Distillation

Distillation is an ancient **separation** technique, with its roots in the preparation of alcoholic spirits (such as vodka and whisky) and pre-chemistry studies (called alchemy). A **still** is the apparatus used for distillation. The term **distil** comes from the Latin root words meaning 'to drop down'.

The separation technique involves **evaporating** or **boiling** a **liquid**, collecting the **vapour** and **condensing** the vapour back to a liquid.

Distillation therefore combines two state changes: **vaporisation** (liquid to gas) and **condensation** (gas to liquid).

Scientists use distillation to separate liquids from mixtures with **soluble** and **insoluble** solids, and from mixtures with other liquids, for example:

- a mixture of water and sand (an insoluble solid)
- a mixture of water and sodium chloride (a soluble solid)
- a mixture of water and ethanol (a soluble liquid)

The condensed liquid collected during distillation is called the **distillate**.

Did you know … ? Part of the water cycle can be considered as distillation. The sun heats surface water and it evaporates. The vapour rises in the atmosphere, cools and condenses, then precipitates back to the surface, for example as rain.

Heating

Distillation in the school chemistry laboratory involves actively heating the mixture.

You can provide heat with:

- a Bunsen burner or fuel burner
- a water bath – electric or Bunsen burner-heated
- a heating mantle – electric heating of a metal block
- a sand or oil bath – electric heating of sand or oil

You heat the mixture inside a glass vessel that you connect to the condensing apparatus.

Apparatus

In a simple distillation setup you contain the mixture in a **boiling tube**, connected to a **delivery tube** by a bung. The vapour passes through the delivery tube, the air cools it, it condenses and is collected in a **receiving flask**.

A more sophisticated setup uses a water-cooled **condenser**. The most common condenser used in school chemistry laboratories is the **Liebig condenser**. This is made from two concentric tubes. The vapour passes through the inner tube. Cooling water

passes through the outer tube. You heat the mixture in a **round-bottomed** (or a **pear-shaped**) **flask** which you connect to the condenser by a **still head**. You may use a **still receiver** to connect the condenser to the receiving flask. School chemistry laboratories usually use special glassware called Quickfit™ for this type of distillation.

Did you know … ? A similar process is used in a **solar still** to produce water in remote areas or during emergencies. Heat from the Sun evaporates water from dirty mixtures, the vapour is trapped on a surface and the condensed water drips into a cup.

Separating liquids

Separating liquid mixtures involves selectively boiling off one of the substances in the mixture, so careful heat control is required. For good separation, the boiling points of the liquids need to be significantly different, usually by more than 100°C.

When boiling points are closer together, the distillate formed is a **concentrated** mixture rather than a pure substance. For example, distilling mixtures of ethanol and water produces a more concentrated ethanol solution, as ethanol has a boiling point of 78°C and water has a boiling point of 100°C.

This is the basis of the production of alcoholic spirits. For example, fermented mixtures of barley and wheat produce an approximately 10% ethanol solution. This is then distilled to an approximately 40% ethanol solution to make whisky. Adding a **fractionating column** between the boiling flask and still receiver allows for improved separation of liquids with close boiling points. This separation is called **fractional distillation**.