University of Al maarif

Department of Medical Instrumentation Techniques Engineering

Laboratory Medical Instrumentation II

Second Class

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Lecture Four

Water Distillation

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Water Distillation

Distillation is a separation process that involves heating a liquid to its boiling point, transferring the vapour to a different portion of the apparatus, then condensing the vapour and collecting the condensate in another container. This technique is one of the most useful for separating a mixture of liquids when the components have different boiling points. Chemically, distillation is the principal method for purifying liquids (e.g. samples, or solvents for performing reactions). Successful distillation depends on several factors, including the difference in boiling points of the materials in the mixture, and therefore the difference in their vapour pressures, the type of apparatus used, and the care exercised by the experimentalist.

1. Operation Principle of Distillation

Distillation works by exploiting the different boiling temperatures of liquids. To separate two or more liquids by distillation, you first heat them in a flask. The more volatile liquid (the liquid with the lower boiling point) will typically evaporate first and the vapour will pass into a condensing column, where it can revert into a liquid (condense) on the cool glass where it trickles into a collection flask. Heating further will cause the less volatile liquids to evaporate and distill at higher temperatures. The two main kinds of distillation are simple distillation and fractional distillation, and both are used widely.

2. Distillation of a Pure Liquid

A pure liquid has a constant boiling point as long as liquid and vapor are in equilibrium. In a simple distillation of a pure substance, as the temperature rises, the vapour pressure increases. As the vapor expands, it passes out of the heated portion of the apparatus until it comes into contact with the cold surface of the water-cooled condenser. When the vapour is cooled, it condenses and passes down the condenser into the receiver.

3. Parts of a Water Distiller

Water distiller consist of the following Components as shown in figure 1:-

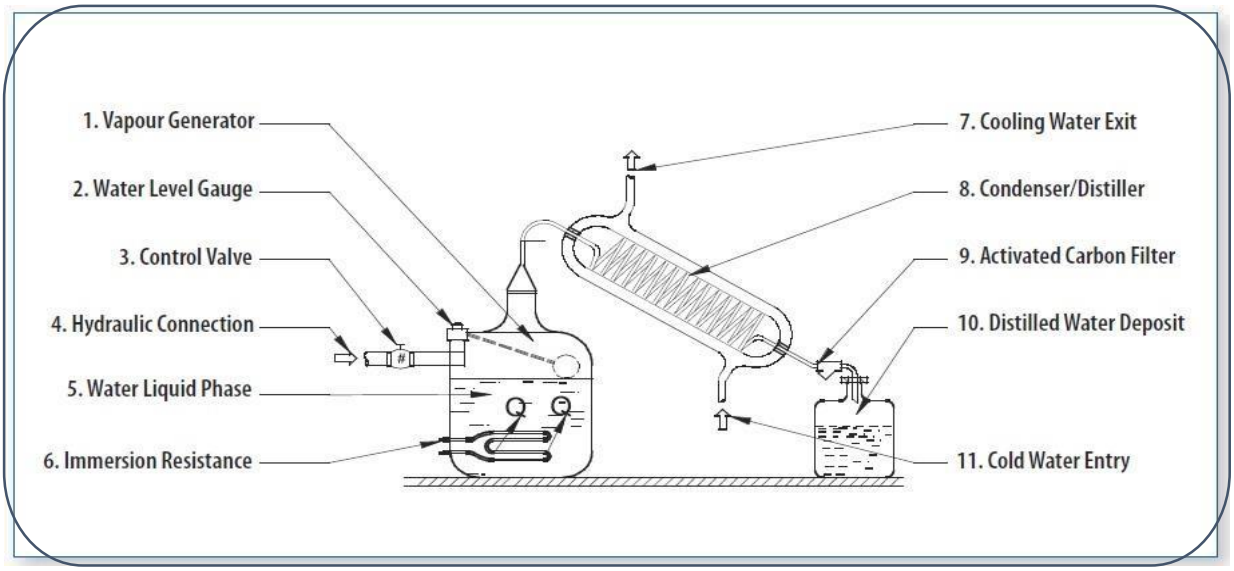


Figure 1: Shows the Diagram of Water Distiller

1. Vapour generator (boiling tank): the container where the water to be distilled is stored.

2.Water level: Device which allows the quantity of water to be regulated inside the vapor generator.

3. Control valve: Mechanical or electromechanical device which allows the flow of water towards the vapour generator tank to be regulated.

4. Hydraulic connection: Network which supplies water in liquid phase to the vapour generator tank.

5. Water in liquid phase: Water inside the vapour generator tank. It receives thermal energy from the immersion resistors and it is converted to vapour when the required temperature and pressure conditions are met.

6. Immersion resistors: Devices generating heat when an electrical current circulates through them.

7. Refrigeration water outlet: Line carrying the water used for condensing the water vapour thus removing the thermal energy from it (cooling).

8. Condenser: Device in which the vapour loses thermal energy, cools and returns to its liquid phase.

9. **Filter:** Distillers have activated carbon filters located at the exit of the condenser or collector. These eliminate flavours or particles which may be present in the vapour being condensed.

10. **Distilled water container:** Device in which the fluid completing the distillation process is collected. Distilled water must be stored in special plastic containers to avoid ionic contamination.

4. Types of Distillation

There are two types of distillation:-

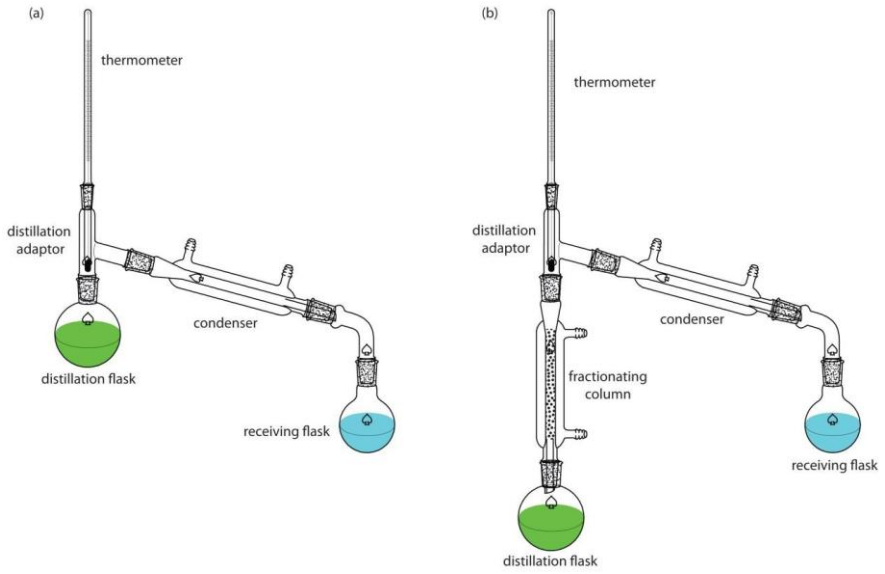
1. Simple Distillation

The setup for a simple distillation is shown in Figure 1. A simple distillation apparatus consists of a boiling flask (round-bottom flask) attached to an adapter holding a thermometer (to determine the boiling temperature of the liquid). The adapter connects to a condenser into which cold water is constantly passed through. The condenser leads into a collection flask for the purified liquid.

2. Fractional Distillation

Fractional distillation is essentially the same as simple distillation except that a fractionating column is placed between the boiling flask and the condenser. The fractionating column is usually filled with glass or plastic beads. These beads improve the separation between the liquids being -distilled. The reason that fractional distillation gives better separation between the liquids is because the glass beads in the fractionating column provide "theoretical plates" on which the refluxing liquid can condense, re-evaporate, and condense again, essentially distilling the compound over

and over. The more volatile liquids will tend to push towards the top of the fractionating column, while more boiling liquids will stay towards the bottom, giving a better separation between the liquids. Of course, the more theoretical plates that you add to a column (the more surfaces or beads), the longer the distillation will take (typically), and the more energy required to keep re-evaporating liquid in the fractionating column (this is more of a concern in industrial distillations than in an academic lab where energy cost is not a major cause for worry).



Figure(2): figure shown the difference between the types of distillation.

Comparison between simple and fractional distillation:

	Simple distillation	Fractional distillation
Advantages	• Simpler setup than fractional. • Faster distillation time. • Consume less energy.	• Much better separation between liquids than simple distillation. • Can more readily purify complex mixtures than simple distillation.
Disadvantages	• Requires the liquids to have large boiling point differences (>70°C). • Gives poorer separation than fractional distillation. • Only works well with relatively pure.	• More complicated setup than simple distillation. • Takes longer for liquids to distill. • Consumes more energy than simple distillation.
Best used for	Separating relatively pure liquids with large boiling differences or liquids with solid impurities.	Separating complex mixtures of liquids with smaller boiling point separations.