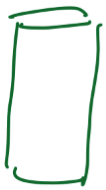
3 The Atmosphere

3.1 Composition of air

The atmosphere is a gaseous layer surrounding the Earth. Air is a mixture of gases and other substances making up the atmosphere.



78 cm³ Nitrogen
21 cm³ Oxygen
惰性氣體
unreactive

The approximate composition of air (by volume)

Composition	Percentage by volume (%)
nitrogen : food packing	78
oxygen : for patients' breathing	21
noble gases (e.g. helium, neon and argon) → for filling the light bulb	0.9
carbon dioxide : fire extinguisher	0.03 - 0.04
water vapour	variable
other substances like dusts and harmful gases (e.g. sulphur dioxide) → from burning coal which contains sulphur	very small amount

came from human activities

99

Example 3.1

Dry air contains 78% nitrogen and 21% oxygen.

無水的

(a) Name two gases that make up the remaining 1% by volume of dry air.

(b) State the most abundant compound in dry air.

(c) Suggest a test for oxygen.

Answer

noble gases

(a) carbon dioxide / helium / neon / argon

(b) carbon dioxide

(c) Test with a glowing splint. Oxygen will relight a glowing splint.

air : nitrogen oxygen noble gas carbon dioxide.

b.p -196°C -183°C -186°C -79°C

close boiling point

↓

fractional distillation

↳ a fractionating column is used to get a better separation.

3.2 Separation of oxygen and nitrogen from air

Oxygen and nitrogen are important industrial materials. Oxygen and nitrogen can be separated from air by **fractional distillation of liquid air** because they have **different boiling points**.

Steps of fractional distillation of liquid air

Step 1: Air is **purified** to remove dusts, carbon dioxide, water vapour etc.

-79°C 100°C or other impurities.

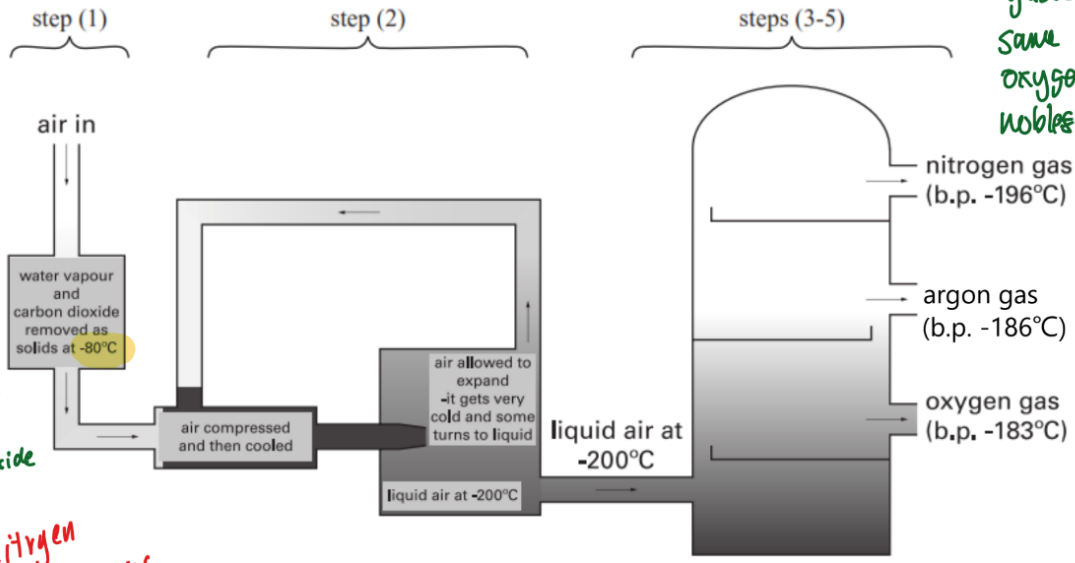
filtration

Step 2: Purified air is **compressed and cooled** repeatedly to about **-200°C**. The air changes **from gas to liquid** at this temperature.

Step 3: The liquid air is passed into a **fractionating column** and warmed up slowly.

-200°C is lower than all boiling point of gases in air, nitrogen, oxygen and noble gases turn into liquid.

When temperature reaches at -196°C, nitrogen firstly boils off and leave as gases. At the same time, oxygen and noble gas are liquid.



water vapour becomes ice.

-80°C < -79°C

-80°C is lower than the b.p. of CO_2, carbon dioxide is converted into solid

At -80°C, nitrogen oxygen and noble gas remains as gaseous state.

Note:

1. Nitrogen (b.p. = -196°C) boils and is separated from the mixture first.
2. Argon (b.p. = -186°C) boils and is separated from the mixture at a higher temperature.
3. Oxygen (b.p. = -183°C) boils and is separated from the mixture at the highest temperature.