CHANGES OF STATE

A given substance can exist as a solid, a liquid or a gas. Change of state is brought about by a change in temperature (i.e. heating or cooling). When a substance is heated, its particles acquire more kinetic energy. When cooled, they become less energetic.

Melting

When a solid is heated, the particles acquire more kinetic energy and vibrate more violently. Eventually at a certain temperature called *melting point* of the solid, the force of the vibrations overcomes the binding forces and the crystalline structure collapse suddenly. The particles are no longer held in fixed positions, but instead are free to move about. We say the solids have melted or liquefied.

The presence of an impurity in the crystal will lower the melting point of a solid and may cause it to liquefy gradually instead of suddenly. In

some cases,e.g. iodine, the molecules my break away from the crystal and change directly into the vapour (or gaseous) state when the solid is heated. This is known as sublimation.

Evaporation

Particles in a liquid are attracted by neighbouring particles equally in all directions. Particles at the surface of a liquid body, however, are attracted only inwards and sideways by the neighbouring particles. The surface of the liquid is level and like a tightly-stretched skin. Such a liquid surface tends to prevent liquid molecules from escaping into the space above the liquid.

In a given sample of liquid, (e.g. water, petrol), some particle are more energetic than others. When such energetic particles come near a liquid surface, they can break away from the attractive forces of the nearby liquid molecules and escape into the space above, i.e. vapourize. When this happens we say the liquid *evaporates*.

Evaporation of a liquid occurs at all temperatures, but the rate of evaporation increases with increase in temperature. This is because the average kinetic energy of a liquid is greater at a higher temperature, so there are more particles with sufficient energy to vapourize.

The rate of evaporation also depends on the type of liquid. Generally, the rate of evaporation is lower in electrovalent liquids than in covalent liquids. This is because the force of attraction is greater between the positive and negative ions in an electrovalent liquid, than between the simple neutral molecules in a covalent liquid. Thus, covalent liquids are said to be volatile.

Vapour Pressure. When a liquid evaporates in a closed container, the escaped particles will gradually accumulate in the space above the liquid. Here the particles collide frequently with one another and with the walls of the vessel and consequently exert a pressure which is known as the *vapour pressure*. At the same time, some

vapour molecules hit the liquid surface and reenter the liquid, i.e. condense.

Condensation increases as the vapour pressure rises, i.e. as more and more liquid particles evaporate. Thus, two opposing forces are occuring in this system.

$$\text{Liquid particles} \underset{\text{condense}}{\overset{\text{evaporate}}{\rightleftharpoons}} \text{Vapour particles}$$

The vapour pressure continues to rise until a stage is reached when, at any given instant, the number of particles condensing into the liquid equals the number of particles evaporating from the liquid. At this point, an equilibrium is established. This equilibrium is called the saturated vapour pressure of the liquid at that temperature. The vapour pressure of a liquid only depends on the temperature and the nature of the liquid, i.e. the type of cohesive forces binding the particles together.

Boiling

When a liquid is heated, the rate of evaporation increases. The saturated vapour pressure of the liquid also increases until a temperature is reached, at which it equals the prevailing atmospheric pressure. When this happens bubbles of vapour form in the liquid and rise to the surface. The liquid is then said to boil and the temperature at which this happen is known as the *boiling point* of the liquid, at the prevailing atmospheric pressure. The boiling point increases or decreases with a rise or fall in atmospheric pressure respectively. It also increases in the presence of impurities.

Freezing and Condensation

While heating causes melting and boiling, cooling causes condensation and freezing. Condensation is a process whereby a vapour loses some of its kinetic energy to a colder body and changes into the liquid sate. This is what happens when a bottle

of milk is taken out of the refrigerator and placed on a table at room temperature. Droplets of water can be seen on the outside surface of the milk bottle. The water vapour around the bottles loses some of its energy to the cold bottle and condenses as droplets of liquid water on the surface of the bottle.

When a liquid cools, it loses heat energy to its surroundings, causing its temperature to drop. If cooling is allowed to continue, the temperature of the liquid keeps on dropping until it reaches the *freezing point* of the liquid. At this temperature, the liquid changes into the solid state. The freezing point of a substance is the same as its *melting point*.