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A 3D cutaway of Earth showing the atmosphere and internal layers, with a bright light source above.

TOPIC 10: AIR & ATMOSPHERE



THE ABOUT

CHAPTER ANALYSIS



TIME

- Simple but content heavy chapter
- Requires revision before test/exams



EXAM

- Straight forward questions
Require knowledge of pollutants & effects
- Will always link to other chapters:
 - → Chemical Equations, Redox Reaction



WEIGHTAGE

- Light overall weightage
- Constitute to **2%** of marks for past 5 year papers

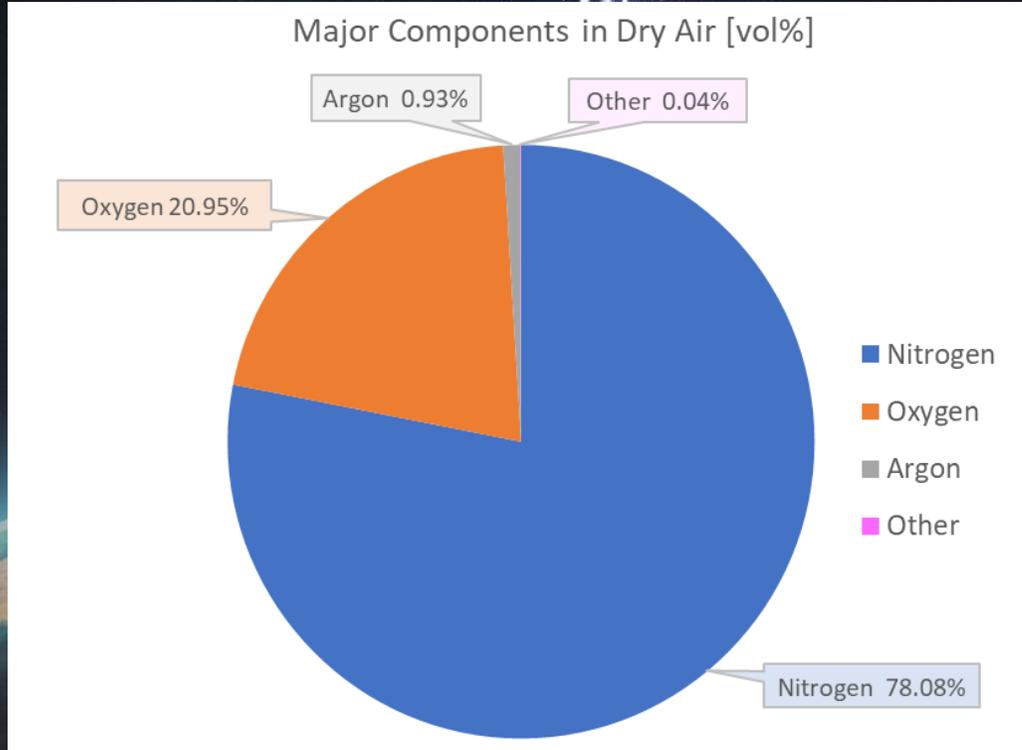
KEY CONCEPT

AIR & ATMOSPHERE

COMPOSITION OF AIR

POLLUTANTS





COMPOSITION OF AIR

COMPOSITION OF AIR

Air is a mixture of gases that **largely** made up of **nitrogen and oxygen**.

The **other gases are noble gases (like argon), carbon dioxide and water vapour**.

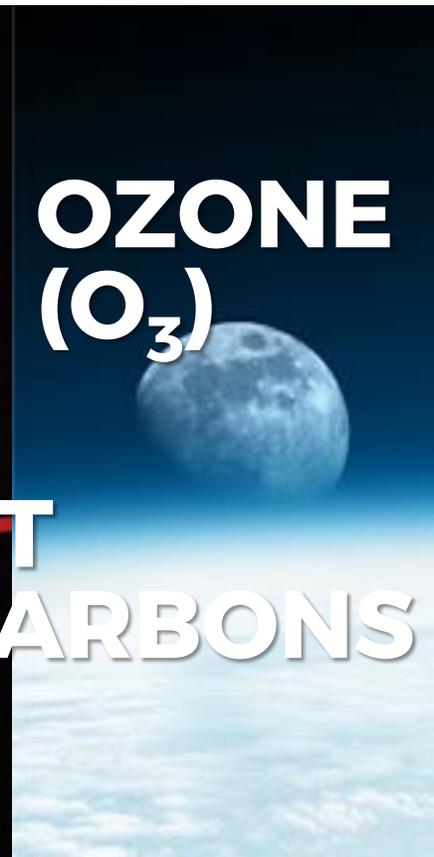
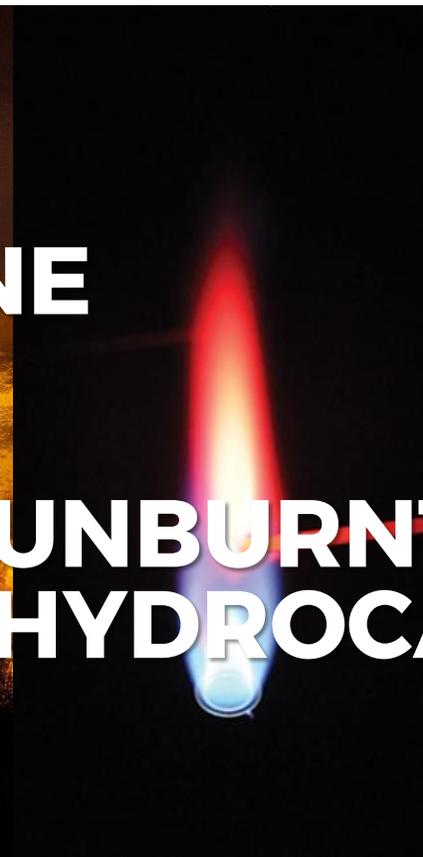
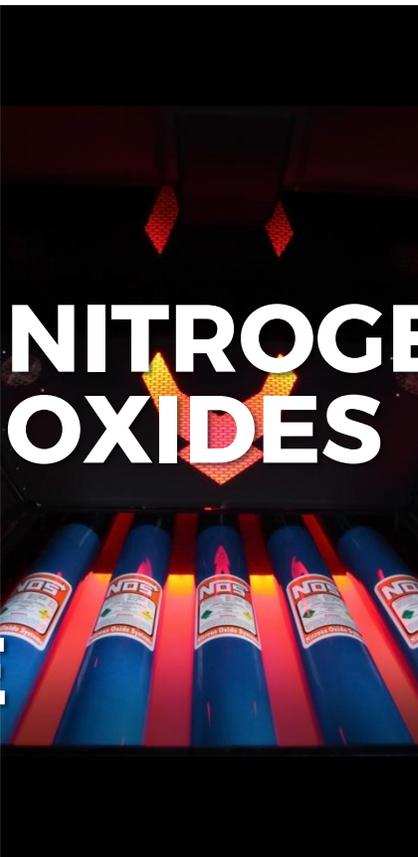
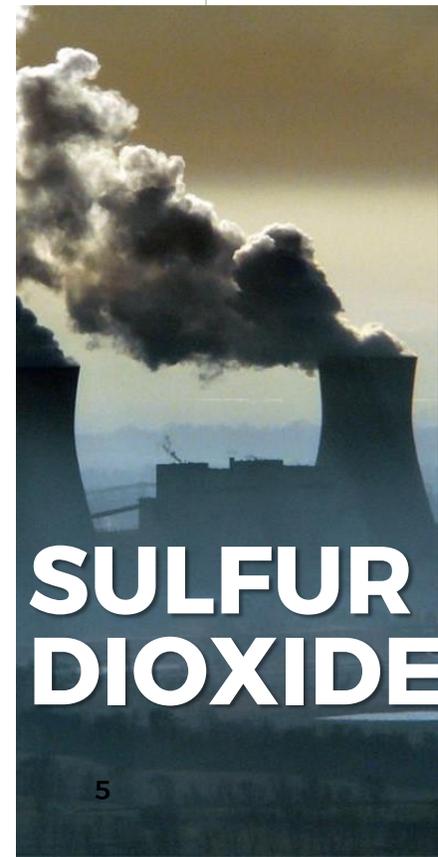
Percentage:

Nitrogen - 78%

Oxygen - 21%

Carbon Dioxide - 0.03%

6 COMMON AIR POLLUTANTS



MUST KNOW

Summary Table

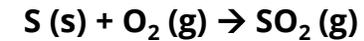
Gas	Sources	Effects
Sulfur Dioxide	Sulfur that are present in fossil fuels (crude oil) undergoes combustion	Breathing difficulties Acid rain $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}_2\text{SO}_4(\text{aq})$ $4\text{NO}_2(\text{g}) + \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow 4\text{HNO}_3(\text{aq})$
	Volcanic eruptions	
Nitrogen Monoxide / Nitrogen Dioxide	NO and NO ₂ are formed in car engines or chemical factories under very high temperature and pressure	
	Heat energy released by lightning during thunderstorms allows both nitrogen and oxygen in air reacts with each other	
Carbon Monoxide	CO is produced from incomplete combustion of petroleum in vehicle engines	CO binds to haemoglobin that is present in red blood cells, which would reduce its ability to transport oxygen, hence causing respiratory problems
Methane	Sheep and cows' fart/burps	Greenhouse gas that causes global warming
	Decomposition of plant and animal matter	
Unburnt Hydrocarbons	Incomplete combustion of fuel in car engines and chemical plants	Causes cancer
Ozone	Form from photochemical smog as a by-product from reaction between nitrogen dioxide and unburnt hydrocarbons in the presence of sunlight	Breathing difficulties
		Damage crops



SULFUR DIOXIDE

SULFUR DIOXIDE

Sulfur is a **type of impurity present in fossil fuels**. When fossil fuels undergo combustion, sulfur would react with the oxygen in air to form sulfur dioxide.



Large volumes of sulfur dioxide can also be produced during **volcano eruptions**.

Harmful Effects:

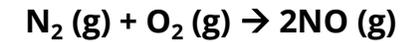
- Causes **respiratory difficulties**
- Causes formation of acid rain, which results in erosion of buildings and environmental damages.



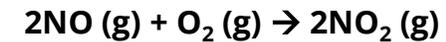
NITROGEN OXIDES

NITROGENOUS OXIDES

Under very high temperatures, nitrogen and oxygen in air reacts to form nitrogen monoxide (NO).



Nitrogen monoxide can continue reacting with oxygen in air to form nitrogen dioxide (NO₂).

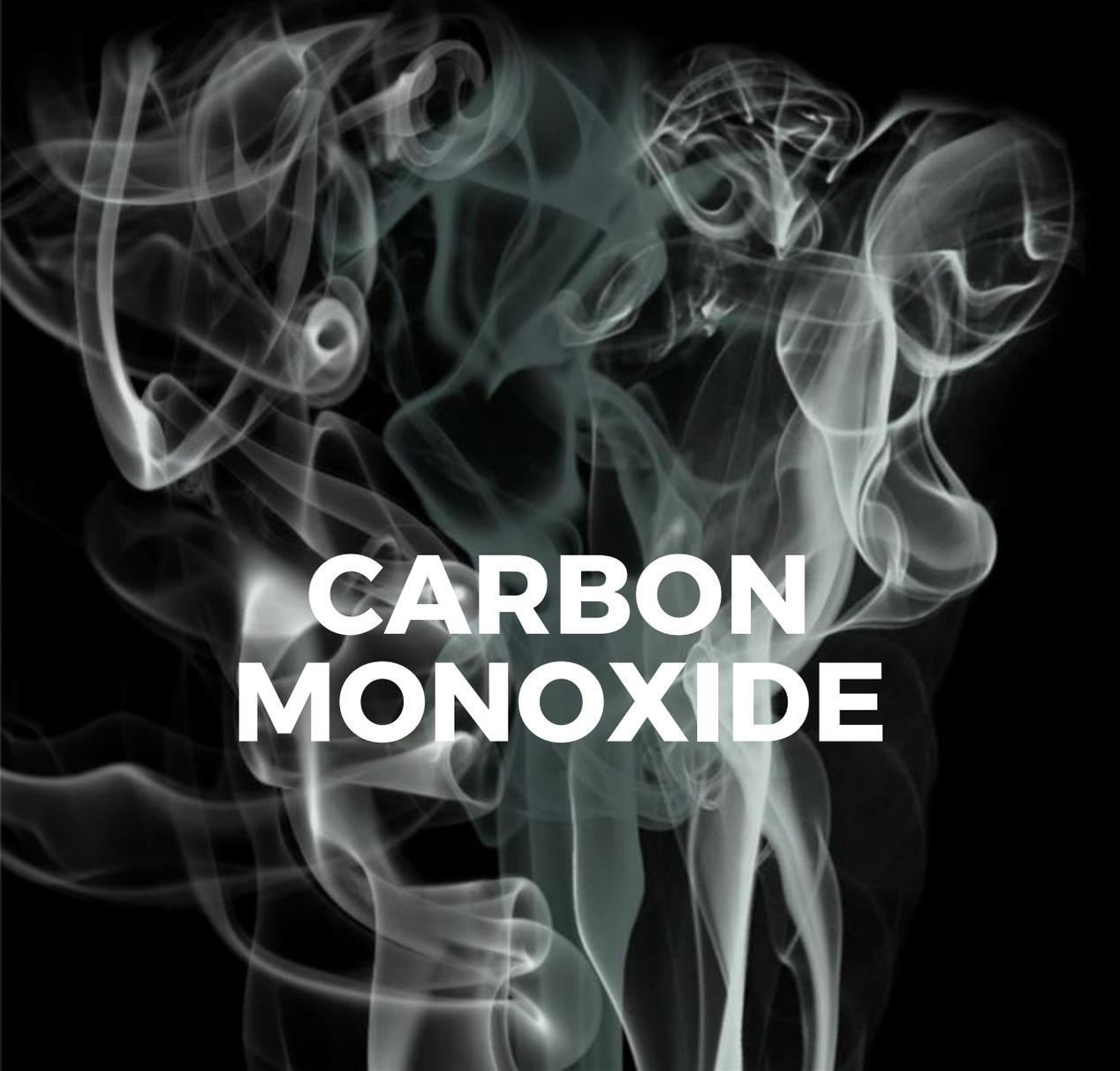


NO_x is usually produced in **vehicle engines**, power stations, factories and incinerators which are high temperature environments.

NO_x is can also be produced during **thunderstorms and forest fires** as well.

Harmful Effects:

- Causes irritation to our lungs
- Causes the formation of acid rain, which results in erosion of buildings and environmental damages
- NO₂ may react to produce harmful ozone in the presence of sunlight



CARBON MONOXIDE

When you leave your car engine on while stationary, the air your engine takes in is stagnant and after a while, incomplete combustion will cause the production of carbon monoxide!

So try and turn off your engine if the car is going to stationary for a while!

CARBON MONOXIDE

When carbon undergoes **incomplete combustion** due to the lack of oxygen, it produces carbon monoxide (CO).



Incomplete combustion commonly occurs in **vehicle engines**.

Carbon monoxide (CO) **binds to haemoglobin** that is present in red blood cells, which would reduce its ability to transport oxygen, hence causing respiratory problems.

Harmful Effects:

- Poisonous gas **causing respiratory problems** by reducing the body's ability to transport oxygen effectively (by binding with haemoglobin in red blood cell).



METHANE

METHANE

Methane is a type of **greenhouse gas** that traps heat on Earth.

Produced due to activities such as **cattle farming** (rearing of cows, sheeps etc...).

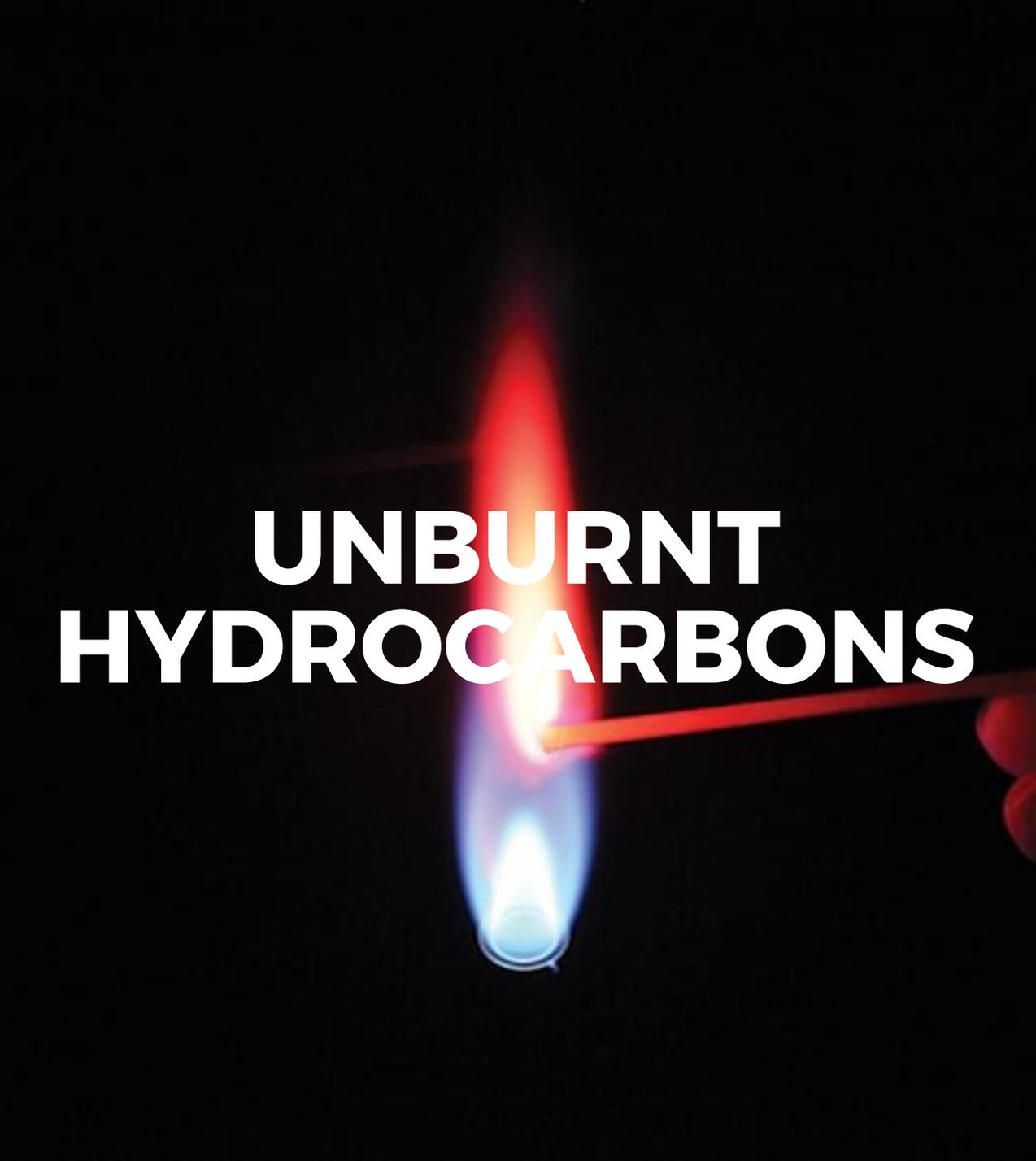
These livestock produce methane in their digestive systems and release it in their farts and burps.

Methane is also produced **from bacteria decay process**.

The increase in the amount of methane produced causes **enhanced greenhouse effect** which in turn traps more heat on Earth, resulting in **global warming**.

Harmful Effects:

- Huge and increasing amounts of methane produced leads to **enhanced greenhouse effect** which causes **global warming**



UNBURNT HYDROCARBONS

UNBURNT HYDROCARBONS

Due to **incomplete combustion of fuels** when there is a lack of oxygen, unburnt hydrocarbons are formed.

Harmful Effects:

- Can be cancerous
- Reacts in the presence of sunlight and other pollutants to form harmful ozone



OZONE

Ozone

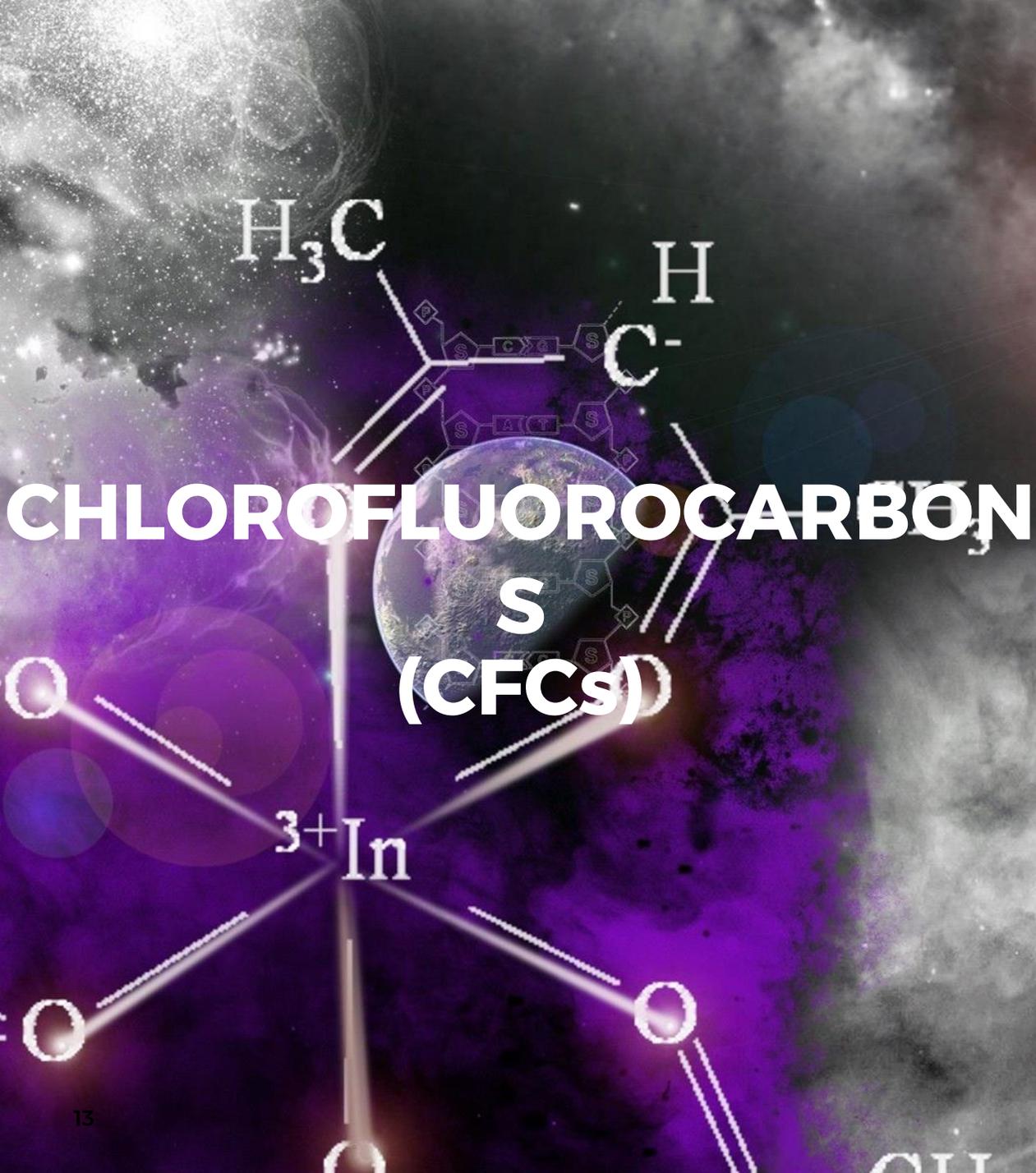
Ozone (O_3) exists as a colourless gas.

Ozone, in the presence **UV radiation or sunlight**, is formed from **photochemical smog**, which contains a mixture of gases such as **nitrogen dioxide, carbon monoxide and volatile organic compounds (VOCs)**.

Ozone that is present at ground level would irritate the eyes, nose, throat and is an air pollutant.

Harmful Effects:

- Irritation to the eyes, nose and throat
- Causes respiratory problems such as asthma

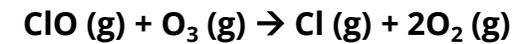


CHLOROFLUOROCARBONS S (CFCs)

CHLOROFLUOROCARBONS

CFCs are released when using **propellants in aerosols** and **are present in coolants in air conditioners and refrigerators.**

CFCs causes **depletion of the ozone layer** as CFC molecules decompose in the UV light into highly reactive chlorine atoms that will react with ozone molecules in the atmosphere.



Harmful Effects:

- Depletion of ozone layer, which would allow harmful UV rays to enter the earth's atmosphere
- Exposure to harmful UV rays can cause skin cancer

KEY CONCEPT

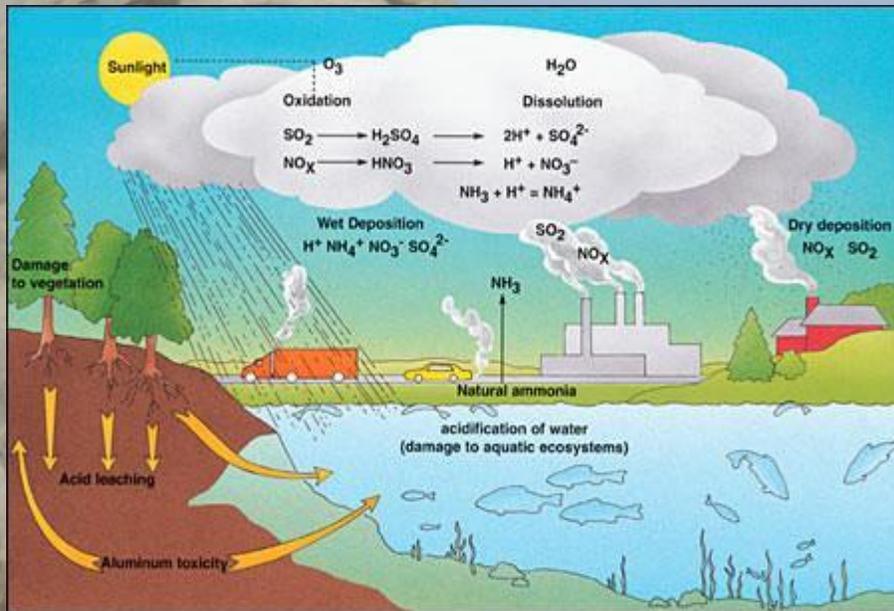
AIR & ATMOSPHERE

EFFECTS OF AIR POLLUTION

DESULFURISATION & CATALYTIC CONVERTER

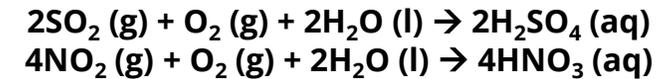


ACID RAIN



ACID RAIN

Acid rain is formed when acidic oxides (e.g. **sulfur dioxide and nitrogen dioxide**) react with oxygen and water in the atmosphere to form acid.



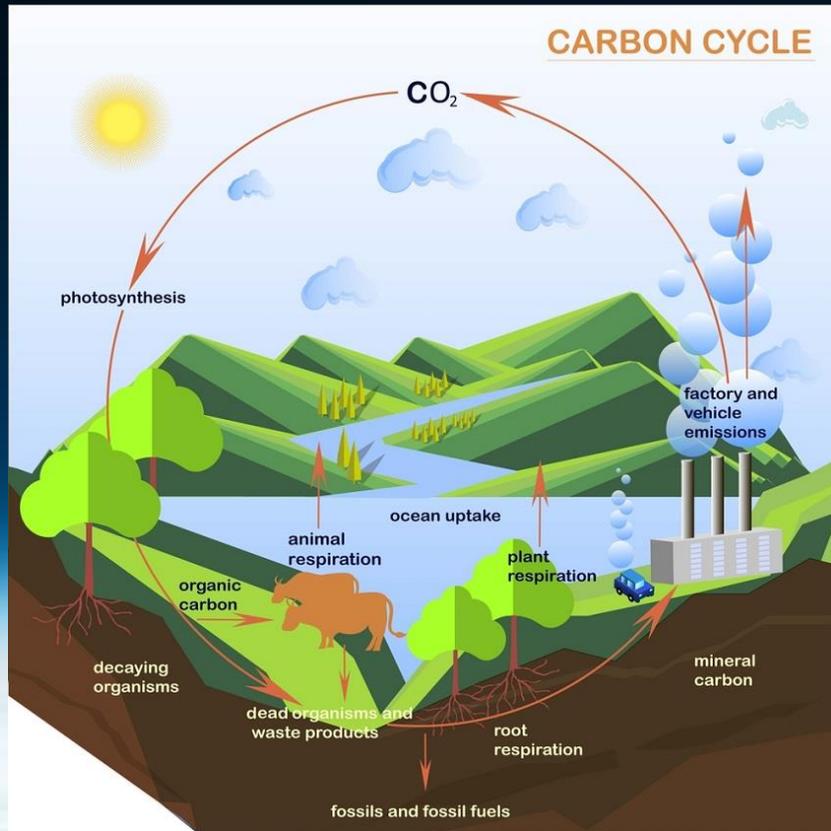
Harmful Effects:

- Acid rain causes **corrosion to buildings and statues** that are built using materials containing limestone, cement or **metallic structures** as acids react with metal.
- Acid rain disrupts the pH balance of the soil, making it **acidic**, making it less optimal for the growth of plants and trees.
- Acid rain decreases the **pH of lake water**, causing it to be unsuitable for aquatic organisms to survive.

Ways to reduce harmful effects of acid rain:

- **Refrain from using fuels containing sulfur**, like coal or oil.
- **Cleansing the air** that contains pollutants like **sulfur dioxide and nitrogen dioxide** before releasing it.
- Neutralise the high acidity in soils by using **slaked lime** (calcium hydroxide) or **limestone** (calcium carbonate).

GLOBAL WARMING



The carbon cycle describes the **movement of carbon dioxide** in our environment.

Carbon dioxide is continuously flowing. It is taken out of the atmosphere by green plants through photosynthesis, and returns back into the atmosphere through various processes such as respiration, combustion and decay.

GLOBAL WARMING

Global warming refers to the Earth heating up and experiencing an **increase in temperature**.

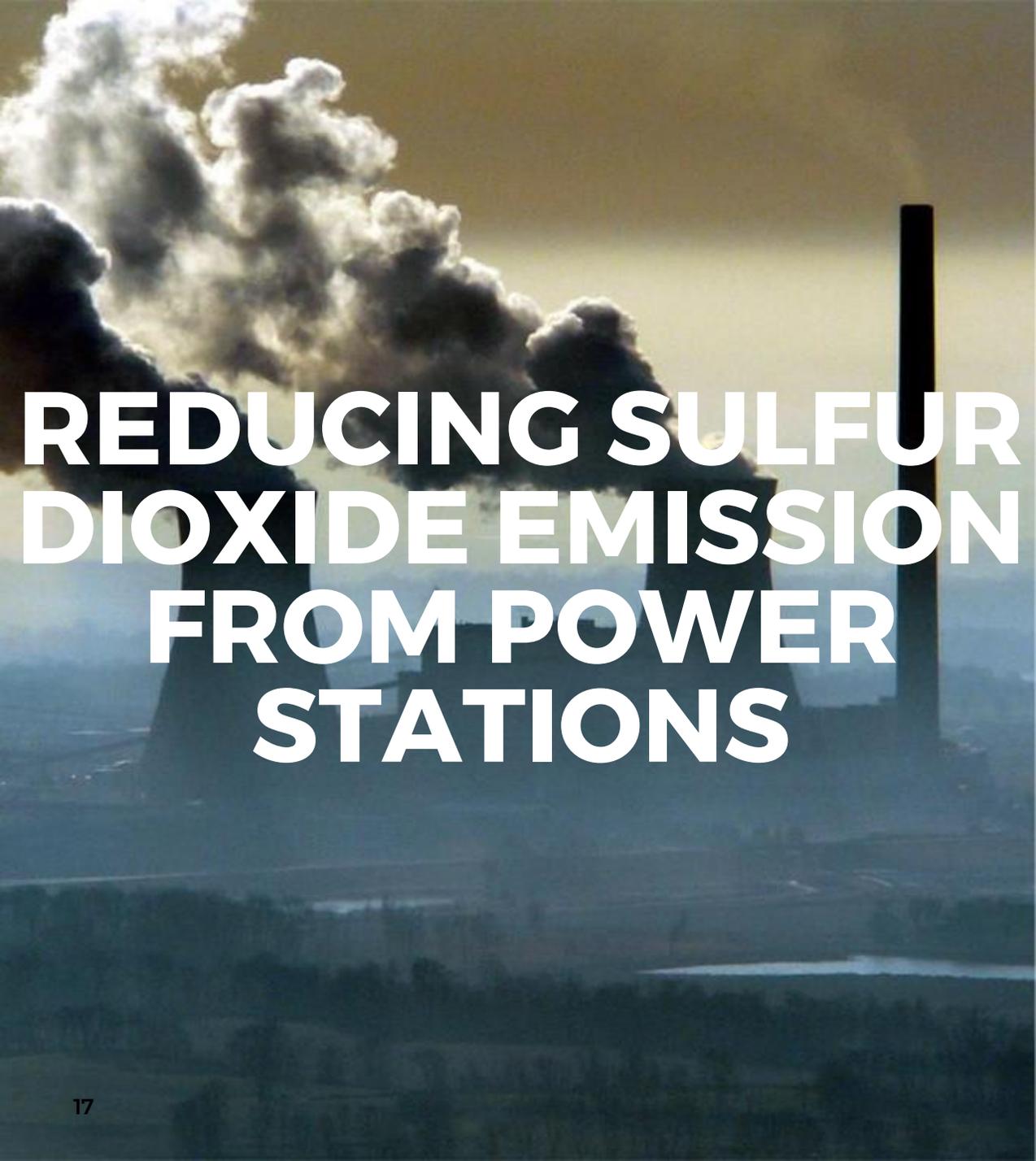
Methane, carbon dioxide and other greenhouse gases **trap heat** from the Sun, resulting in the increase in temperature on Earth, which leads to global warming.

Harmful Effects:

- **Melting of polar ice caps** causes rising **sea levels** which causes **flooding of low-lying lands**.
- **Higher rainfall in equatorial climates**, while countries in the **Northern hemisphere** (United States and Europe) are likely to experience **more droughts**.
- **Food shortages** will happen as **certain crops will struggle to grow** in such bad conditions.

How to reduce the effect of global warming:

- **Switch from using non-renewable sources of energy** (e.g. fossil fuels) **to using renewable sources of energy** (e.g. wind and solar energy)
- Switch to **electric or hydrogen powered vehicles**

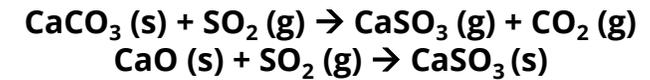


REDUCING SULFUR DIOXIDE EMISSION FROM POWER STATIONS

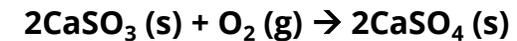
WASTE GAS DESULFURISATION

Sulfur dioxide can be removed from waste gas through its reaction with powdered limestone (**calcium carbonate**).

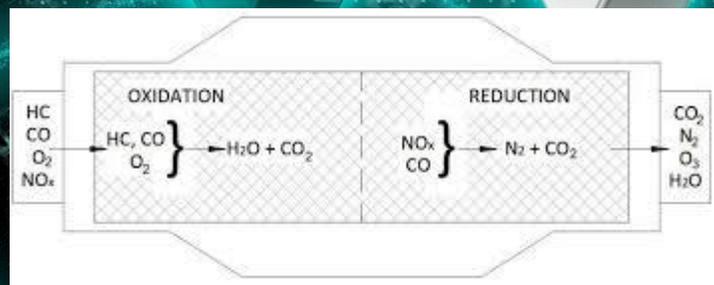
Sulfur dioxide in waste gas reacts with **calcium carbonate & calcium oxide** to produce solid calcium sulfite.



The resultant calcium sulfite is then further oxidised, forming an insoluble solid calcium sulfate.



FITTING CARS WITH CATALYTIC CONVERTORS

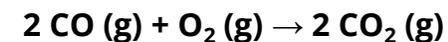


REDUCING HARMFUL GASES EMISSION FROM VEHICLES

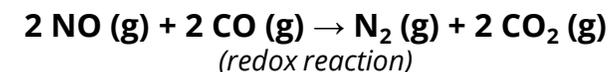
Through the use of **catalytic converters**, pollutants are converted into non-polluting gases.

Hot exhaust gases from vehicle engines that contains **carbon monoxide, oxides of nitrogen and unburnt hydrocarbons** are passed through the platinum catalyst in a catalytic converter.

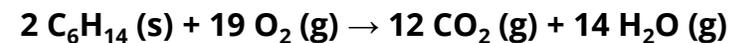
Carbon monoxide would be oxidised to form carbon dioxide:



Oxides of nitrogen would be reduced to nitrogen gas:



Unburnt hydrocarbons like hexane would be oxidised to form carbon dioxide and water:



In Singapore, all cars are required to be installed with catalytic converters!

Try it yourself! (TYS Question)

12. In the catalytic converter of a car, what type of chemical reaction takes place to change the harmful exhaust gases, carbon monoxide and nitrogen monoxide, into less harmful gases?

(N2020/P1/Q29)

A combustion
C precipitation

B evaporation
D redox

()

Answer:

12. **D**
 $2\text{CO} + 2\text{NO} \longrightarrow 2\text{CO}_2 + \text{N}_2$
Carbon monoxide is oxidised to carbon dioxide while nitrogen monoxide is reduced to nitrogen.

Try it yourself! (TYS Question)

13. Which process removes carbon dioxide from the atmosphere?

(N2020/P1/Q30)

A combustion of fuels
C respiration

B photosynthesis
D volcanic activity

()

Answer:

13. **B**
Plants take in carbon dioxide during photosynthesis.

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