

Topic 9- Chemistry of the Atmosphere

- Triple Science Content only in purple
- Triple Science and Higher Content Only in blue

The Earth's Atmosphere

Proportion of the gases:

- **80% nitrogen**
- **20% oxygen**
- There are **small amounts** of other gases such as water vapour and noble gases

Formation of the Early Atmosphere

Scientists believe that when the Earth first formed (around **4.6 billion years ago**), it was **extremely hot**.

- The surface was covered in **volcanoes** that released large amounts of gases.
- These volcanic eruptions are thought to have produced the **early atmosphere**.

Gases released by volcanoes:

- **Carbon dioxide (CO₂)** - the main gas
- **Water vapour (H₂O)**
- **Nitrogen (N₂)**
- Small amounts of **methane (CH₄)** and **ammonia (NH₃)**

The early atmosphere was **similar to that of Mars and Venus today**, containing very little **oxygen**.

Condensation and Formation of Oceans

As the Earth cooled:

1. **Water vapour condensed** to form **oceans**.
2. The oceans **absorbed large amounts of carbon dioxide** from the atmosphere.
3. This process helped to **reduce the amount of CO₂** in the air.

How Oxygen Levels Increased

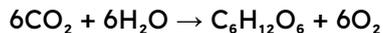
Once the oceans formed, **life began to evolve**.

Step 1: Development of Photosynthetic Organisms

- Around **2.7 billion years ago**, **cyanobacteria (algae)** and **simple plants** evolved.
- These organisms used **photosynthesis** to make glucose, releasing oxygen as a by-product:

Equation:

Carbon dioxide + Water → Glucose + Oxygen



Step 2: Build-up of Oxygen in the Atmosphere

- Over millions of years, oxygen produced by photosynthesis **accumulated in the atmosphere**.
- This allowed **aerobic organisms** (that use oxygen for respiration) to evolve.
- The increase in oxygen also led to the **formation of the ozone layer (O₃)**, which protects Earth from harmful UV radiation.

As a result, the composition of the atmosphere gradually changed to what we have today.

How Carbon Dioxide Levels Decreased

There were **several processes** that reduced carbon dioxide levels over time:

1. Dissolving in Oceans

- Carbon dioxide dissolved in the oceans, forming **carbonates**.
 $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ (carbonic acid)
- This reacted with minerals to form **insoluble carbonate compounds**, which were trapped in rocks or taken up by marine organisms.

2. Formation of Sedimentary Rocks and Fossil Fuels

- Marine organisms (like shellfish and corals) used dissolved carbon dioxide to make **calcium carbonate (CaCO_3)** for their shells and skeletons.
- When these organisms died, their remains were buried and **compressed**, forming:
 - **Limestone** (mainly calcium carbonate)
 - **Fossil fuels** such as **coal**, **oil**, and **natural gas** (formed from dead plants and plankton)
- This process **locked away carbon** underground for millions of years.

3. Photosynthesis

- As algae and plants evolved, they **absorbed CO_2** to make glucose and release oxygen.
- This further **reduced carbon dioxide** levels and helped to **stabilize the atmosphere**.

Greenhouse gases

- Help to **maintain temperatures** on earth high enough.
- Include: **water vapour, CO₂ & CH₄**

What's the greenhouse gas effect?

- **Electromagnetic radiation** from the sun goes through the Earth's atmosphere
- Some of this radiation is **absorbed by the earth**. Some is reflected as **Infrared Radiation**.
- IR radiation is absorbed by **greenhouse gases** in the atmosphere
- Atmosphere warms up leading to **global warming**

What increases greenhouse gas levels in the atmosphere?

Human activity increases the levels of greenhouse gases, for example:

- **Driving (Carbon dioxide)**
- **Consuming electricity (CO₂)**
- **Raising livestock (methane)**
- **Decay of organic waste in landfill sites (methane)**

Let's talk about global climate change...

- One cause of global climate change, is the increase of the earth's average temperature
- Effects of global climate change-

It can lead to the extinction of species
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It can lead to the raising of sea levels as polar ice caps melt

It will lead to migration as people move away from flooding/drought.
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It can lead to a decrease in crop yield

Carbon footprint

- **Carbon footprint:** how much CO₂ and other greenhouse gases were given out over the full

life cycle of a product or a service

- It can be **reduced** by reducing emissions of carbon dioxide and methane e.g. by using **less** electricity, by **reducing** the amount of travel in vehicles, and by **planting more trees (takes in more CO₂)**

Atmospheric pollutants from fuels

- Atmospheric pollutants can come from **combustion**
- Some hydrocarbons (compounds containing hydrogen and carbon) **contain sulphur**
- **In complete combustion** - the products are Carbon Dioxide, and water vapour, and possibly oxides of nitrogen formed in high temperatures

In **incomplete combustion (not enough oxygen)**- carbon monoxide, water, soot (carbon particulates)

If it contains Sulphur, it can also react with the moisture in the air to **form acid rain**.

Properties and effects of atmospheric pollutants

- **Carbon monoxide:** toxic, colourless and odourless gas
- **Sulphur dioxide and oxides of nitrogen (nitrogen oxide/dioxide):** cause acid rain and respiratory problems .
- **Particulates:** cause global dimming