Maintaining Air Quality

Composition of Air

Composition (by volume) of Air

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- **Nitrogen:** 78%
- **Oxygen:** 21%
- **Argon:** 0.96%
- **Carbon Dioxide:** 0.04%

Humidity

Humidity is the measurement of water vapour content in air and the water vapour content in air varies.

Suggest a possible reason why the water vapour content in air varies

Humidity is affected by **temperature** and **pressure**.

Location can also affect the humidity. In the desert, it is likely that there will be less water vapour present as compared to the coastal areas.

Separation of Air

How can air be separated to obtain the various constituent gases?

Type of Gas	Composition by Volume	Boiling Point / °C
Nitrogen	78%	-196.0
Oxygen	21%	-183.0
Argon	0.93%	-185.0
Carbon dioxide	0.04%	-78.5

Based on the table, each gas has its own boiling point and **through fractional distillation of liquefied air,** it is possible to obtain each individual gas.

- In the Haber Process, the nitrogen used in the manufacture of ammonia is obtained through distillation of liquefied air.
- However, this is not encouraged for gases aside from nitrogen.
    - That is due to the fact that attempting to obtain any gas aside from nitrogen from liquefied air gives a low yield as the composition of gases in air shows that majority of air is made up of nitrogen.

Types of Air Pollutants

Air pollutants, their sources, and effects

Carbon Monoxide, CO

Source of Pollutant

- **Incomplete combustion** of carbon-containing fuels
- Examples of sources:
  - Vehicles and industrial plants
  - Forest fire

Effects of Pollutant

- Colourless, odourless **toxic** gas that **reduces the ability of haemoglobin in blood to transport oxygen to the rest of the body.** (due to formation of carboxyhaemoglobin)
- Leads to **breathing difficulties, headaches, fatigue before death.**

Ways to Reduce Pollutant

- **Catalytic converters** to convert carbon monoxide to carbon dioxide
- **Reduce** the use of carbon-containing fuels

Relevant Chemical Equations

Chemical equations in catalytic converters:

- $2\ NO\ (g) + 2\ CO\ (g) \rightarrow 2\ CO_2\ (g) + N_2\ (g)$
- $2\ CO\ (g) + O_2\ (g) \rightarrow 2\ CO_2\ (g)$

Oxides of Nitrogen - NO, NO_2

Source of Pollutant

- N_2 and O_2 in the air reacts at **high temperatures** to form NO.
- NO then further reacts with O_2 to form NO_2.

Examples:

- Combustion engine of vehicles
- Forest fire
- Lightning

Effects of Pollutant

Impact on Health

- Irritates eyes and lungs, causing breathing difficulties

Effects on Environment

- Forms **acid rain** which **corrodes buildings and harms plants and aquatic life (Give the impacts!)**

Ways to Reduce Pollutant

- **Catalytic Converters** to convert nitrogen monoxide to nitrogen

Relevant Chemical Equations

How are oxides of nitrogen produced?

1. $N_2\,(g) + O_2\,(g) \rightarrow 2\,NO(g)$
2. $2\,NO\,(g) + O_2(g) \rightarrow 2\,NO_2\,(g)$

How is acid rain formed?

$$4\,NO_2\,(g) + 2\,H_2O\,(l) \rightarrow 4\,HNO_3(aq)$$

How does catalytic converter reduce oxides of nitrogen?

$$2\ NO\ (g) + 2\ CO\ (g) \rightarrow 2\ CO_2\ (g) + N_2\ (g)$$

Sulfur Dioxide - SO_2

Source of Pollutant

- Combustion of fossil fuel such as coal, petroleum

Examples of Sources:

- Power stations
- Volcanic eruption

Effects of Pollutant

Impact on Health

- Irritates eyes and lungs, causing breathing difficulties

Impact on Environment

- Forms **acid rain** which corrodes buildings and harms plants and aquatic life.

Ways to Reduce Pollutant

- Expensive method:
  - Remove fossil fuels before they are burnt
- Cheaper method:
  - Flue gas desulfurisation

Relevant Chemical Equations

How is sulfur dioxide produced?

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

How is acid rain formed?

1. $2\ SO_2(g) + 2\ H_2O(l) \rightarrow 2\ H_2SO_4(aq)$
2. **or** $SO_2 + H_2O \rightarrow H_2SO_3$
3. $2\ H_2SO_3 + O_2 \rightarrow 2\ H_2SO_4$

How does flue gas desulfurisation work?

- $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
- $CaO(s) + SO_2(g) \rightarrow CaSO_3(s)$
- $2\ CaSO_3(s) + O_2(g) \rightarrow 2\ CaSO_4(s)$

Unburnt Hydrocarbons (e.g. octane)

Source of Pollutant

- Incomplete combustion of fuels in vehicle engine

Effects of Pollutant

Impact on Health

- Cancer causing (carcinogenic)
- Reacts with sunlight and other pollutants to form ozone.

Ways to Reduce Pollutant

- **Catalytic converters** to convert unburnt hydrocarbons to carbon dioxide and water
- Use of cleaner fuels such as hydrogen

Relevant Chemical Equations

How do catalytic converters reduce unburnt hydrocarbons?

$$2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (g)$$

Effects of Acid Rain

Ground level ozone, O_3

Source of Pollutant

- Forms when **unburnt hydrocarbons and nitrogen oxides** react in the presence of sunlight

Effects of Pollutant

Impact on health

- Creates **photochemical smog** (a mixture of ozone, unburnt hydrocarbons, and nitrogen oxides) which **irritates eyes and lungs, causing breathing difficulties**

Impact on environment

- damages crops

Ways to Reduce Pollutant

see methods of reducing unburnt hydrocarbons and nitrogen oxides as they react to produce ground level ozone.

Ozone Layer

Ozone and its Importance

- Ozone is an important part of the stratosphere
- Acts as shield, **filtering out some of the harmful ultraviolet radiation**, *reducing the chances of getting skin cancer, genetic mutations and eye damage*.

How is Ozone Similar to Oxygen?

- Ozone is an allotrope of oxygen, formed out of 3 oxygen atoms.

Important Fact

- In small concentrations, ozone is non-toxic
- However, in high concentrations (100 ppm), **ozone becomes toxic**
- Too much ozone can damage the tissues of the respiratory tract.

Chlorofluorocarbons

- Chlorofluorocarbons are examples of ozone-depleting substances (ODS)
- Also known as CFCs, they are compounds that contain the elements carbon, fluorine, and chlorine.
- **CFCs are generally used in the manufacture of aerosol sprays, blowing agents for foams and packing materials, as solvents, and as refrigerants.**

Role of CFCs

CFCs in the atmosphere are decomposed by sunlight to produce chlorine radicals. These chlorine radicals then react with ozone molecules and destroy them by converting them into oxygen molecules.

1. $CFCl_3 \rightarrow CFCl_2^+ + Cl^-$ with UV light.
2. $Cl^- + O_3 \rightarrow ClO^- + O_2$
3. $ClO^- + O^- \rightarrow O_2 + Cl^-$

Carbon Cycle

- Describes the process in which carbon atoms continually travel from the atmosphere to the Earth and then back into the atmosphere.
- This cycle is important for maintaining a stable climate and carbon balance on Earth.
- Carbon dioxide is **0.03%** of atmosphere content by volume
- This represents a huge reservoir of carbon, which is constantly being removed from and returned to the atmosphere by a variety of processes.

Process that takes in carbon from the atmosphere	Process which gives out carbon to the atmosphere
Photosynthesis by plants	Respiration by animals
Ocean uptake	Respiration by plants
	Combustion of carbon-containing fuels
	Bacterial decomposition of organic matter