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S1 New Curriculum chemistry

Theme: Air and environment

S1 New Curriculum Chemistry Chapter 7 – Air

Air is a **mixture of gases** that surrounds the Earth and makes life possible. It is mostly composed of:

- **Nitrogen (78%)** – Helps plants grow and is essential for life.
- **Oxygen (21%)** – Vital for breathing and combustion.
- **Argon (0.93%)** – An inert gas used in industry.
- **Carbon dioxide (0.04%)** – Used by plants for photosynthesis and plays a role in climate change.
- **Other gases** – Includes small amounts of neon, helium, methane, and water vapor.

Oxygen

Uses of oxygen

Oxygen in air plays a crucial role in many natural and industrial processes. Here are some key uses: It is obtained by fractional distillation of air from which water and carbon dioxide have been removed by freezing.

- **Breathing and Respiration** – Oxygen is essential for humans and animals to survive. It helps in cellular respiration, where food is converted into energy.

Glucose + Oxygen

Energy + Carbon dioxide + water

- **Combustion** – Fuels like wood, gas, and coal burn in the presence of oxygen to produce heat and energy.
- **Medical Applications** – Oxygen is used in hospitals to support patients with breathing difficulties.
- **Water Purification** – Oxygen helps maintain water quality in lakes and rivers by supporting aquatic life.
- **Industrial Use** – It is used in welding, metal cutting, and the production of steel.
- **Rocket Fuel** – Liquid oxygen is used in rocket engines as an oxidizer to help burn fuel.
- **Ozone Formation** – Oxygen molecules form ozone (O_3), which protects the Earth from harmful ultraviolet rays.

Experiment to measure the percentage of oxygen in air

(a) Using a candle and water

We can measure the percentage of **oxygen in air** using a simple experiment with a burning candle and a gas jar. This experiment relies on the fact that oxygen supports combustion, and when consumed, the air volume decreases.

Materials Needed

- A small candle
- A gas jar or transparent container
- A shallow dish filled with water
- Matches

Procedure

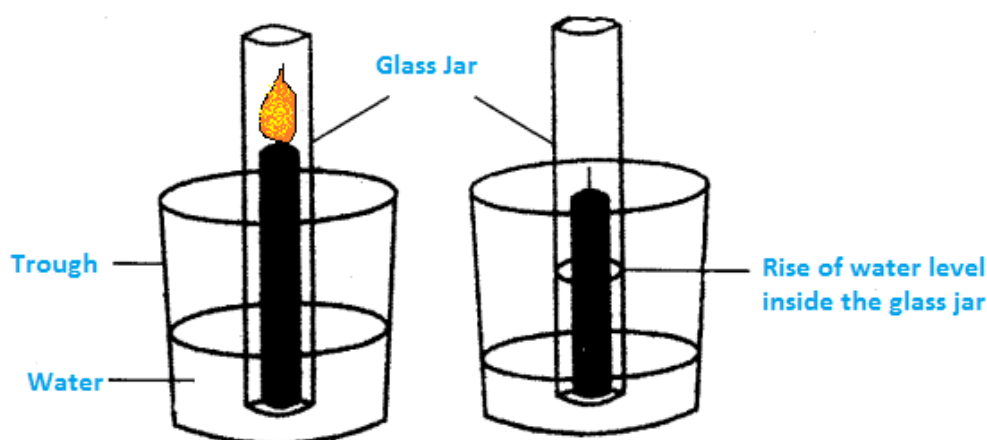
- Fill the Dish** – Pour water into the shallow dish.
- Place the Candle** – Stand the candle upright in the center of the dish.
- Light the Candle** – Use matches to ignite the candle flame.
- Cover with the Gas Jar** – Quickly place 100cm³ jar over the burning candle, sealing it in.
- Observe Water Movement** – As the oxygen inside the jar is used up, the flame goes out, and water rises into the jar to replace the lost oxygen.

Observation

The water level in the jar rises to 21cm³ in the jar

Hence volume of oxygen used up = 21cm³

Percentage of oxygen in air = $\frac{21}{100} \times 100 = 21\%$



Conclusion

Air is 21% oxygen

(b) Using copper fillings

Materials

Hard glass

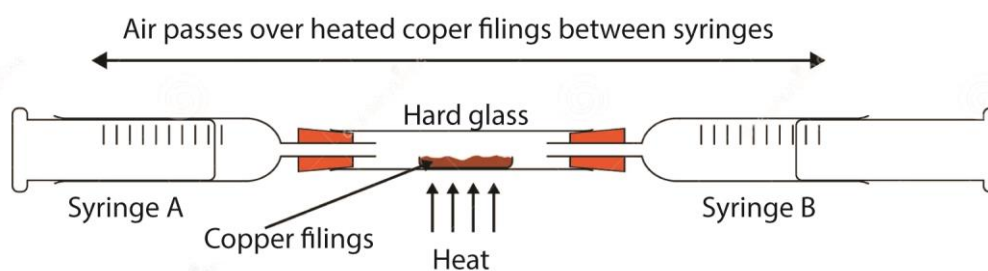
Copper filings

2 gas syringes

Source of heat

Setup

A tube of hard glass is connected to two gas syringes A and B. the tube is packed with copper filings. At the start syringe A contains 100cm³ of air



Procedure

- (i) Heat copper filings while forcing air continuously over the filings from syringe A to syringe B and from syringe B to syringe A until there is not further change in the volume of air.
- (ii) Leave the apparatus to cool
- (iii) Push all air to syringe A and measure the remaining air.

Observations

Starting volume of air = 100cm³

Final volume of air = 79cm³

Volume of oxygen used = 100 – 79 = 21cm³

Percentage of oxygen in air = $\frac{21}{100} \times 100 = 21\%$. Hence percentage of oxygen in air = 21%

Conclusion: Air is 21% oxygen

Carbon dioxide

Uses of carbon dioxide from air

Carbon dioxide (CO₂) in the air has several important uses across nature and industry.

- **Photosynthesis** – Plants absorb CO₂ from the air to produce oxygen and food through photosynthesis, supporting all life on Earth.
- **Carbonated Drinks** – Used to add fizz to soda, sparkling water, and beer.
- **Fire Extinguishers** – CO₂ helps put out fires by displacing oxygen and cooling flames.
- **Refrigeration** – Used as a cooling agent in food preservation and transport.
- **Industrial Manufacturing** – Used in producing chemicals, dry ice, and welding processes.
- **Medicine** – Helps regulate breathing in patients and is used in medical treatments.
- **Enhanced Oil Recovery** – CO₂ is injected into oil wells to push out remaining oil for extraction.

Experiment to show that exhaled air contains carbon dioxide

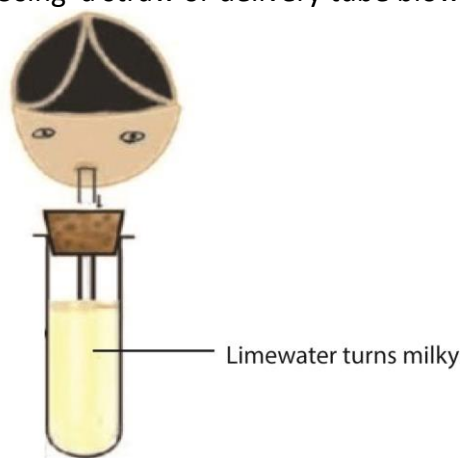
You can perform a simple experiment to show that **exhaled air contains carbon dioxide (CO₂)** using **limewater**. Limewater turns **cloudy** when it reacts with CO₂, proving its presence in exhaled air.

Materials Needed

- **Limewater** (a dilute solution of calcium hydroxide)
- **Two test tubes**
- **Drinking straw or delivery tube**
- **Source of fresh air** (optional for comparison)

Procedure

- Using a straw or delivery tube blow air through lime water as shown below



Observation

The limewater in the test tube turns cloudy due to the reaction between **carbon dioxide** and **limewater**, forming **calcium carbonate**.

Conclusion

The exhaled air contains carbon dioxide

Water

Experiment to show that exhaled air contains water

Materials Needed

- A **clean mirror or glass**
- A **cool surface** (can be refrigerated for a few minutes)
- Your **breath**

Procedure

1. Cool a mirror in a refrigerator for a few minutes.
2. Breathe out onto the cold mirror

Observation

A **thin layer of mist** forms on the surface.



Explanation of the Observation

The mist is caused by **water vapor** in breath condensing on the cool surface.

Conclusion

Exhaled air contains water vapour.

Nitrogen

Nitrogen, which makes up about **78% of the air**, has many important uses in nature and industry. It is obtained by fractional distillation of air from which water and carbon dioxide have been removed by freezing. Nitrogen is inert because a lot of energy is needed to break the strong bond between the two nitrogen atoms

Uses of nitrogen

- **Plant Growth** – Plants need nitrogen to produce proteins and chlorophyll. It's absorbed from the soil in the form of nitrates.
- **Food Preservation** – Used in food packaging to keep snacks and other products fresh by preventing oxidation.
- **Medical Applications** – Liquid nitrogen is used to freeze and remove unwanted tissue, such as warts.
- **Industrial Use** – Helps in welding, metal cutting, and making ammonia for fertilizers.
- **Fire Prevention** – Used in environments where reducing oxygen levels prevents fire hazards.
- **Oil & Gas Industry** – Used for pressurizing pipelines and removing impurities.
- **Cryogenics** – Liquid nitrogen cools and preserves biological samples, including blood and tissues.
- **Electronics Manufacturing** – Helps in semiconductor production for devices like computers and smartphones.

Air pollution

Air pollution refers to the presence of harmful substances in the air, negatively affecting health, the environment, and climate. It can come from both natural and human activities.

Causes of Air Pollution

1. **Burning Fossil Fuels** – Emissions from vehicles, factories, and power plants release carbon dioxide, sulfur dioxide, and nitrogen oxides.
2. **Industrial Waste** – Factories produce chemicals and particulates that pollute the air.
3. **Deforestation** – Fewer trees mean less absorption of carbon dioxide, increasing pollution.
4. **Agricultural Activities** – Pesticides, fertilizers, and methane from livestock contribute to pollution.
5. **Natural Causes** – Volcanic eruptions, forest fires, and dust storms release pollutants into the air.

Effects of Air Pollution

- **Health Problems** – Causes respiratory issues, heart disease, and lung cancer.
- **Climate Change** – Increases global warming and extreme weather events.
- **Acid Rain** – Damages buildings, soil, and aquatic ecosystems.
- **Harm to Wildlife** – Polluted air affects animals and plant life.

Ways to Reduce Air Pollution

- Use clean energy sources like solar and wind power.
- Reduce vehicle emissions by using public transport, cycling, or electric cars.
- Plant trees to absorb carbon dioxide.
- Adopt sustainable farming practices.
- Implement stricter environmental regulations.

Combustion

Combustion is a chemical reaction of a substance with oxygen.

Oxides

These are products of reaction of elements with oxygen. These reactions usually require heat.

Reactions of metals with oxygen

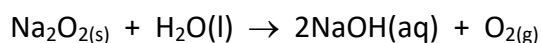
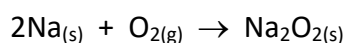
Oxygen combine vigorously with many metals to form basic oxides i.e. the solution of metal oxide in water turns red litmus paper blue

METALS + OXYGEN → METALLIC OXIDES

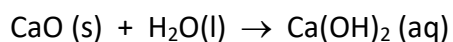
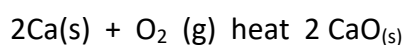
Examples

(a) Sodium (Na)

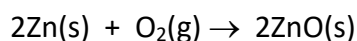
Burns with a bright yellow flame and form a yellowish solid



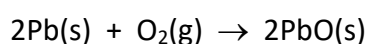
(b) Calcium (Ca): Burns with a bright red flame and form a white solid



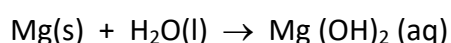
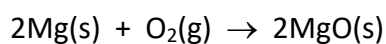
(c) Zinc: On burning it decomposes to a yellow solid when hot and turns white on cooling.



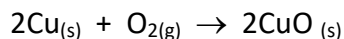
(d) Lead: Melts and then forms yellow oxides when hot and yellow when cold



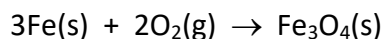
(e) Magnesium: burns in oxygen with a very bright light and forms a light white ash.



(f) **Copper:** burns with a green flame

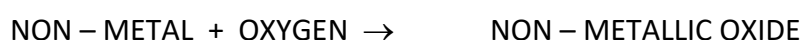


(g) **Iron filings** (or wire): burn with a shower of bright sparks and forms a blue-black solid insoluble in water

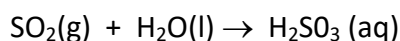
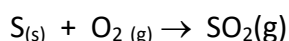


Non-metals

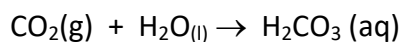
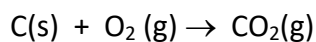
Oxygen combine vigorously with many metals to non-metals to form acidic oxides, i.e. the solution of oxides of non-metals in water turn blue litmus paper red.



(a) **Sulphur:** Burns with a bright blue flame and forms cloudy fumes with a choking smell



(b) **Carbon:** burns with an orange flame and makes bright sparks



Types of oxides

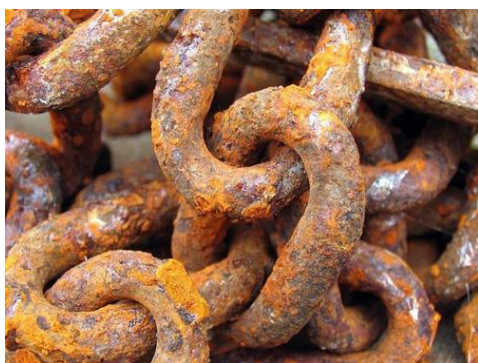
Basic oxide: is a metallic oxide, which react with acid to produce a salt and water only. When dissolved in waters, it forms an alkaline solution or solutions that turn red litmus paper blue. Example of basic oxides are metal oxides such calcium oxide (CaO) and sodium oxide (Na₂O)

An acidic oxide: is a non-metallic oxide when combined with element of water produces an acid or solutions that turn blue litmus paper red. Examples of acidic oxides are sulphur dioxide (SO₂).

Amphoteric oxide: is metallic oxide, which can show both basic and acidic properties. (it reacts with both acids and bases to produce water only and a salt e.g. ZnO, Al₂O₃)

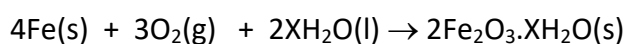
Neutral oxide: - is an oxide which shows neither basic nor acidic character e.g. H₂O, CO

Rusting



Rust: is a brown layer/coating that form on iron/steel when left in damp air

Rust is hydrated Iron III oxide.



Disadvantages of rusting

Rusting is a major problem for metal objects and structures, leading to several disadvantages:

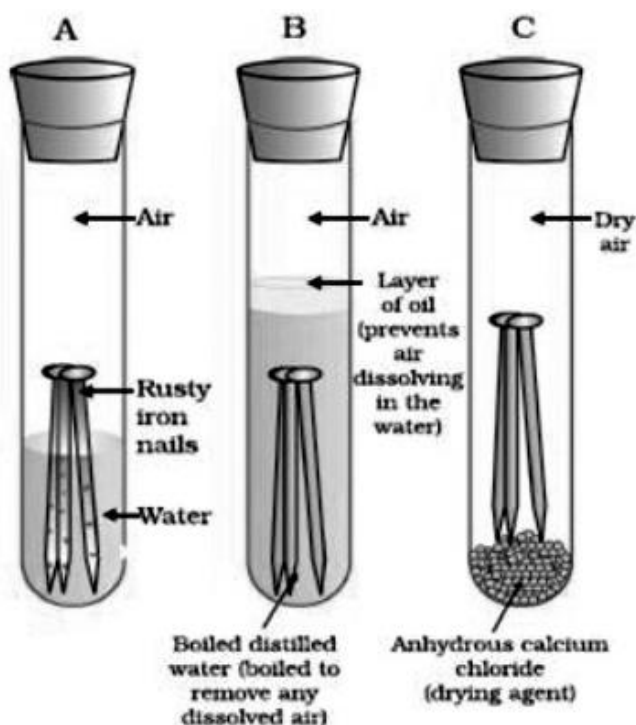
- **Weakens Structures** – Rust makes iron and steel brittle, causing bridges, buildings, and vehicles to weaken over time.
- **Economic Loss** – Industries spend billions on maintenance, repairs, and replacements due to rust damage.
- **Aesthetic Issues** – Rust makes metal surfaces look unattractive, reducing their value.
- **Malfunction of Machinery** – Rust can cause machines and tools to stop working properly, leading to breakdowns.
- **Environmental Pollution** – Rusted metal can flake off and contaminate soil and water sources.
- **Safety Hazards** - Rusted structures and vehicles can collapse or fail, posing dangers to people.

To investigate the conditions necessary for Iron to rust

Materials Needed

- Three test tubes
- Iron nails
- Water
- Boiled water + oil
- Dry calcium chloride (a drying agent)
- Labels

Procedure



1. **Test tube A: Air and Water Present**
 - Place an **iron nail in tap water**, leave space for air and stopper.
 - This exposes iron to both **oxygen** and **water**, allowing rusting.
2. **Test Tube B: Water Present, No Oxygen**
 - Place an **iron nail in boiled water** and add a **layer of oil** to prevent oxygen from entering.
 - Without oxygen, rust cannot form.
3. **Test Tube C: Oxygen Present, No Water**
 - Place an **iron nail in a test tube with dry calcium chloride** and **seal the tube**.
 - The calcium chloride **absorbs moisture**, keeping the nail dry.

Observations

- **Test Tube A** – The nail rusts because both **oxygen** and **water** are present.
- **Test Tube B** – No rust forms because **oxygen is absent**.
- **Test Tube c** – No rust forms because **moisture is absent**.

Conclusion

Iron rusts **only when both oxygen and water are present**.

Factors that influence rusting

- Nature of the metal
- pH
- temperature

- humidity
- surface state of metal
- nature of protective film

Method used to prevent rusting:

- (i) **Oil or Grease:** A layer of oil or grease is put on the metal.
- (ii) **Paint or tar:** paint is put on the iron metal e.g door, windows etc. and tar is put on iron that we do not see e.g. at the bottom of the bridges ship.
- (iii) **Tinplate:** made by dipping a sheet of iron into molten tin.
- (iv) **Galvanized iron:** Made by dipping a sheet of iron in molten zinc.
- (v) **Chromium- plate:** Iron coated with chromium (and nickel)
- (vi) **Alloying:** Stainless steel: Is iron that contains carbon, chromium, nickel and other elements.

Revision questions

1. Name two major components of air.
2. Give the uses of the following gases
 - (i) Oxygen
 - (ii) Nitrogen
 - (iii) Carbon dioxide
 - (iv) Argon
3. Describe an experiment to show that air contains carbon dioxide and water vapour.
4. Describe an experiment to determine the percentage of oxygen in air
5. Describe an experiment to show the conditions necessary for rusting.
6. Mentions ways of minimizing rusting

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Thanks

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