Cambridge (CIE) IGCSE Chemistry

Your notes

Air Quality & Climate

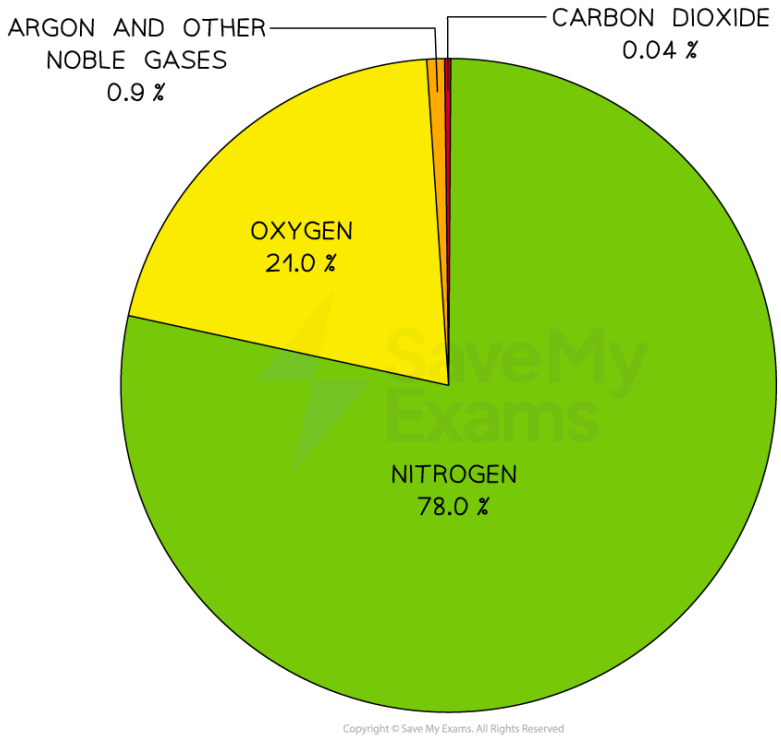
Contents

Your notes

The composition of air

- The present composition of gases in the atmosphere has not changed much in 200 million years
  - About four-fifths of the air is nitrogen and one-fifth is oxygen
  - The remaining gases include carbon dioxide, water vapour and trace quantities of the noble gases

Pie chart of the current atmosphere



The two main gases in the air are nitrogen and oxygen

Air pollution

- In addition to the gases present naturally in our atmosphere, other gases are present due to human activities and are classed as air pollutants

Carbon dioxide

- **Sources:**
  - Complete combustion of carbon-containing fuels such as fossil fuels
  - For example, the complete combustion of methane:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

- **Adverse effects:**
  - Increases global warming, which leads to climate change

Your notes

Carbon monoxide

- **Sources**:
  - Incomplete combustion of carbon-containing fuels such as fossil fuels
  - For example, the incomplete combustion of gasoline / octane:

$$C_8H_{18} + 10O_2 \rightarrow 5CO + 3CO_2 + 9H_2O$$

- **Adverse effects**:
  - Toxic / poisonous
  - It combines with haemoglobin in the blood and prevents it from carrying oxygen

Particulates

- **Sources:**
  - Incomplete combustion of carbon-containing fuels such as fossil fuels can also produce particulates of carbon (soot)
  - For example, the incomplete combustion of methane can produce CO and C:

$$2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$$

$$CH_4 + O_2 \rightarrow C + 2H_2O$$

- **Adverse effects**:
  - Respiratory problems
  - Cancer

Methane

- **Sources:**
  - Waste gases from digestive processes of animals
  - Decomposition of vegetation
  - Bacterial action in swamps, rice paddy fields and landfill sites
- **Adverse effects**:
  - Increases global warming, which leads to climate change

Oxides of nitrogen

- **Sources**:

- Reaction of nitrogen with oxygen in the presence of high temperatures, e.g. in car engines, high-temperature furnaces and when lightning occurs
- It is also a product of bacterial action in the soil

- **Adverse effects**:
  - Produces photochemical smog
  - Dissolves in rain to form **acid rain** which causes corrosion to metal structures, buildings and statues made of carbonate rocks, damage to aquatic organisms
  - Pollutes crops and water supplies
  - Irritates lungs, throats and eyes and causes **respiratory** problems

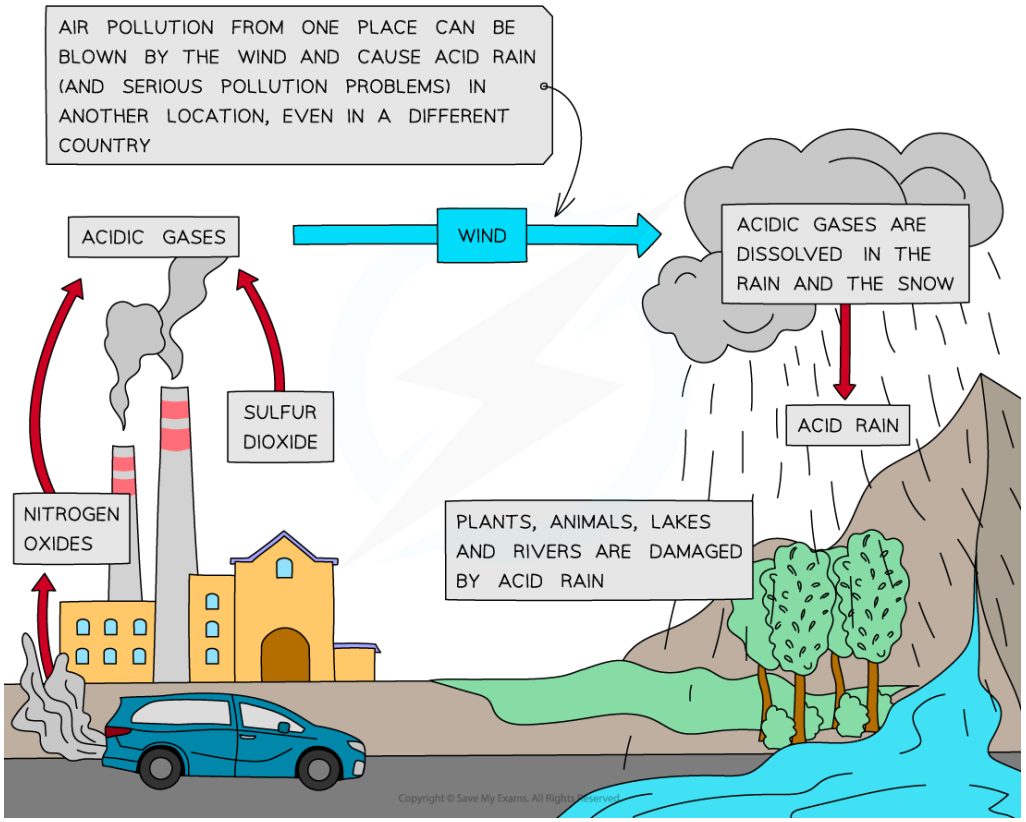
Your notes

Sulfur dioxide

- **Sources**:
  - Combustion of fossil fuels containing sulfur compounds:

$$S + O_2 \rightarrow SO_2$$

- Power stations are a major source of sulfur dioxide
- **Adverse effects**:
  - Dissolves in rain to form **acid rain** with similar effects as the acid rain caused by oxides of nitrogen



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Examiner Tips and Tricks

Complete and incomplete combustion of hydrocarbons produce different products.

- Complete combustion occurs in **excess** oxygen and produces **CO_2** and **H_2O**.
- Incomplete combustion occurs in **oxygen-deficient** conditions and produces **CO**, **H_2O** and sometimes particulates of **carbon** (soot).

Your notes

Effects of greenhouse gases

Extended Tier Only

- The Sun emits energy in the form of radiation that enters the Earth's atmosphere
- Some thermal energy is **reflected** from the Earth's surface
- Most thermal energy is **absorbed** and **re-emitted** back from the Earth's surface
- The energy passes through the atmosphere where some thermal energy passes straight through and is **emitted** into space
- But some thermal energy is absorbed by greenhouse gases, such as **carbon dioxide** and **methane**, and is re-emitted in all directions
- This reduces the thermal energy lost into space and traps it within the Earth's atmosphere, keeping the Earth warm
  - This process is known as the **greenhouse effect**
- As the concentration of greenhouse gases in the atmosphere increases due to human activity, more thermal energy is trapped within the Earth's atmosphere causing the Earth's average temperature to rise (**global warming**)
  - This process is called the **enhanced greenhouse effect**

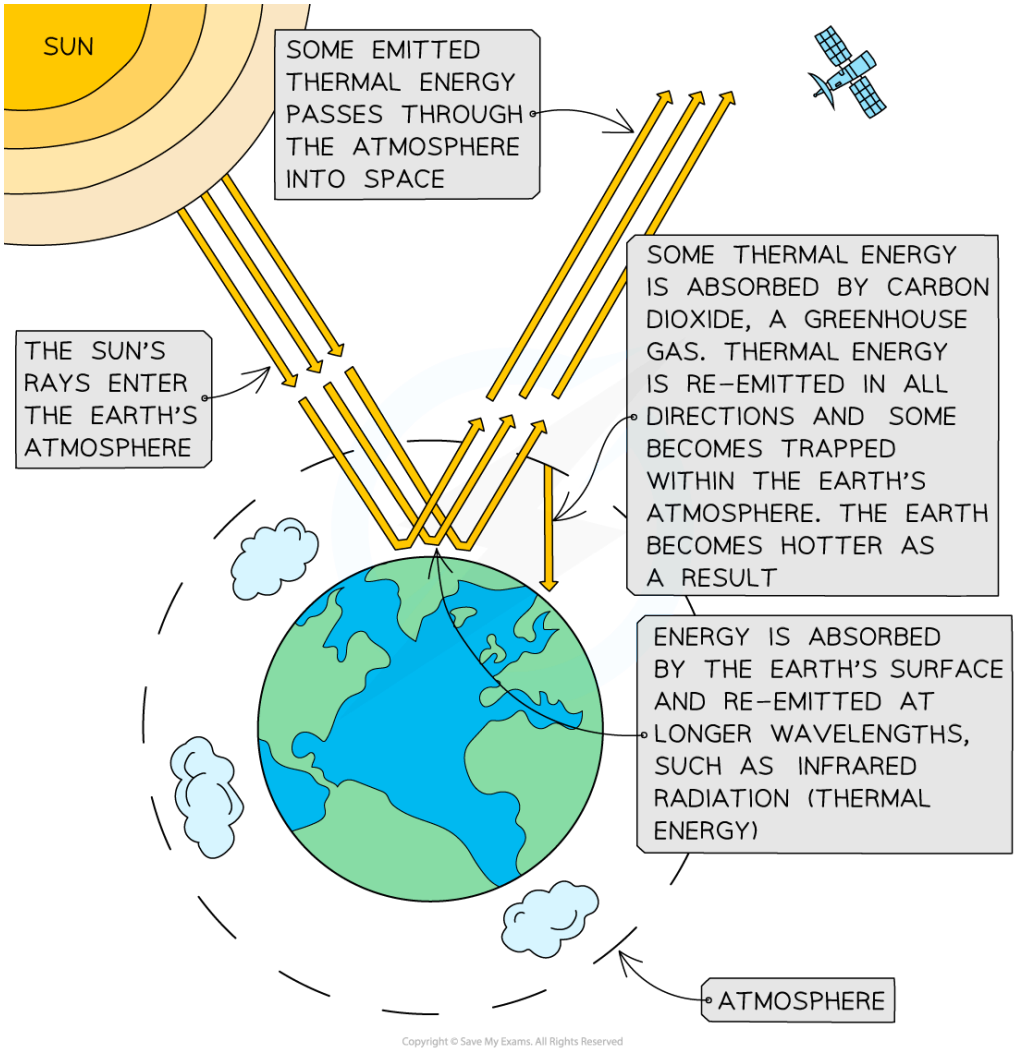

Diagram showing how the greenhouse effect occurs

Consequences of global warming

- Climate change due to the increase in Earth's temperature
- Water levels will rise as glaciers melt because of high temperatures, causing flooding in low-lying countries
- Extinction of species due to the destruction of natural habitats
- Migration of species as they will move to areas that are more habitable (no droughts)
- Spread of diseases caused by warmer climate
- Loss of habitat due to climate change (animals that live on glaciers or in low-lying countries)

Your notes

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Reducing the effects of environmental issues

- Two of the main environmental issues are climate change and acid rain
- There are strategies that can be used to reduce the impact of these issues

Strategies to reduce climate change

- The production of greenhouse gases, specifically carbon dioxide and methane, needs to be reduced drastically to reduce climate change

Reducing carbon dioxide emissions

- Some measures that can be taken include:
  - Being more 'responsible consumers' of energy by:
    - Using **hydrogen** and **renewable** energy supplies such as **solar** or **wind** energy instead of burning fossil fuels
    - Using more fuel-efficient vehicles, e.g. electric and hybrid cars
    - Reducing the number of vehicles on the road, e.g. using public transport, car-sharing
    - Recycling or reusing products made from crude oil and its derivatives
    - Reducing household energy consumption, e.g. turning lights out, using more efficient appliances
  - Reducing deforestation and / or re-forestation
    - Planting more trees, can help reduce the amount of atmospheric carbon dioxide through photosynthesis

Reducing methane emissions

- Reduce the amount of livestock farming
  - Methane is produced during digestion in animals

Strategies to reduce acid rain

- Acid rain is caused by oxides of nitrogen and sulfur dioxide
- The effects of acid rain can be reduced by decreasing the amount of oxides of nitrogen and sulfur dioxide that are produced
- Catalytic convertors in vehicles can be used to remove oxides of nitrogen

Reducing sulfur dioxide emissions

- Using fuels which contain low levels of sulfur
- Flue gas desulfurisation
  - This is the main way to reduce sulfur dioxide emissions
  - Waste gases from coal fired power stations are passed into a scrubbing chamber
  - They are sprayed with a wet slurry of calcium oxide and calcium carbonate
  - The calcium compounds react with sulfur dioxide to produce calcium sulfate

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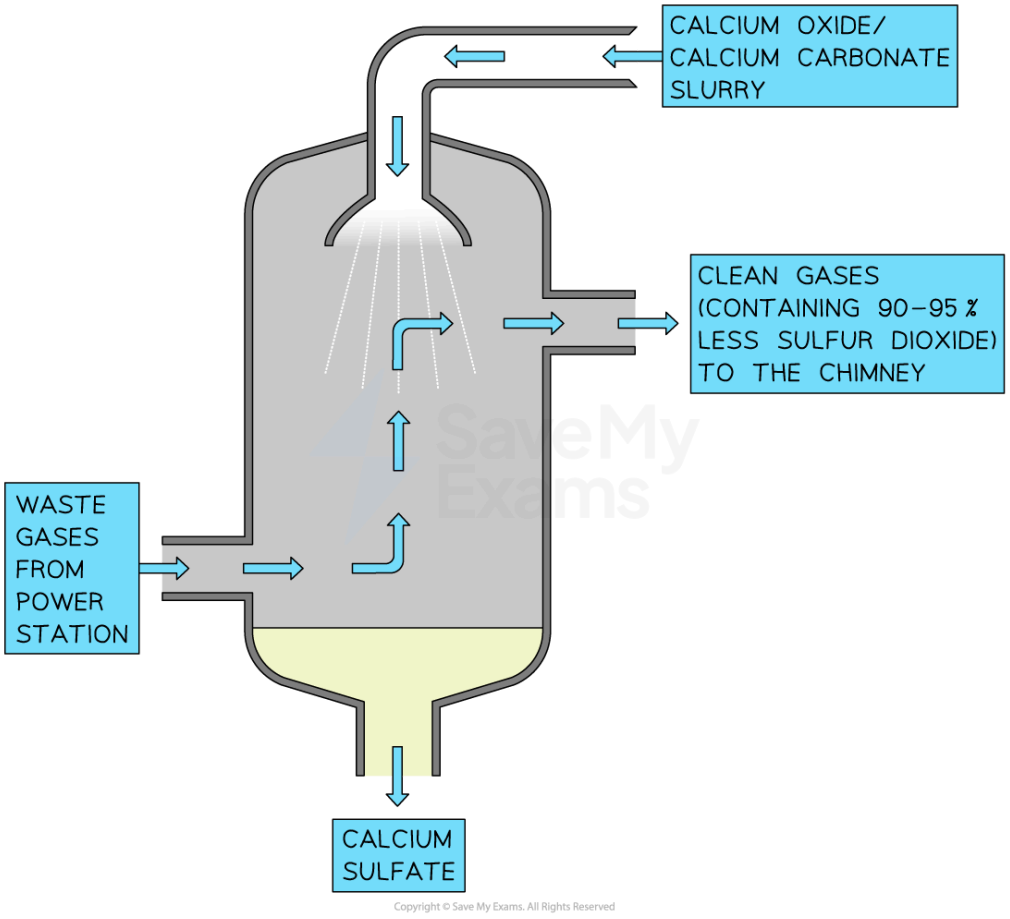
Sulfur dioxide scrubber



The scrubber sprays a lime slurry over the waste gases to remove 90 - 95% of the sulfur dioxide

Examiner Tips and Tricks

There are many other ways that carbon dioxide, methane, oxides of nitrogen and sulfur dioxide can be reduced, e.g. by reducing energy usage to reduce CO_2 emissions but it is only the examples stated above that you need to know.

Oxides of nitrogen in car engines

Extended tier only

Your notes

Oxides of nitrogen

- These compounds (NO and NO_2) are formed when nitrogen and oxygen react in the **high pressure** and **temperature** conditions of **internal combustion engines** and blast furnaces
- Exhaust gases also contain unburned hydrocarbons and carbon monoxide
- Cars are fitted with catalytic converters which form a part of their exhaust systems
- Their function is to render these exhaust gases harmless

Catalytic converters

- They contain a series of **transition metal catalysts** including platinum and rhodium
- The metal catalysts are in a **honeycomb** within the converter to increase the surface area available for reaction
- A series of redox reactions occurs which neutralises the pollutant gases
- Carbon monoxide is oxidised to carbon dioxide:

$$2CO + O_2 \rightarrow 2CO_2$$

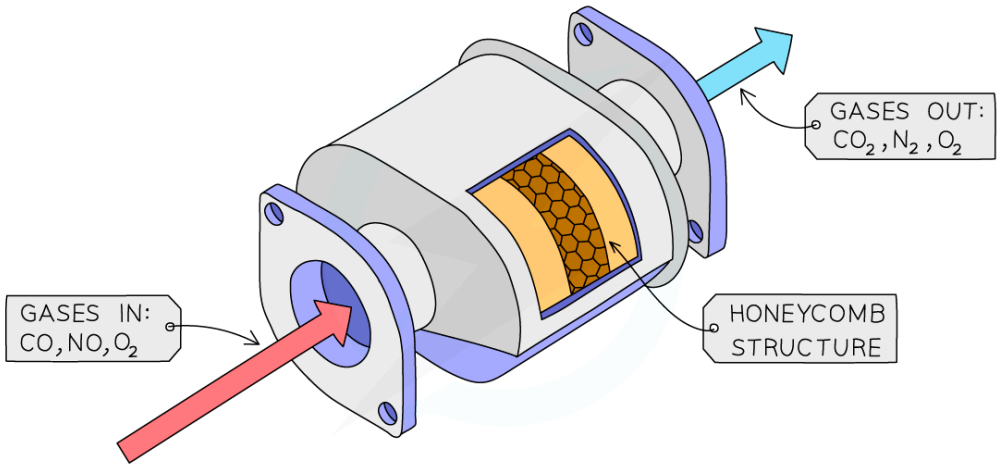
- Oxides of nitrogen are reduced to N_2 gas:

$$2NO \rightarrow N_2 + O_2$$

$$2NO_2 \rightarrow N_2 + 2O_2$$

- A single reaction can summarise the reaction of nitrogen monoxide and carbon monoxide within a catalytic convertor:

$$2NO + 2CO \rightarrow N_2 + 2CO_2$$



Catalytic converters are designed to reduce the polluting gases produced in car exhausts

- Unburned hydrocarbons can also be oxidised to carbon dioxide and water:

$$C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$$

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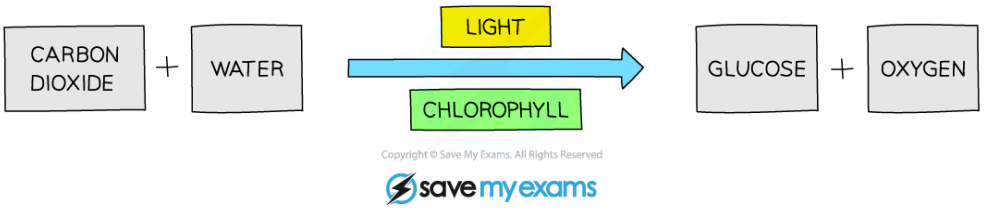
Photosynthesis

- Photosynthesis is an endothermic reaction
  - Energy is taken in from the environment by chloroplasts / chlorophyll
- The reactants for photosynthesis are carbon dioxide and water
- They are converted into glucose and oxygen
- Chlorophyll (found in chloroplasts) and energy from light are required for this reaction to occur
- The **word equation for photosynthesis** is:

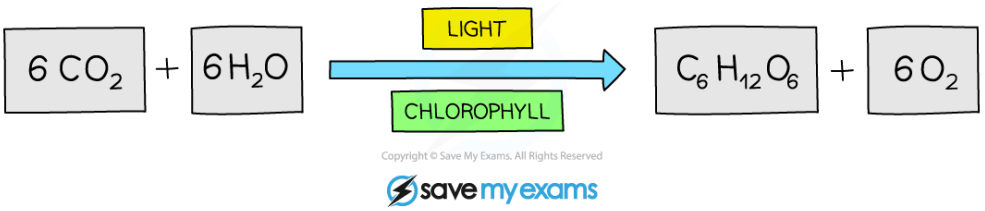


Carbon dioxide and water producing glucose and oxygen during photosynthesis

Symbol equation for photosynthesis

Extended tier only

- The balanced symbol equation for photosynthesis is:



Balanced symbol equation for photosynthesis