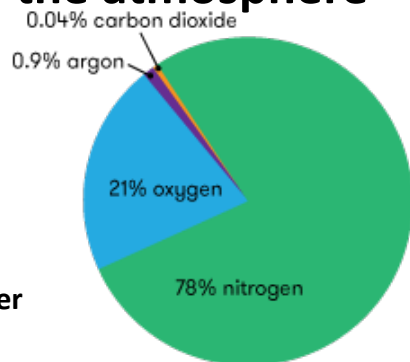


Chemistry of the Atmosphere – Composition and Evolution

1 (a). Composition of the atmosphere

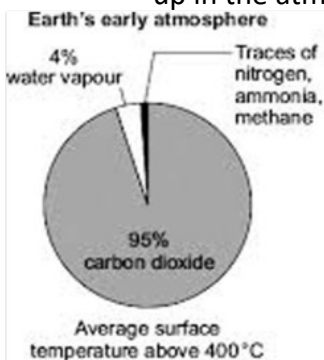
For the last 200 million years, the composition of the atmosphere has been **much the same**:

- 78% **nitrogen**
- 21% **oxygen**
- Small amounts of other gases (including **carbon dioxide**, **water vapour** and **noble gases**)



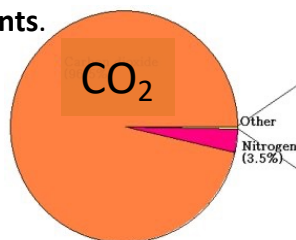
1 (b). The early atmosphere

- When the Earth first formed **4.6 billion** years ago, the atmosphere was very different.
- We **cannot be certain** what the early atmosphere was like as it happened a very long time ago, but scientists have a **theory** that is widely accepted:
 1. During the first **billion years**, there was lots of **volcanic activity**, which released gases that formed the atmosphere.
 2. These gases consisted mainly of **carbon dioxide** and **water vapour** (which condensed to become the **oceans**).
 3. The volcanoes also produced **nitrogen** which gradually built up in the atmosphere.



4. When the oceans formed, the carbon dioxide **dissolved** in the water and produced **sediments**.

The early atmosphere was very similar to that of **Mars and Venus** today.



2. Evolution of the atmosphere

As the Earth evolved, the atmosphere changed. The amount of **oxygen increased** and **carbon dioxide decreased**:

How oxygen increased

- Plants make their own food through **photosynthesis**:

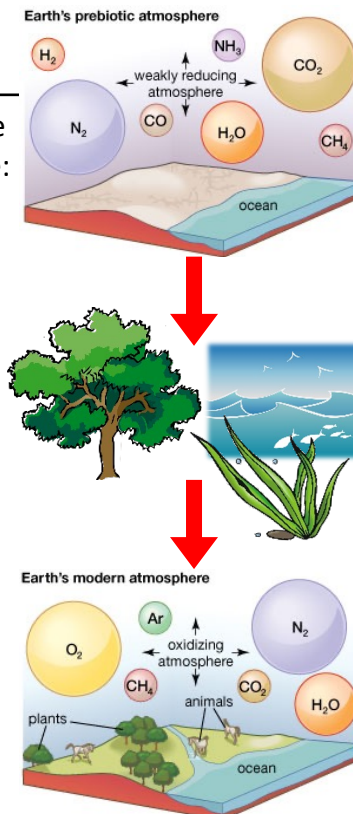


- Algae first produced oxygen about **2.7 billion years ago**.
- Over the next billion years, plants **evolved** and the percentage of oxygen in the atmosphere **increased** to a level that allowed animals to **evolve**.

How carbon dioxide decreased

There are 3 ways in which carbon dioxide was removed from the early atmosphere:

1. When the oceans formed, carbon dioxide **dissolved** into the water and formed **soluble carbonates**. These were then **precipitated** as **sedimentary rocks** (e.g. limestone).
2. Carbon dioxide dissolved in the oceans was also **absorbed by algae** for photosynthesis.
3. Carbon dioxide was **absorbed by plants**, which then **died**. Some of these became **fossil fuels** (coal, oil and gas) which contain carbon. Compression and heating over millions of years formed **trees into coal**, and **plants/small organisms into oil/natural gas**.



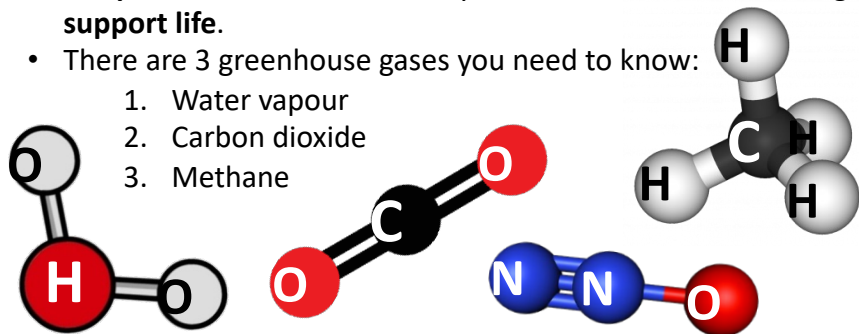
Chemistry of the Atmosphere – Greenhouse Gases

3 (a). Greenhouse gases

- Greenhouse gases are gases in the atmosphere that **increase the temperature of the Earth**. They make the Earth warm enough to **support life**.

- There are 3 greenhouse gases you need to know:

- Water vapour
- Carbon dioxide
- Methane



3 (b). The greenhouse effect

The greenhouse effect is how the Earth is warmed by greenhouse gases. **How it works:**

- Electromagnetic radiation passes through the Earth's atmosphere.
- The Earth **absorbs** most of the radiation and **heats up**.
- The Earth **emits infrared radiation**.
- Some of the infrared radiation is transmitted into **space**.
- Greenhouse gases **absorb** the infrared and **release energy** in all directions. This warms up the Earth's **lower atmosphere**.

- The **carbon footprint** of something is the **total amount of greenhouse gases it produces** during its lifetime.

- To calculate the carbon footprint of an **object** (e.g. a car), you have to consider the greenhouse gases released when:

- mining and transporting the parts.**
- generating electricity to power it.**
- using the object.**
- the object is **disposed of/recycled**.

- To calculate the carbon footprint of a **person**, you have to consider the greenhouse gases released when:

- they use **electricity/boilers at home**.
- they **use transport** (e.g. cars, planes).
- they eat **beef or rice** (releases methane).

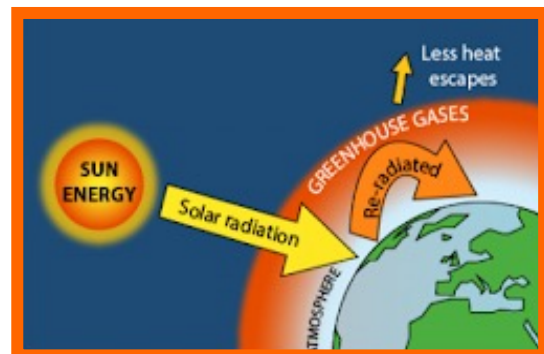
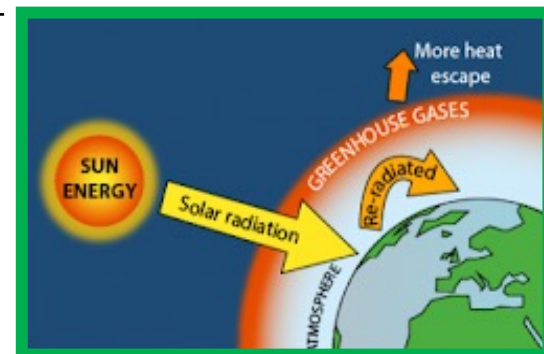
It can be **difficult** to reduce your carbon footprint (e.g. if you are too far away from work to cycle/walk).

Natural Greenhouse Effect

- This is the emission of greenhouse gases through **natural causes**.
- Carbon dioxide** is produced through **respiration** of animals and **volcanic activity**.
- Methane** is produced through the **formation of coal** and **decomposition** (usually in wetlands).

Enhanced Greenhouse Effect

- This is **overproduction** of greenhouse gases due to **human activities**.
- Carbon dioxide** is released through **deforestation** and the **burning of fossil fuels** (coal, oil, and gas).
- Methane** is released through the **decomposition of landfills, burning biomass** and **digestive emissions** from cattle.
- Nitrous oxides** are released through **car exhaust fumes** and **fertilisers** used on farms.



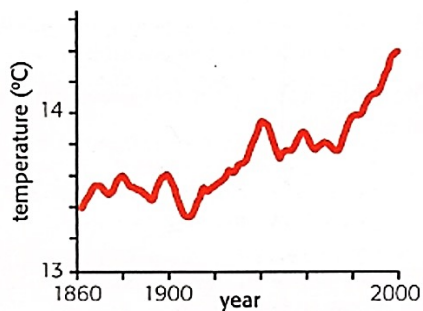
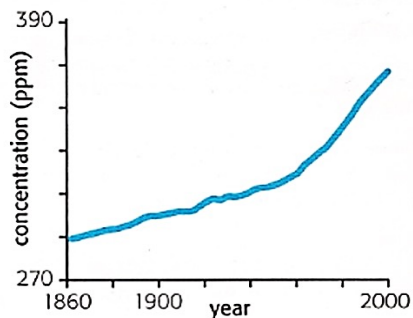
Chemistry of the Atmosphere – Climate Change and Pollution

4. Climate change

- **Global warming** describes how the Earth's temperature has risen in the past 200 years.
- **Climate change** is the long-term alteration of the Earth's climate.
- Based on **peer-reviewed evidence**, most scientists believe that human activities will result in **global climate change** due to the Earth getting warmer.
- However, this is **difficult to model**, which leads to lots of speculation and opinion in the media that may be **biased**.
- The main evidence that humans are causing climate change is the **strong correlation** between the **rise of CO₂ levels** due to human activities and the **rise in global temperature**:

Carbon dioxide in the atmosphere

Average global temperature



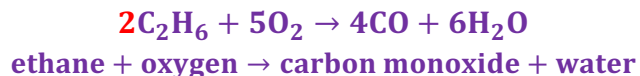
When evaluating the **quality of evidence** on an issue like climate change, you should consider:

- Who **did** the research.
- Who **funded** the research.
- What **methods were used** to collect and analyse the data.
- Which **organisation** is reporting/publishing the evidence.

Incomplete Combustion

- Happens when there is a **poor supply of oxygen**.
- Releases **less** energy.
- Can produce **carbon monoxide** and/or **soot** (carbon particles) instead of carbon dioxide.

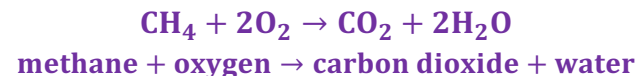
Example:



Complete Combustion

- Happens when there is a **good supply of oxygen**.
- Releases the **maximum** amount of energy.
- Produces **carbon dioxide** and **water**.

Example:



5. Pollutants and their sources

Pollutant	Source	Effect
carbon dioxide (CO ₂)	Complete combustion	Greenhouse gas
carbon monoxide (CO)	Incomplete combustion	Poisonous, odourless and colourless gas
soot (C)	Incomplete combustion	Irritates lining of the lungs, can cause cancer, global dimming
unburned hydrocarbons	Hydrocarbon fuel molecules which have not been oxidised	Reacts with other pollutants to create ozone (in smog), global dimming
sulphur dioxide (SO ₂)	Combustion of fuel that contains sulphur	Causes acid rain, which harms the environment
nitrogen oxides (NO _x)	Inside vehicle engines	Causes acid rain and smog (harmful to health)

- **Combustion** is the burning of fuels. It is a **major contribution** to atmospheric **pollutants**.
- Burning fuels may release **carbon dioxide, water vapour, carbon monoxide, sulphur dioxide** and **nitrous oxides**.

There are 2 types of combustion:

