

# INDUSTRIAL SEPARATION OF A MIXTURE

Syllabus reference 8.2.1

Read the following information then answer the questions.

| ELEMENT                    | BOILING POINT (°C) | PROPERTIES   |
|----------------------------|--------------------|--|
| Argon (Ar)                 | -186.0             | colourless, odourless gas, slightly soluble in water |
| Nitrogen (N <sub>2</sub> ) | -196.0             | colourless, odourless gas, slightly soluble in water |
| Oxygen (O <sub>2</sub> )   | -183.0             | colourless, odourless gas, slightly soluble in water |

## Production process in separating air

The intake air is filtered to remove particulates (solid particles and liquid droplets) then passed over various adsorbents and cooled to about  $-80^{\circ}\text{C}$ . These steps remove or freeze out water vapour, carbon dioxide and most pollutants such as sulfur dioxide, nitrogen dioxide, ammonia and organic vapours (except for the lightest hydrocarbons). The cleaned air is then compressed to between 100 and 200 atmospheres, cooled down again (compression heats up gases), then allowed to expand through a throttle into a region of low pressure. Such expansion causes the gas to cool and it cools to such a low temperature (about  $-200^{\circ}\text{C}$ ) that most of the air liquefies. The residual gas, mainly helium, neon and hydrogen, is removed. Silica gel is then used to remove traces of low molecular weight hydrocarbons that have remained dissolved in the liquid: such impurities in liquid air, particularly ethylene, have been the major cause of explosions in liquid air plants.

The cleaned liquid air is then fractionally distilled (still at very low temperatures): gaseous nitrogen emerges from the top of the column and a liquid mixture of argon and oxygen is taken from the bottom. The nitrogen is either recondensed for use as liquid nitrogen or put into high pressure steel cylinders for use as a gas. The oxygen-argon mixture is then fractionally distilled: gaseous argon comes from the top and is put into high-pressure cylinders for use as a gas (there is no demand for liquid argon). The remaining liquid is virtually pure oxygen and is used as liquid in various industrial processes or stored as a gas in high-pressure cylinders.

In industrial plants the design is such that the processes described here occur continuously: atmospheric air is taken in and the five products, liquid and gaseous nitrogen and oxygen and gaseous argon, are continuously produced.

# Uses

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Nitrogen

- used to protect products from the atmosphere
- used to remove the risk of fire explosion when handling flammable solvents (nitrogen blanket)
- used in industrial applications where there is a need to freeze products

Oxygen

- steel making
- smelting copper, lead, antimony and zinc
- chemical manufacturing
- pulp and paper industries
- medical and life support applications

Argon

- shielding gas primarily in the metal welding industry
  - fill in incandescent light globes along with nitrogen
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## QUESTIONS

1 Which of the three gases in the table is the most volatile and which is least?

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2 Name and describe the technique used to separate nitrogen, argon and oxygen in the above process.

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3 Identify the properties of the components which are used to separate the mixture.

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4 Name the products of separation and give two uses of each product.

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5 What are the waste products of this separation?

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6 Given the following information, why are these other gases not also extracted?

| ELEMENT                    | BOILING POINT (°C) |
|----------------------------|--------------------|
| Hydrogen (H <sub>2</sub> ) | -253               |
| Helium (He)                | -269               |
| Neon (Ne)                  | -246               |

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7 Do you consider the waste products from the process to pose an environmental threat? Justify your answer.

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8 In 1883 William Ramsay and his colleagues removed the main components of air (O<sub>2</sub>, N<sub>2</sub>, H<sub>2</sub>O, CO<sub>2</sub>, pollutants) and found there was still some mixture remaining. They undertook fractional distillation of the remaining mixture and discovered the noble gases.

Suggest:

a why these elements had not been obtained through other separation techniques

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b the effect this had on the periodic table.

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