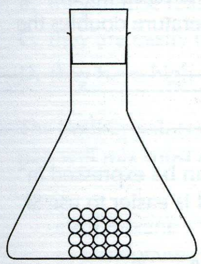
Changes of state and kinetic theory

SOLID STATE

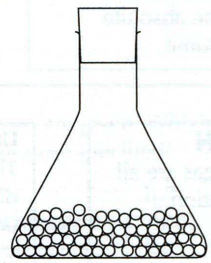
- Fixed shape
- Fixed volume
- Particles held together by intermolecular forces in a fixed position
- Particles can vibrate about a fixed point but do not have translational velocity.



melting ⇌ freezing

LIQUID STATE

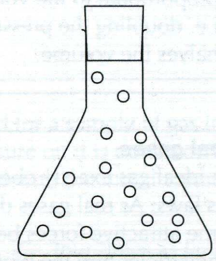
- Fixed volume
- Takes up shape of container
- Particles held closely together by intermolecular forces
- Particles have translational velocity so diffusion can occur.



boiling ⇌ condensing

GASEOUS STATE

- Widely spaced particles that completely fill container
- Pressure of the gas due to gaseous particles colliding with the walls of the container
- Intermolecular forces between particles negligible
- Volume occupied by molecules themselves negligible compared with total volume of gas
- Particles moving with rapid, random motion so diffusion can occur.



CHANGE OF STATE

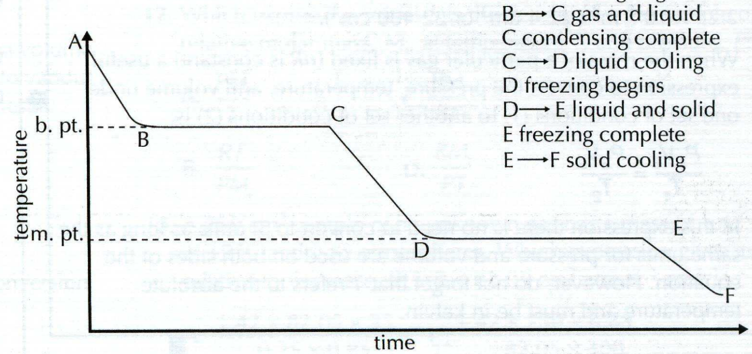
The absolute temperature of a substance is proportional to its average kinetic energy ($\frac{1}{2}$ mass × velocity^2). When heat is continually supplied to a substance the following changes take place.

- The solid particles increase in temperature as the kinetic energy increases due to greater vibration of the particles about a fixed position.
- At a certain temperature the vibration is sufficient to overcome the attractive forces holding the lattice together and the solid melts.
- During melting the temperature does not rise as the heat energy (enthalpy of fusion) is needed to overcome these attractive forces.
- Once all the solid has melted the liquid particles move faster and the temperature increases.
- Some particles move faster than others and escape from the surface of the liquid to form a vapour.
- Once the pressure of the vapour is equal to the pressure above the liquid the liquid boils.
- During boiling the temperature remains constant as the heat is used to overcome the intermolecular forces of attraction between the particles (enthalpy of vaporization).
- When all the liquid has turned into a gas the temperature continues to increases as the particles move ever faster.

A cooling curve shows this process in reverse.

COOLING CURVE

A ⟶ B gas cooling
B condensing begins
B ⟶ C gas and liquid
C condensing complete
C ⟶ D liquid cooling
D freezing begins
D ⟶ E liquid and solid
E freezing complete
E ⟶ F solid cooling



MAXWELL–BOLTZMANN DISTRIBUTION

The moving particles in a gas or liquid do not all travel with the same velocity. Some are moving very fast and others much slower. The faster they move the more kinetic energy they possess. The distribution of kinetic energies is shown by a Maxwell–Boltzmann curve. When a liquid evaporates it is the faster moving particles that escape so the average kinetic energy of the remaining particles is lower. This explains why a volatile liquid feels cold as it is evaporating.

At higher temperatures the area under the curve does not change as the total number of particles remains constant. More particles have a very high velocity resulting in an increase in the average kinetic energy, which leads to a broadening of the curve.