Introduction

Most substances exist in three different physical states, each having distinctive properties:

- **Gas**: The substance fills all the space available to it by a process of diffusion. Gases are of low density, are compressible, can exert a uniform pressure on surfaces in any direction. They are often invisible.
- **Liquid**: The substance readily changes its shape and normally requires a container to stop it spreading horizontally. Usually it is constrained by gravity to form a horizontal surface. Liquids are typically 1000 times denser than gases.
- **Solid**: The substance retains a fixed shape unless it is squeezed or stretched by the action of external forces. Many (but not all) solids are denser than liquids.

Temperature and melting point

The state of a given substance depends upon its temperature. The temperature of transition between liquid and solid is called the melting point. Thus a substance above its melting point is in a liquid state whilst below the melting point it is in the solid state. At room temperature, all liquids have a melting point below room temperature, whilst all solids have a melting point above room temperature. A list of substances and their melting points allows the state of any substance to be determined at any chosen temperature. Water exists in the liquid state in the temperature range 0 to 100 degrees Celsius. In the laboratory, the change of state between liquid and solid is most conveniently observed for substances whose melting point lies within this range.

Kinetic theory; bonds, latent heat, energy

The Kinetic Theory of matter envisages all matter to be composed of multiples of identical particles (atoms or molecules) in a state of perpetual vibratory or random motion. In liquids and solids the particles are sufficiently close to each other for attractive forces to prevail and hold the substance together. In the solid state, the packing of particles is so close as to make them occupy a rigid pattern in which individual particles may vibrate but not change places. In the liquid state, the particles are spaced further apart and more loosely held together, their motion is more random than in a solid and they readily change position. In the gas state the particles move randomly at much greater speeds and are on average much further apart than in the liquid state. The natural motion of particles is associated with the temperature of the substance; in gases and liquids, higher temperatures are associated with higher average velocities of the particles; in solids, higher temperatures are associated with higher frequencies and amplitudes of vibration of particles.

The temperature of a substance may be thought of as being related to the kinetic energy of the particles; thus, supplying heat energy to a solid can be thought of as increasing the average vibrational kinetic energy of the particles.

When a body loses or gains heat from its surroundings, the rate of heat transfer ($\Delta Q/\Delta t$) depends upon the difference in temperature between the body and its surroundings:

$$\frac{\Delta Q}{\Delta t} = -K \cdot (T - T_s)$$

- where T and Ts are the temperatures of the body and surroundings respectively and K is a constant of proportionality.

In macroscopic terms, the heat (ΔQ) required for temperature change of (ΔT) of mass (m) is described by:

$$\Delta Q = m \cdot c \cdot \Delta T$$

- where 'c' is the specific heat capacity of the substance.

Whilst heating a substance, at a critical temperature, the melting point, some of the supplied energy is used to break the attractive bonds between the particles with the result that the substance loses its rigid shape and becomes a liquid. The additional energy supplied to break these bonds is the latent heat of fusion. Whilst the supplied energy is utilised in this way, the average temperature remains constant at the melting point. When all the substance has changed into the liquid state, the further supply of heat causes the temperature to rise. When a liquid is cooled, the reverse process occurs: that is, the solidification of the substance liberates latent heat, which becomes lost to the surroundings. The amount of liberated heat is related to the mass ( ) of substance, which has solidified thus:

$$\Delta Q = L \cdot \Delta m$$

- where L is the amount of heat liberated when 1 kg of substance solidifies.

During the transition from liquid to solid, the temperature remains steady at the melting point.