

**ATMOSPHERE** *Pollutants: substances that are present in our atmosphere that can harm living things or damage non-living things.*

### Hydrocarbons

#### Source

- Unburnt hydrocarbons eg octane from internal combustion engines due to insufficient oxygen or insufficient time in the cylinders for hydrocarbons to burn completely.
- Methane from bacterial decay of
- vegetable matter in stagnant water
- from rubbish buried in landfills

#### Consequences

- In the presence of sunlight, unburnt HC reacts with ozone & oxides of nitrogen to give rise to photochemical smog
- Photochemical smog causes respiratory illness and tearing of eyes

### Nitrogen Monoxide & Nitrogen Dioxide

#### Source

- Reaction between nitrogen and oxygen (from the air) due to high temperature in the internal combustion engine of cars
- $N_2(g) + O_2(g) \rightarrow 2NO(g)$
- $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
- Reaction between nitrogen & oxygen due to lightning activity

#### Consequence

- Give rise to Photochemical Smog  $\rightarrow NO_2$  reacts with hydrocarbon in the presence of sunlight to produce oxygen atoms. Oxygen atoms then react with oxygen molecules to form ozone. Unburnt hydrocarbons, ozone and oxides of nitrogen will give rise to photochemical smog that cause respiratory problems and tearing of eyes
- Dissolve in rain water to form nitrous & nitric acid, resulted in **acid rain**.
- $NO + H_2O \rightarrow HNO_2$
- $NO_2 + H_2O \rightarrow HNO_3$

### Ozone

#### Consequence

- In the presence of sunlight, unburnt HC reacts with ozone & oxides of nitrogen to give rise to photochemical smog
- Photochemical smog causes respiratory illness and tearing of eyes

### Carbon Monoxide

#### Source

- Incomplete combustion of carbon- containing fuels e.g petrol from motor vehicles due to insufficient oxygen

#### Consequence

- Poisonous - Carbon monoxide reacts with irreversibly with haemoglobin in the blood to form a stable compound, carboxyhemoglobin. This prevents the blood to transport oxygen round the body. Hence, our cells die due to lack of oxygen

### Sulfur Dioxide

#### Source

- Combustion of fossil fuel eg coal which contain sulfur as impurities in the coal-fired power stations
- Volcanic eruption

#### Consequence

- Irritates eyes, give rise to respiratory problems and can cause bronchitis.
- Dissolve in rain water to form sulfurous acid which is then oxidised to form sulfuric acid, resulting in **acid rain**.
- $SO_2 + H_2O \rightarrow H_2SO_3$
- $2H_2SO_3 + O_2 \rightarrow 2H_2SO_4$

### Composition of Clean Air

- Nitrogen -> 78%
- Oxygen -> 21%
- Carbon Dioxide
- Water Vapour
- Noble Gases (Argon mainly)

### Greenhouse Effect

Greenhouse gases: Carbon dioxide, **Methane** and nitrous oxide

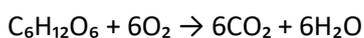
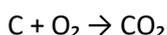
These gases absorb infrared radiation and reduce the amount of heat energy escaping from earth. Heat energy thus trapped in the atmosphere and causes Global Warming.

Consequences: (i) Melting of ice in the North and South Pole and cause the sea levels to rise and flood low lying countries

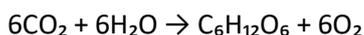
(ii) Decrease in crop yields worldwide. Areas that are currently covered by vegetation may become deserts and unsuitable for cultivating crops.

### Carbon Cycle

CO<sub>2</sub> is released into the atmosphere by combustion and respiration.



CO<sub>2</sub> is absorbed from the atmosphere by photosynthesis. In the presence of sunlight, green plants (containing chlorophyll) convert CO<sub>2</sub> and water to glucose and oxygen.



The carbon cycle regulates the amount of carbon dioxide in the atmosphere.

### Ozone (O<sub>3</sub>)

#### Benefits of Ozone

- Absorbs UV Radiation from the sun, preventing it from hitting the Earth

### Cause of Ozone Depletion

- Propellants in aerosols release Chlorofluorocarbons (compounds containing carbon, fluorine and chlorine) into the atmosphere.
- In the presence of sunlight, CFCs decompose to form chlorine atoms.
- Chlorine atoms react with ozone to form chlorine oxide and oxygen molecules, thus destroying the ozone layer in a **self-propagating chain reaction**.

### Consequence of Ozone Depletion

- Depletion of ozone layer allows more harmful ultraviolet rays to reach the earth which will result in skin cancer, eye cataract and genetic mutation

### Acid Rain

#### Formation

- Sulfur dioxide dissolves in rain water to form sulfurous acid.  
 $SO_2 + H_2O \rightarrow H_2SO_3$
- Sulfurous acid is oxidised slowly by oxygen in the air to form sulfuric acid.
- In the presence of oxygen and water, oxides of nitrogen are converted to nitric acid.  
 $4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$

#### Consequence

- Lower pH of soil, kills plants
- Lower pH of water, kills aquatic life
- Corrode limestone statues, metal structures through acid-carbonate or acid-metal reaction.

#### Remedy

- Use of **calcium carbonate** to reduce the acidity in soil/lakes

### Reducing Air Pollution

#### **Flue Gases Desulfurisation**

- Flue gases are passed through a suspension of Calcium Carbonate to form solid calcium sulfite.
- $\text{CaCO}_3 + \text{SO}_2 \rightarrow \text{CO}_2 + \text{CaSO}_3$
- Sulfur dioxide can also be removed by Calcium oxide.
- $\text{SO}_2 + \text{CaO} \rightarrow \text{CaSO}_3$
- Calcium sulfite is further oxidised to calcium sulfate by atmospheric oxygen.

#### **Catalytic Converter**

- Carbon monoxide, oxides of nitrogen and unburnt hydrocarbons are passed through a catalytic converter fitted with Palladium, Platinum and Rhodium catalyst to undergo catalytic reactions.
- Oxides of nitrogen are Reduced to nitrogen gas. (from +2 (in NO) to 0 (in N<sub>2</sub>))
- $2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$
- Carbon monoxide is Oxidised to carbon dioxide: Oxidation state of C increase from +2 (in CO) to +4 (in CO<sub>2</sub>)
- $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$
- Unburnt hydrocarbons are Oxidised to carbon dioxide and water.
- $2\text{C}_8\text{H}_{18} + 25\text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O}$