbon monoxide from incomplete combustion of carbon-containing substances
  - (ii) methane from bacterial decay of vegetable matter
  - (iii) nitrogen oxides from lightning activity and internal combustion engines
  - (iv) ozone from photochemical reactions responsible for the formation of photochemical smog
  - (v) sulfur dioxide from volcanoes and combustion of fossil fuels
  - (vi) unburned hydrocarbons from internal combustion engines

- (f) describe the reactions used in possible solutions to the problems arising from some of the pollutants named in (d)
  - (i) the redox reactions in catalytic converters to remove combustion pollutants
  - (ii) the use of calcium carbonate to reduce the effect of 'acid rain' and in flue gas desulfurisation
- (g) discuss some of the effects of these pollutants on health and on the environment
  - (i) the poisonous nature of carbon monoxide
  - (ii) the role of nitrogen dioxide and sulfur dioxide in the formation of 'acid rain' and its effects on organisms and buildings
- (h) discuss the importance of the ozone layer and the problems involved with the depletion of ozone by reaction with chlorine-containing compounds, chlorofluorocarbons (CFCs)
- (i) describe the carbon cycle in simple terms, to include
  - (i) the processes of combustion, respiration and photosynthesis
  - (ii) how the carbon cycle regulates the amount of carbon dioxide in the atmosphere
- (j) state that carbon dioxide and methane are greenhouse gases and may contribute to global warming, give the sources of these gases and discuss the possible consequences of an increase in global warming

## 10.2 Water

- (a) state that water from natural sources contains a variety of dissolved substances
  - (i) naturally occurring (mineral salts; oxygen; organic matter)
  - (ii) pollutant (metal compounds; sewage; nitrates from fertilisers; phosphates from fertilisers and detergents; harmful microbes)
- (b) discuss the environmental effects of the dissolved substances named in (a)
  - (i) beneficial, e.g. oxygen and mineral salts for aquatic life
  - (ii) pollutant, e.g. hazards to health; eutrophication
- (c) outline the purification of the water supply in terms of
  - (i) filtration to remove solids
  - (ii) use of carbon to remove tastes and odours
  - (iii) chlorination to disinfect the water
- (d) describe how seawater can be converted into drinkable water by desalination

# Air and water pollution

## Air and oxygen

### composition of Air

Nitrogen 79%

Oxygen 20%

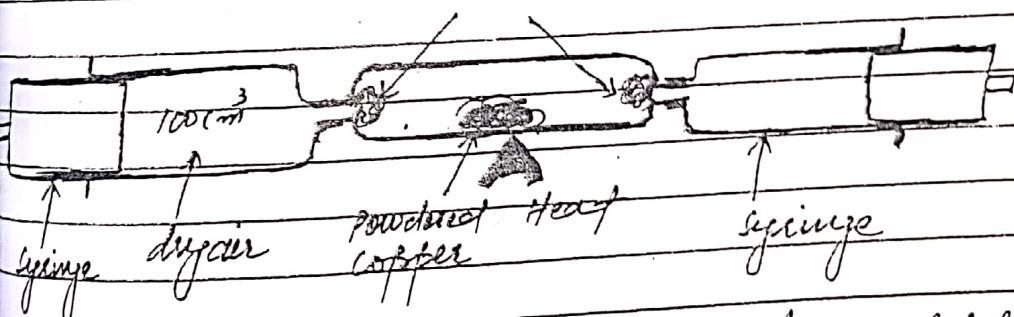
Carbon dioxide 0.0321%

Noble gases 1%

mainly Argon

### Verification of percentage of O<sub>2</sub> in the air

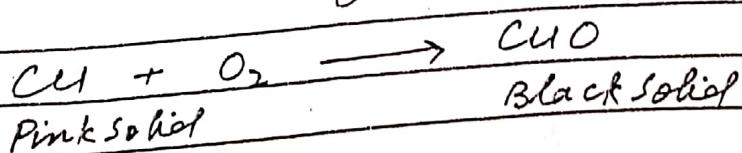
cottonwool



Cottonwool:- To prevent entering of copper pieces in the syringe which can give an inaccurate results.

During experiment only oxygen reacts with copper to form copper(II) oxide. This decreases the volume of air till its reaches

80 cm<sup>3</sup>



## separation of gases from the air

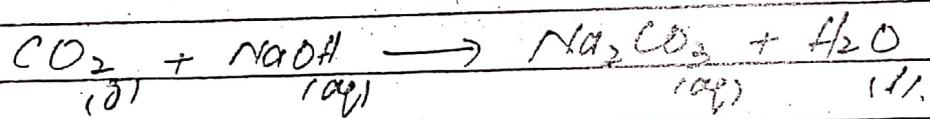
separation of gases from the air is comprised of two main steps

- (i) Liquefaction of air
- (ii) Fractional distillation of liquid air

### (i) Liquefaction of air

#### (a) Removal of $\text{CO}_2$

$\text{CO}_2$  can be removed from air by passing air through an aqueous solution of an alkali e.g;  $\text{aq NaOH}$



#### (b) Removal of water

water molecules from the air are removed by passing air through a drying agent e.g, concentrated  $\text{H}_2\text{SO}_4$ .

Both  $\text{CO}_2$  and  $\text{H}_2\text{O}$  are removed from the air as they are solidified at  $-78^\circ\text{C}$  and  $0^\circ\text{C}$  respectively and block the pipes during the next step which is "compression and expansion".

Following are the boiling points and solidifying points of gases in the air.

$\text{N}_2 - 196^\circ\text{C}$ ,  $\text{Ar} - 186^\circ\text{C}$ ,  $\text{O}_2 - 183^\circ\text{C}$

$\text{CO}_2 - 78^\circ\text{C}$  (sublimes),  $\text{H}_2\text{O} 0^\circ\text{C}$  (freezing point)

### (C) Repeated compression and expansion

Dry air is liquefied by carrying out repeated compression and expansion till the temperature of the air is dropped to  $-200^{\circ}\text{C}$  where following gases are liquefied.

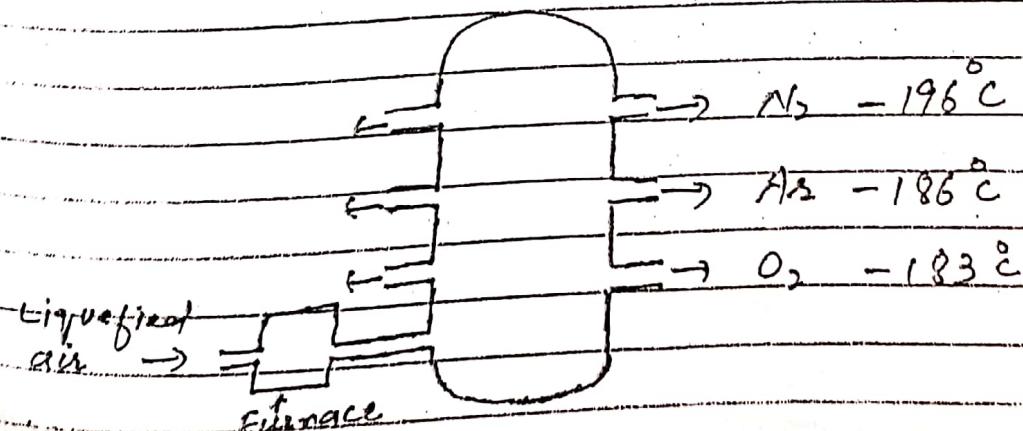
$\text{N}_2 = -196^{\circ}\text{C}$  Liquefies in the end

$\text{Ar} = -186^{\circ}\text{C}$

$\text{O}_2 = -183^{\circ}\text{C}$  Liquefies first

### (2) Fractional distillation of liquid air

Liquid air is introduced in a fractionating tower and is warmed. Nitrogen having lowest boiling point is boiled first at  $-196^{\circ}\text{C}$  and is collected from the upper part of the tower. Argon boils 2nd and is collected from the middle part of the tower at  $-186^{\circ}\text{C}$  while  $\text{O}_2$  with highest B.P.  $-183^{\circ}\text{C}$ , boils in the end and is collected from the lower part of the tower.



## uses of oxygen

- ⇒ It is used in oxygen cylinders in hospitals for the patients of pneumonia, by deep sea divers and by mountain climbers.
- ⇒ oxygen is used in welding along with acetylene gas and produces oxy-acetylene flame which has a temp of  $3000^{\circ}\text{C}$ . This flame is used for cutting of metals.
- ⇒ oxygen is used to convert pig iron to steel.

## Green House effect

Carbon dioxide gas, chlorofluoro carbons (CFCs),  $\text{CH}_4$  and other unburnt hydrocarbons make a layer around earth which allows certain infrared rays of the sun to reach earth and then trap these rays. As a result, earth remains warm and vegetation can grow on the earth, this is called green house effect, whereas earth is called a green house.

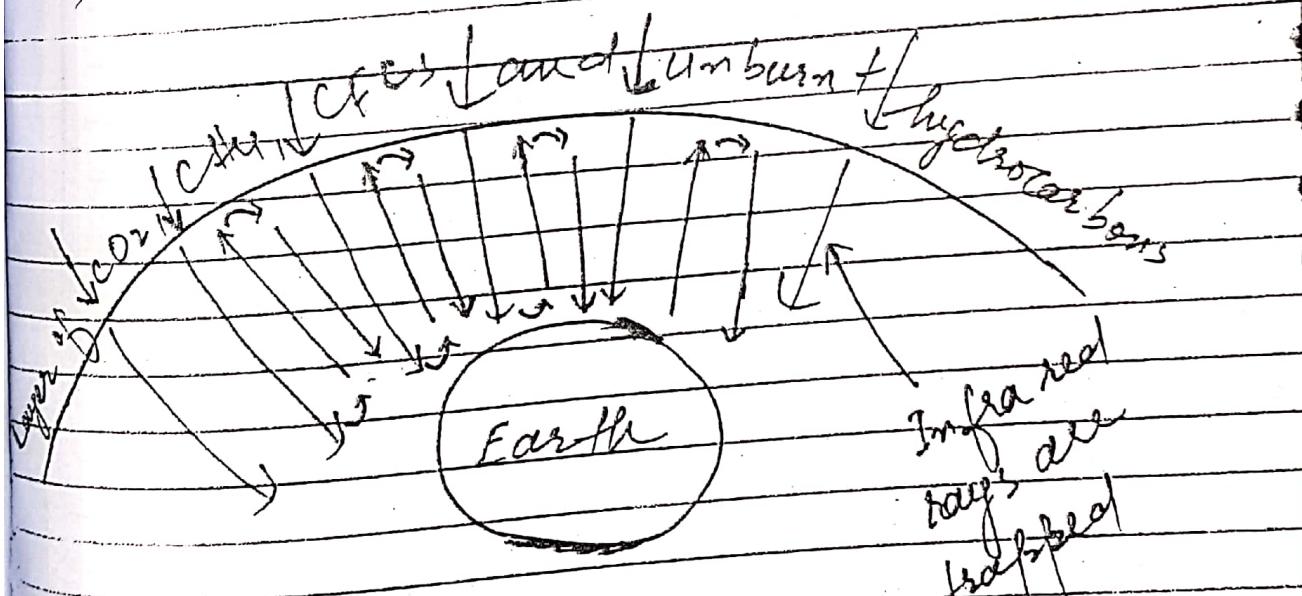
## Global warming

Increase in population, automobiles, industries and deforestation lead

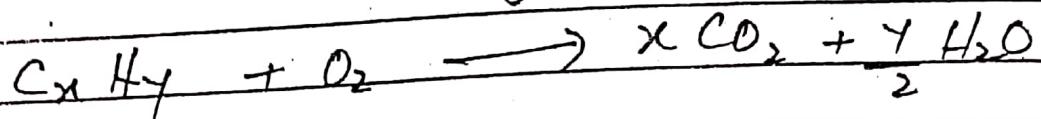
to an increase in greenhouse gases  
e.g. CO<sub>2</sub> and unburnt hydrocarbons  
which allow more infrared rays to  
reach earth and increase earth's  
temperature. This is called global  
warming.

### Consequences of global warming

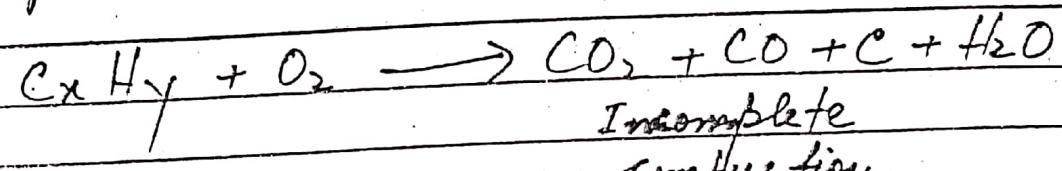
- ⇒ Melting of ice caps and glaciers,  
as a result permanent reservoirs  
are decreased and floods in low  
lying areas of the earth.
- ⇒ Change in animal habitat.
- ⇒ Extreme weather conditions.



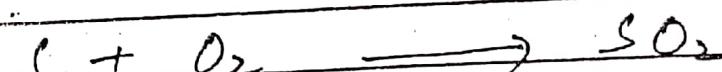
Common chemical reactions  
take place in internal  
combustion engine



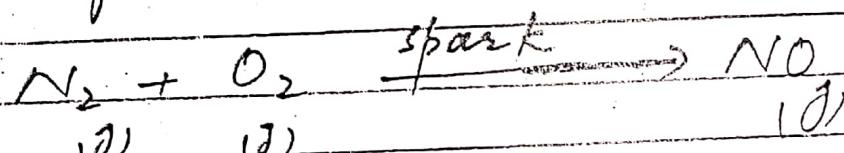
Fossil  
fuel



Incomplete  
combustion



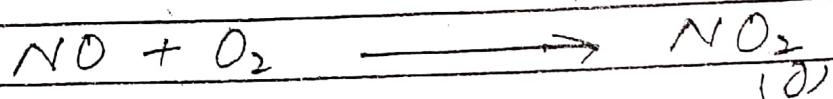
Impurity in  
fossil fuels



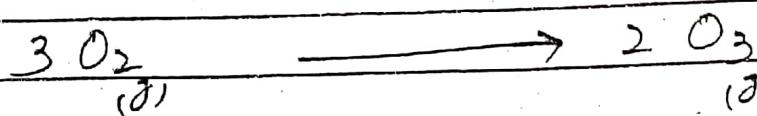
(1) (1)

(1)

From the air



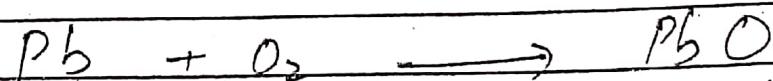
(1)



(1)

From air

ozone



Impurity in  
petrol

(1)

## Q) CFCs

Aerosol spray refrigeration

Global warming

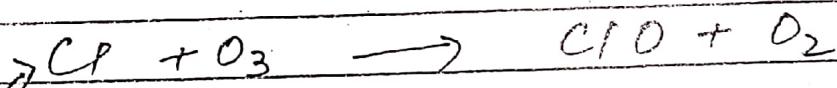
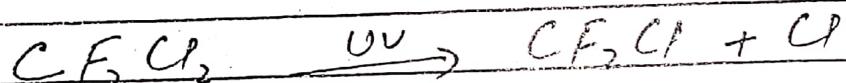
| Pollutants                 | Sources   | Harmful effects  |
|----------------------------|---|--|
| 1) CH <sub>4</sub>         | Bacterial decay of vegetation   | Global warming   |
| 2) Unburnt hydrocarbons    | Exhaust fumes of motor vehicles<br>and thermal power plants                                 | Global warming   |
| 3) CO <sub>2</sub>         | " " "   | " " "  |
| 4) CO                      | Incomplete combustion of fossil fuels   | " " "  |
| 5) SO <sub>2</sub>         | Combustion of fossil fuels in<br>automobiles and volcanic eruption                          | Causes suffocation by forming<br>acidic rain which<br>causes buildings, surfaces<br>kill plants and aquatic<br>animals |
| NO & NO <sub>2</sub>       | Exhaust fumes of automobiles<br>due to electric spark in engines<br>&<br>lightning activity | " " " "  |
| 6)                         |   | " " " "  |
| 7) Lead compounds          | Exhaust fumes of automobiles  | cause brain disease in children  |
| 8) Ozone (O <sub>3</sub> ) | Electric spark in engines,<br>near electric field roads                                     | Forms photochemical smog<br>in towns which initiates changes<br>and air pollution                                      |

## Depletion of Ozone layer

Ozone is depleted by chlorofluorocarbons (CFCs) which are released by aerosol sprays, air conditioners and refrigerators.

These CFCs release chlorine atoms in the upper atmosphere in the presence of UV rays. These chlorine atoms react with ozone to convert it into  $O_2$ .

As a result harmful UV rays of the sun reach earth and cause disease like skin cancer and cataracts.



act as catalyst  
as it is regenerated

## Use of ozone in the lower atmosphere

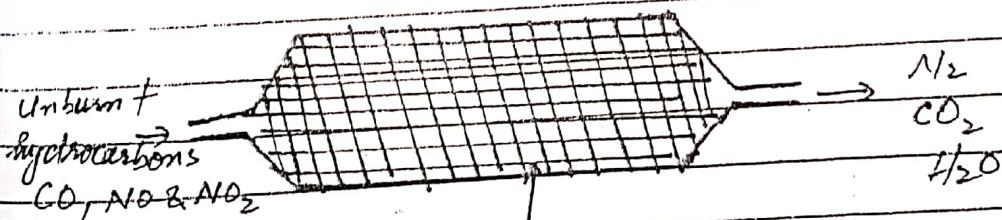
Ozone is used as disinfectant to kill bacteria in slaughter houses and in crowded places.

Methods of preventing escape of pollutant gases in the air

use of catalytic converter in automobiles

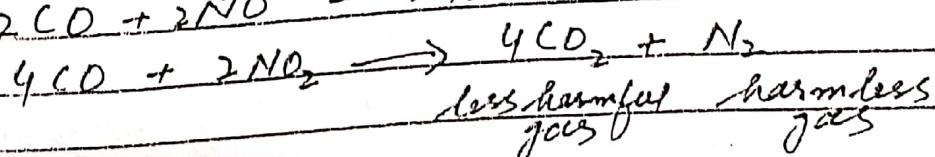
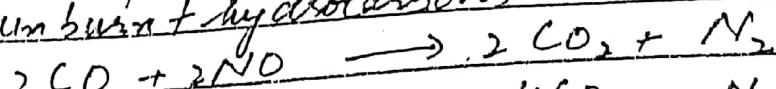
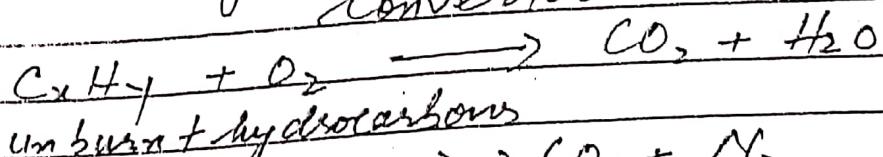
Automobiles are fitted with a catalytic converter, which contains Platinum and palladium gauge as a catalyst which at higher temperature converts unburnt hydrocarbons to  $\text{CO}_2$  and  $\text{H}_2\text{O}$ .

It also converts harmful gases e.g. CO and oxides of nitrogen ( $\text{NO}$  &  $\text{NO}_2$ ) to less harmful gas  $\text{CO}_2$  and a harmless gas  $\text{N}_2$ .



Gauge of Platinum  
and Palladium  
acts as catalyst

Following reactions occur in catalytic converter.



## Use of lime & lime in industries and thermal power plants

OR

## Flue gas desulphurisation

Major gas present in the exhaust of the thermal power plant is  $\text{SO}_2$  which cause acid rain.

This can be removed

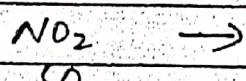
by reacting  $\text{SO}_2$  with a base

which is  $\text{CaCO}_3$ .

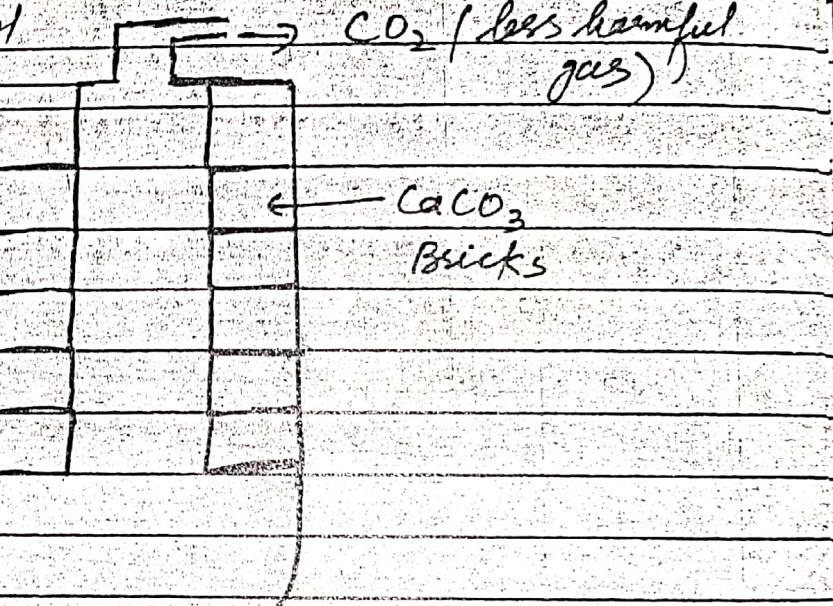
$\text{NO}_2$  being acidic oxide also

reacts with  $\text{CaCO}_3$  to release less

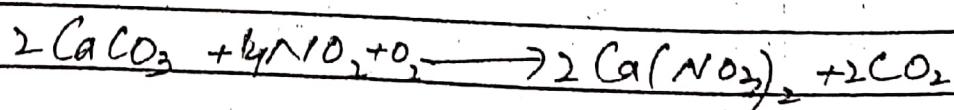
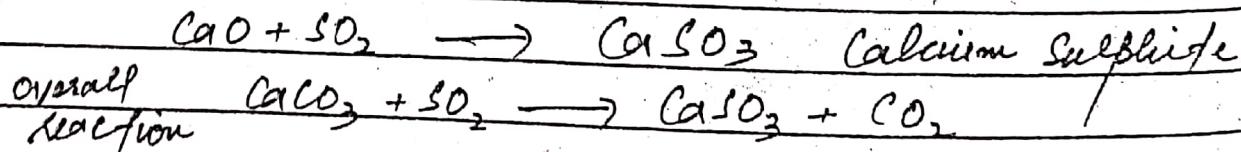
harmful gas  $\text{CO}_2$ .



Acidic gases



Following reactions occur in the chimney of thermal power plants.



Calcium nitrate

OR

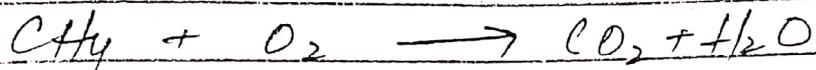
$\text{Ca}(\text{NO}_3)_2$  Calcium nitrate

## Carbon cycle

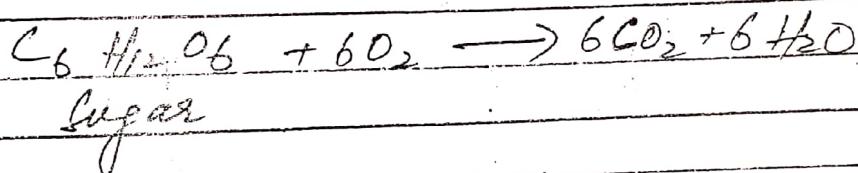
Amount of  $\text{CO}_2$  in the air is controlled by the two opposite processes.

- (1) Combustion and respiration
- (2) Photosynthesis

### i) Combustion and respiration

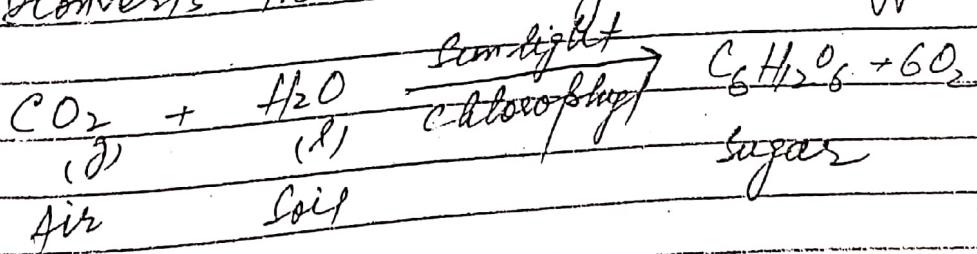


#### Respiration



### ii) Photosynthesis

During photosynthesis plants absorb  $\text{CO}_2$  from the air, water from the soil and in the presence of sunlight and chlorophyll, it converts them into sugar and oxygen.



# Impurities in water

Beneficial impurities      Harmful impurities

| <u>Impurity source</u> | <u>Effect</u>                             | <u>Impurity source</u> | <u>effect</u>                            |
|------------------------|---|------------------------|--|
| (i) Dissolved Oxygen   | Air used for breathing by aquatic animals | Nitrates               | Fertilizers Eutrophication               |
| Minerals salts         | Soil used for plant growth                | Phosphates             | Fertilizers Eutrophication               |
|                        | Sewage                                    | Animal & human waste   | Detergents - cation disease like cholera |
|                        |   |                        | Diarrhea                                 |
|                        |   |                        | Typhoid                                  |

# Impurities in water

## Beneficial impurities

| <u>Impurity</u> | <u>Source</u> | <u>effect</u> |
|-----------------|---------------|---------------|
|-----------------|---------------|---------------|

|                     |      |                                       |
|---------------------|------|---------------------------------------|
| i) Dissolved Oxygen | Air  | used for breathing by aquatic animals |
| ii) Mineral salts   | Soil | used for plant growth                 |

## Harmful impurities

| <u>Impurity</u> | <u>Source</u> | <u>Effect</u> |
|-----------------|---------------|---------------|
|-----------------|---------------|---------------|

|   |                          |  |
|---|--------------------------|--|
| i) Nitrates                               | Fertilisers              | Eutrophication                                     |
| ii) Phosphates                            | Fertilisers & detergents | " "  |
| iii) Sewage                               | animal and human waste   | cause disease like cholera, diarrhoea, typhoid etc |
| iv) Effluent containing<br>Pb, Hg, Cd etc | Industrial waste         | Cause cancer                                       |
| v) Oil                                    | oil spillage             | Kill aquatic animals                               |

# Purification of water

Following steps are involved in the purification of water.

## (i) Flocculation and settling

In water ~~of~~ aluminium sulphate is added which makes small, suspended particles clump together and are settled at the bottom.

## (ii) Filtration

water is passed over a bed of sand and gravel to remove insoluble particles from water.

## (iii) Use of Charcoal

water is passed over charcoal which removes colour and odour from water.

## (iv) Chlorination

Aqueous chlorine is added as disinfectant to kill bacteria.

## (v) Fluoridation

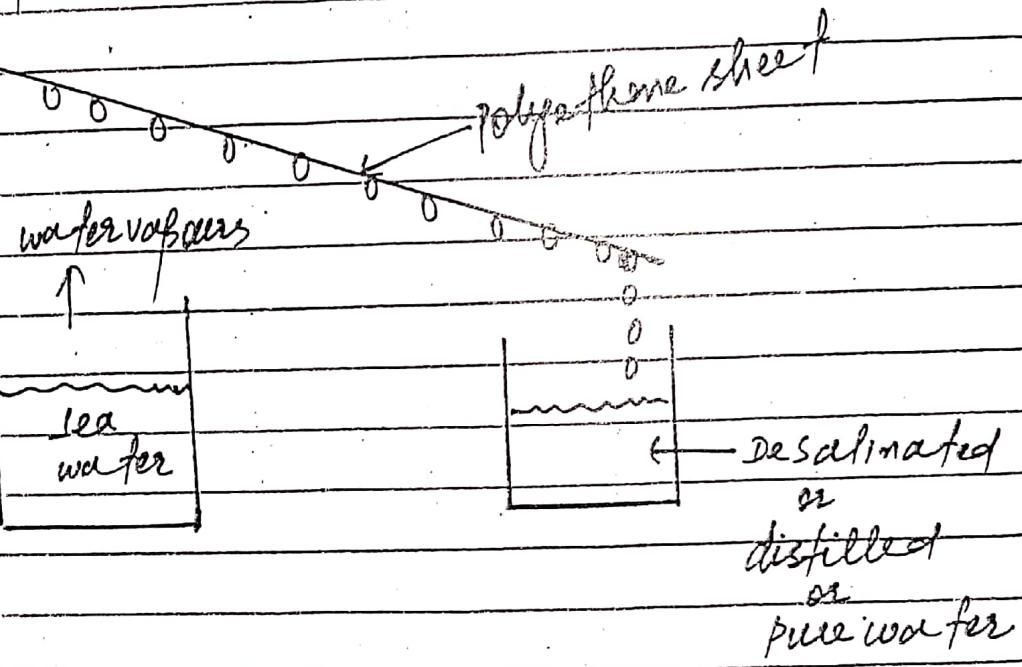
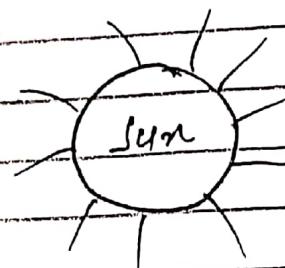
Fluoride ion prevents teeth decay.

## (vi) Use of lime water

Lime water is added to neutralise acidity in the water.

## Desalination of Sea water

Dissolved mineral salts from the sea water can be removed by carrying out solar distillation of water.



## "Eutrophication"

### • Harmful effect of fertilisers

- ⇒ Mineral salts, sulphates, phosphates and mainly nitrates are washed away by the rain water from the farmland to the nearby water reservoirs.
- ⇒ where they promote the growth of suspended plants like algae.
- ⇒ Algae blocks sunlight and does not let oxygen dissolved in water.
- ⇒ Absence of sunlight causes underwater vegetation to die.
- ⇒ Bacteria which decay plants use up dissolved oxygen, absence of oxygen causes aquatic animals to die.