

## Thermal Physics

- Each and every state of matter is consisting of tiny particles called ‘Atoms’.
- Group of atoms is called “molecules”.
- There exists a force of attraction between molecules.
- The force of attraction depends upon inter molecular spaces.
- Atoms collide with each other and the walls of the container.
- Atoms are in continuous random motion.

### Properties of Matter:

#### Solid:

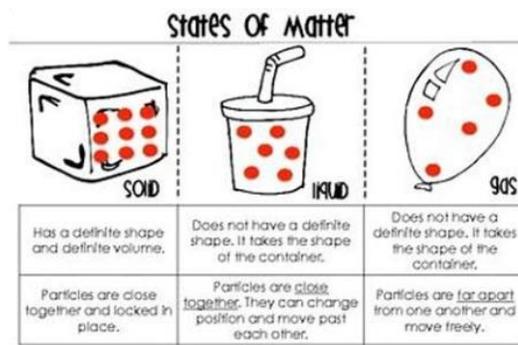
- Force of attraction is greatest because intermolecular distance is less.
- Vibration at the mean position.
- Lattice structure.

#### Liquid:

- Greater intermolecular distance.
- Move in clusters with a random structure.
- Move from one point to another.
- Less force of attraction.

#### Gas:

- Large intermolecular distances.
- Molecules move in random direction.
- Negligible force of attraction.
- Intermolecular distance very large.



### Effect of Temperature on Molecular Motion:

- As the Temperature increases, the molecules gain Energy, K.E of molecules increases.
- K.E is proportional to velocity, therefore velocity increases.
- Hence, the rate of collision increases.

### Motion of molecules and pressure:

- Continuous collision of molecules with the walls of the container produces the pressure exerted by the gas on the container.
- With increase in T, the rate of collision increase hence the pressure increases.
- Pressure is proportional to Temperature. (Pressure Law)

### The relationship between:

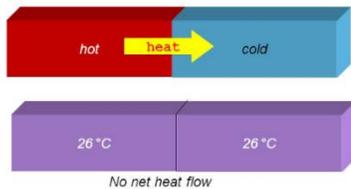
- a) pressure and temperature at constant volume  
 $P \propto T$

- b) volume and temperature at constant pressure  
 $V \propto T$
- c) pressure and volume at constant temperature  
 $P \propto 1/V$

### **Thermal Properties and Temperature:**

#### **Thermal Equilibrium:**

Two bodies are said to be at thermal equilibrium if they are at the same temperature. This means there is no net exchange of thermal energy between the two bodies. The top pair of objects are in contact, but since they are at different temps, they are not in thermal equilibrium, and energy is flowing from the hot side to the cold side.



The two purple objects are at the same temp and, therefore are in thermal equilibrium. There is no net flow of heat energy here.

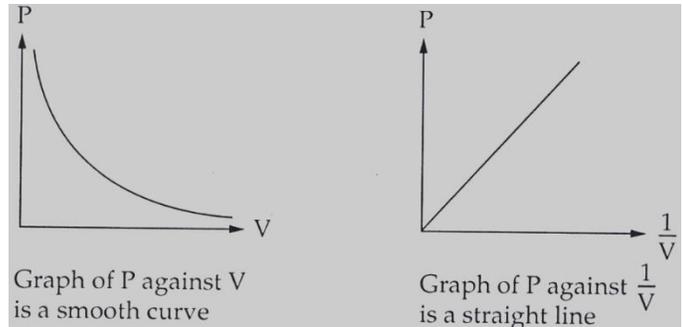
#### **Thermal Expansion of solids, liquids and gases:**

Thermal expansion is the increase in size of an object when it is heated, due to the faster movement of its molecules.

- It occurs in solids, liquids, and gases, but the amount and direction of expansion depends on the material and its shape.
- Thermal expansion can be measured by the change in length, area, or volume per unit temperature change
- Thermal expansion has many practical applications, such as thermometers, bimetallic strips, and railway tracks, as well as some challenges, such as bridges, pipes, and buildings.
- Substances expand or get bigger when they are heated up. They contract or get smaller when they cool down. This property can be useful.
- Thermometers work because the liquid inside them expands & rises up the tube when it gets hotter.
- Metal parts can be fitted together without welding using shrink fitting.  
E.g. Train tracks have small spaced between them which allows them to expand without breaking in summers & shrink in winters.  
Bimetallic Strips are 2 metals coiled together.
- Thermal expansion takes place in all forms of matter, because the intermolecular interactions in gases are the weakest, they expand the most. Intermolecular interactions in liquids are relatively weak and the component molecules are more mobile, their thermal expansion is generally greater than that of solids.

#### **Converting Temperature between Kelvin and Celsius:**

- There is a lowest possible temperature ( $-273^{\circ}\text{C}=0\text{ K}$ ), known as absolute zero, where the particles have least kinetic energy
- Convert temperatures between kelvin and degrees Celsius; recall and use the equation  $T$  (in K) =  $\theta$  (in  $^{\circ}\text{C}$ ) + 273



**Specific Heat Capacity:** is the energy required per unit mass per unit temperature increase. It depends on:

- the mass of the substance heated
- The type of material
- The amount of thermal energy transferred in to the system

If a substance has a **low** specific heat capacity, it heats up and cools down quickly.

If a substance has a **high** specific heat capacity, it heats up and cools down slowly.

Specific heat capacity ( $c$ ) =  $\frac{\text{change in energy } (\Delta E)}{\text{Mass (m) x change in temperature } (\Delta\theta)}$

Mass (m) x change in temperature ( $\Delta\theta$ )

Thermal energy ( $\Delta E$ ) = Mass (m) x Change in temperature ( $\Delta\theta$ ) x Specific heat capacity ( $c$ )

An increase in the temperature of an object increases its internal energy that is the total energy stored inside a system by the particles that make up the system due to their motion and positions.

Motion of the particles affects their kinetic energy, while the positions of the particles relative to each other affects their potential energy. Together, these two make up the internal energy of the system. An increase in the average kinetic energies of all of the particles in the object results in an increase in temperature of an object.

### **Melting, Boiling and Evaporation:**

**Melting:** It is the constant temperature by the addition of thermal energy at which the solid turns into a liquid. M.p of water = 0 °C.

**Solidification:** It is the constant temperature by the subtraction of kinetic energy at which the liquid turns into a solid. S.p of water = 0 °C.

**Boiling:** It is the constant temperature by the addition of thermal energy at which the liquid turns into a gas. B.p of water = 100 °C.

**Condensation:** It is the constant temperature by the subtraction of kinetic energy at which the gas turns into a liquid. C.p of water = 0 °C.

**Evaporation:** Escape of energetic molecules from the surface of liquid.

- Molecules gain energy from surrounding,
- which increases the K.E,
- they break the bonds
- & escape from the surface.
- Evaporation has cooling effect as it allows only energetic molecules to leave the surface leaving behind less energetic molecules. The overall temperature decreases.
- Factors that effect the rate of evaporation:
  - An increase in temperature increases the rate of evaporation.
  - An increase in S.A increases the rate of evaporation.
  - An increase in air-movement increases the rate of evaporation.

Difference between Boiling and Evaporation:

When liquid water is heated by adding thermal energy the temperature of the water rises until the water boils.

- At the boiling point, even if more thermal energy is added, the liquid water does not get any hotter which means that the internal energy is not rising.

The additional thermal energy goes into overcoming the intermolecular forces between the molecules of water.

- As the forces are overcome, the liquid water becomes water vapour (steam) which is evaporation or vaporisation; the water is now a gas.

Latent Heat: is the energy required to change the state of a substance.