ST ANDREW'S SECONDARY SCHOOL

NAME _____ CLASS _____

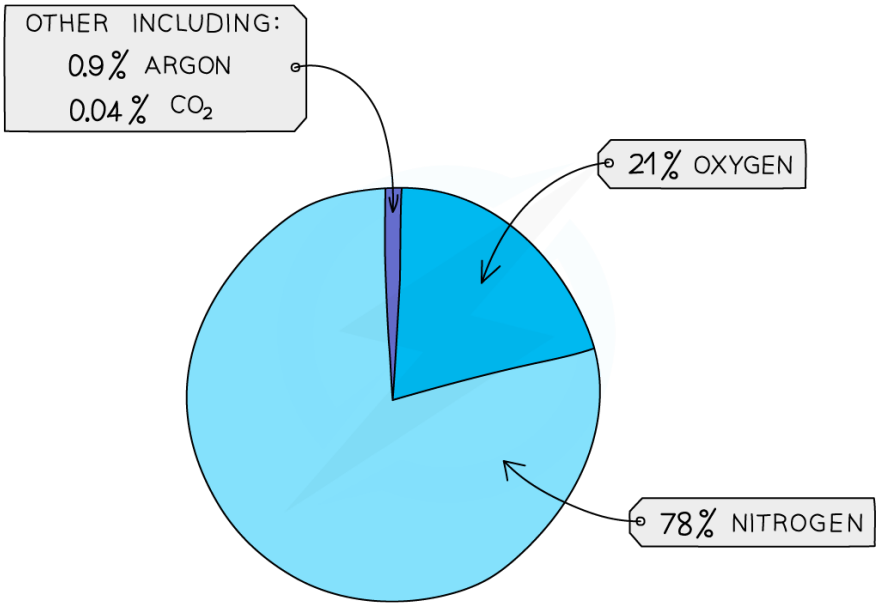
DATE _____

SCIENCE(CHEMISTRY)

Topical Notes (Additional)

Air and Atmosphere

The Composition of Air



Pie chart showing the approximate percentages by volume of the main gases in unpolluted, dry air

Uses of air

- The gases available in the air have many important applications
- Oxygen is used in **steel** making, **welding** and in **breathing** apparatus
- Nitrogen is used in **food packaging**, the production of **ammonia** and in the production of **silicon chips**
- Both of these gases are separated from air by fractional distillation

Fractional Distillation of Air

- The air is first filtered to remove dust, and then cooled in stages until it reaches –200°C
- At this temperature the air is in the liquid state
- Water vapour and carbon dioxide freeze at higher temperatures and are removed using absorbent filters
- The Noble gases are still in the gaseous state at -200°C, leaving a mixture of liquid nitrogen and oxygen
- The liquefied mixture is passed into the bottom of a fractionating column
- Note that the column is warmer at the **bottom** than it is at the top
- Oxygen liquefies at -183°C and nitrogen liquefies at -196°C
- Nitrogen has a lower boiling point than oxygen so it vaporises first and is collected as it rises in the gaseous state to the **top** of the column
- The liquid O2 is then removed from the **bottom** of the column

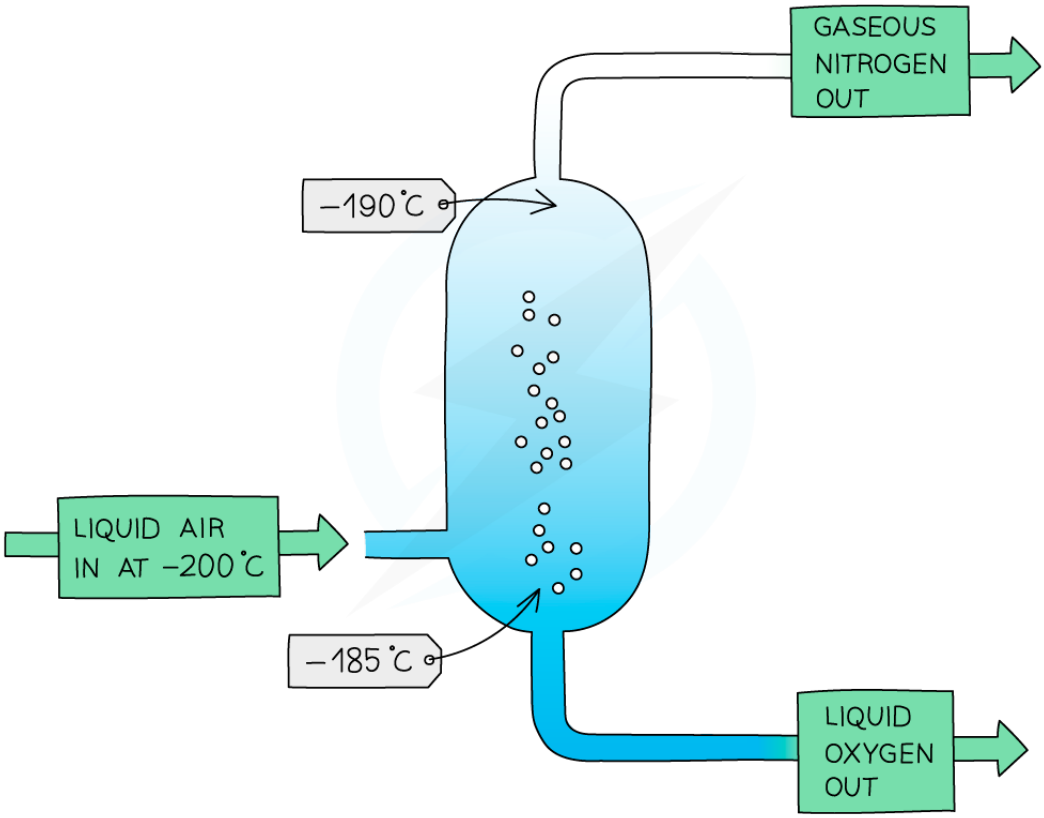


Diagram showing the fractional distillation of liquid air to produce N_2 gas and liquid O_2

Air Pollution

Carbon monoxide

- **Sources**: incomplete combustion of fossil fuels e.g: incomplete combustion of gasoline:

$$C_8H_{18} + 9O_2 \rightarrow 5CO + 2CO_2 + 9H_2O$$

- Adverse effects: poisonous, combining with hemoglobin in blood and prevents it from carrying oxygen

Sulfur dioxide

- **Sources**: combustion of fuels, natural gas and sulfide ores e.g: zinc blende (ZnS) in the extraction of zinc:

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

- **Adverse effects**: 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

Oxides of nitrogen

- **Sources**: reaction of nitrogen with oxygen in car engines and high temperature furnaces and as a product of bacterial action in soil
- **Adverse effects**: acid rain with similar effects as SO2 as well as producing photochemical smog and breathing difficulties, in particular for people suffering from asthma

Compounds of lead

- **Sources**: old water pipes, old paints, petrol in some kinds of racing cars and from very old engines
- **Adverse effects**: causes significant damage to the central nervous system, young infants are particularly susceptible to lead poisoning

EXAM TIP

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 oxygen deficient conditions and produces CO, H_2O and sometimes carbon.

Nitrogen Oxides in Car Engines

Nitrogen oxides

- These compounds (NO and NO2) 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:

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

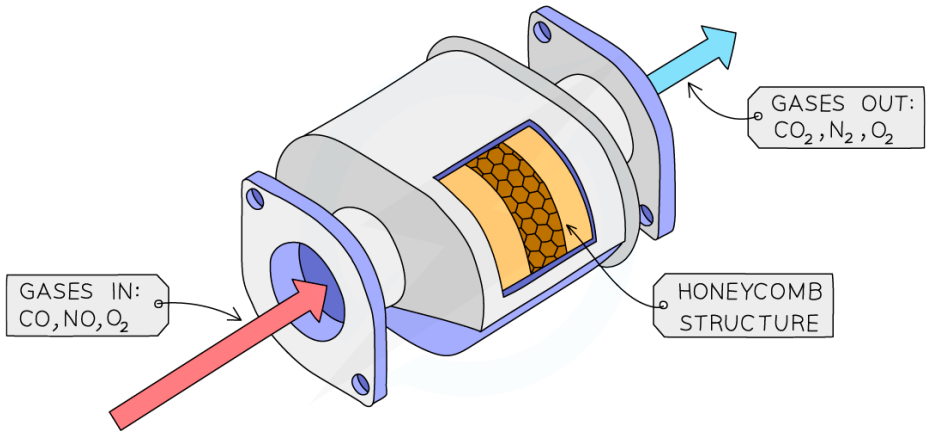
- Nitrogen oxides are reduced to N2 gas:

$$2NO \rightarrow N_2 + O_2$$

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

- Unburned hydrocarbons are oxidised to carbon dioxide and water:

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



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

The Rusting of Iron

Rusting of iron

- Rusting is a chemical reaction between iron, water and oxygen that forms the compound iron (III) oxide
- Oxygen and water must be present for rust to occur
- Rusting is a redox process and it occurs faster in salty water since the presence of sodium chloride increases the electrical conductivity of the water

$$\text{Iron} + \text{Water} + \text{Oxygen} \rightarrow \text{Hydrated Iron (III) Oxide}$$

$$4Fe(s) + 3O_2(g) + xH_2O(l) \rightarrow 2Fe_2O_3.xH_2O(s)$$

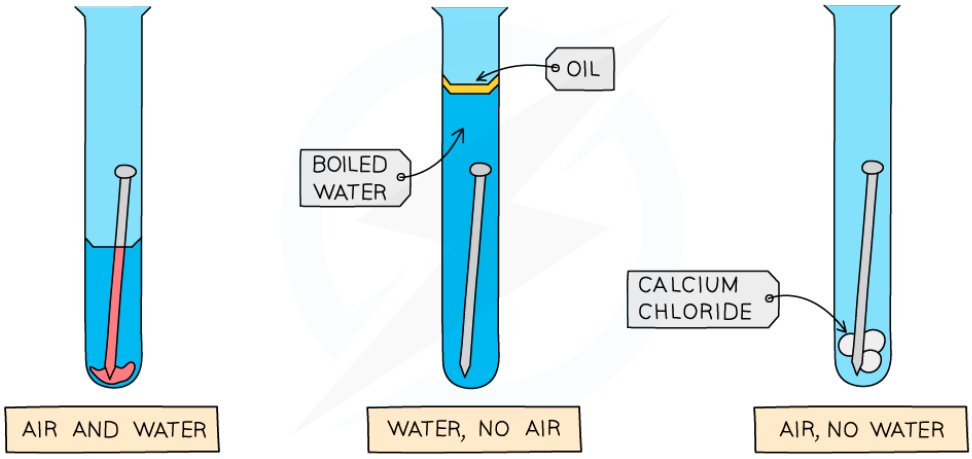


Diagram showing the requirements of oxygen and water for rust to occur: only the nail on the left rusts

Barrier Methods of Rust Prevention

- Rust can be prevented by coating iron with barriers that prevent the iron from coming into contact with water and oxygen
- However, if the coatings are washed away or scratched, the iron is once again exposed to water and oxygen and will rust.

COMMON BARRIER METHODS	
GREASE	OIL
PAINT	PLASTIC

Greenhouse Gases, Carbon Dioxide & Methane

Greenhouse gases

- When shortwave radiation from the sun strikes the Earth's surface it is absorbed and re-emitted from the surface of the Earth as infrared radiation
- However much of the I.R. energy is trapped inside the Earth's atmosphere by **Greenhouse gases** which can absorb and hold the radiation
- Two such gases are carbon dioxide and methane
- They both lead to climate change as they trap heat energy from escaping the Earth's atmosphere, leading to **global warming**

Carbon dioxide

- **Sources**: combustion of wood and fossil fuels, respiration of plants and animals, thermal decomposition of carbonate rocks and the effect of acids on carbonates

Methane

- **Sources**: digestive processes of animals, decomposition of vegetation, bacterial action in swamps and in rice paddy fields

The Greenhouse effect

- Caused by the increased concentration and effect of Greenhouse gases, mainly methane and carbon dioxide

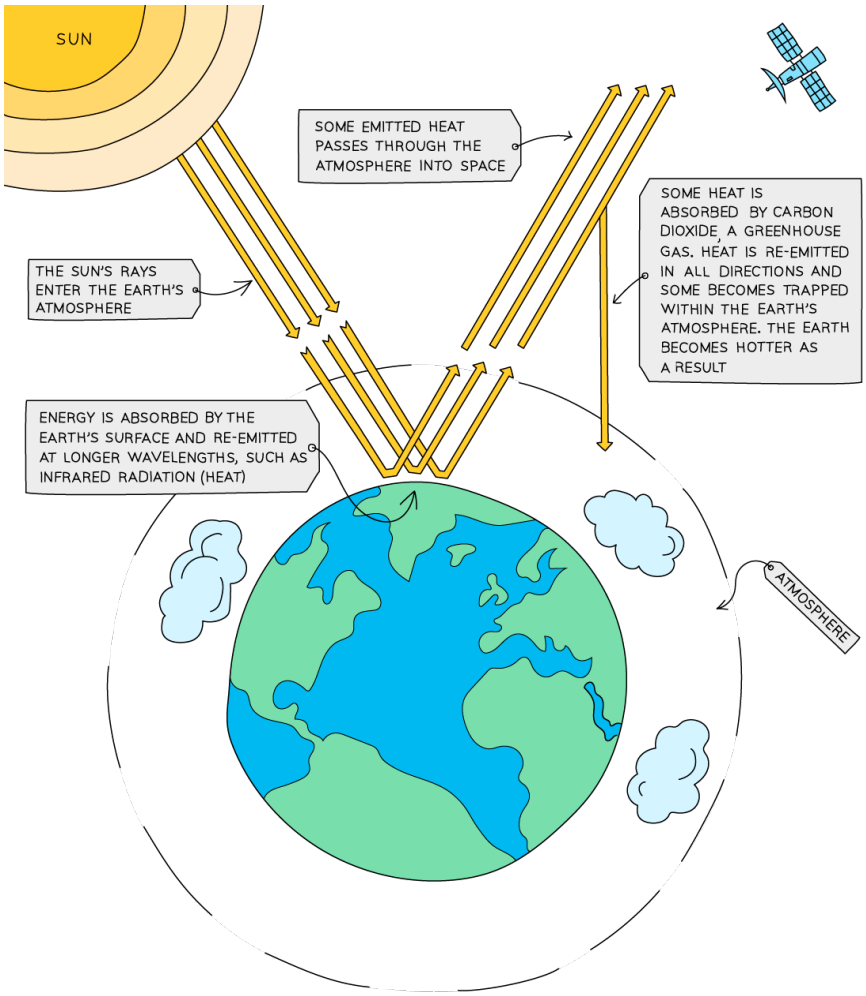


Diagram Showing How the Greenhouse Effect Occurs

Explanation:

- The Sun emits rays that enter the Earth's Atmosphere
- The heat is emitted back from the Earth's surface
- Some heat is reflected back out into Space
- But some heat is absorbed by Greenhouse gases such as carbon dioxide and methane and is trapped within the Earth's Atmosphere, causing the Earth's average temperature to rise as a result

Consequences:

- 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)

The Carbon Cycle

The carbon cycle describes the movement of carbon between the seas, land and atmosphere.

In the atmosphere, the main source of carbon is carbon dioxide.

Sources of CO_2 in the atmosphere

- Combustion of fossil fuels, e.g: methane:

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

- Respiration: the production of energy in living things. The overall reaction of respiration is represented by the equation:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

- Decomposition of limestone
- Reactions of acids with carbonates

Removal of carbon dioxide from the atmosphere

- Photosynthesis: the process of producing glucose and oxygen from carbon and water in plants in the presence of chlorophyll and light:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

- Carbon dioxide dissolves in the water in sea and oceans and is removed by shellfish for making their calcium carbonate shells

Balancing the carbon

- Carbon as carbonate, carbon dioxide or organic carbon compounds is present in the sea, the air and under the Earth
- There is a continuous cycle of these compounds between these sources called the carbon cycle
- There is a constant amount of carbon compounds in the sea, atmosphere and under the Earth
- As long as these are balanced, the amount of carbon dioxide in the atmosphere remains **constant**
- Scientists are worried that increasing the amounts of fossil fuels burned will increase global warming and unbalance the carbon cycle

Astronomers have detected four neighbouring planets with the following composition of gases in their atmospheres.

planet	atmosphere contains
P	methane, carbon dioxide, oxygen
Q	oxygen, nitrogen
R	carbon dioxide, hydrogen
S	carbon dioxide, methane, hydrogen

In which planet is the Greenhouse Effect most likely to take place?

A P & S **B** P, Q & R **C** Q, R & S **D** P, R & S