Heat and Its Effects

- Heat is a form of energy.
- Work done against friction changes into heat energy.
- Temperature of a substance increases on heating and decreases on cooling
- Heat flows from a body of a higher temperature to a body of a lower temperature.

Factors on which the quantity of heat required to raise the temperature of a substance depend:

1. Mass of a substance
2. Nature of the substance
3. Amount of heat supplied

Unit of Heat

1. 1 calorie = Amount of heat required to raise the temperature of 1 gram of water by 1°C.
2. 1 Kilocalorie = 1000 calories
3. 1 Calorie = 4.186 joules

Flow of heat

Heat flows from higher temperature to lower temperature; it flows until both the bodies have equal temperatures – this state is called thermal equilibrium

- The temperature of a body increases on heating; however, the temperature falls on removing heat from a body or by cooling it.
- The addition of a sufficient amount of heat to a substance, or the removal of a sufficient amount of heat from it, can change the state of the substance.
- Substances expand on heating and contract on cooling.
- The physical and chemical properties of substances are altered on heating.

- **Change of state**
  - A change of state occurs because heat energy breaks the force of attraction between particles. Kinetic energy of the particle increases.

- **Melting point**
  - The temperature at which a solid melts into a liquid at normal atmospheric pressure.

- At melting point, the temperature does not change until all solid converts into liquid.

- **Latent heat**
  - The heat required to break the force of attraction between the particles at transition temperature. This heat becomes confined within the material and is called the latent heat.
  - Amount of heat required to change 1 kg of material to change its state at normal atmospheric pressure at transition temperature is called the latent heat for that transition.

- **Sublimation**
  - Solid $\rightleftharpoons$ gas [directly]
  - Example: Ammonium chloride

- **Effect of change of pressure**
  - If pressure is applied,
  - Melting point → decreases
  - Boiling point → increases

- **Dry Ice –** Solid CO_2 [directly converts to gas]

- **Evaporation –** Change of liquid into vapours at any temperature below the boiling point

- **Factors affecting evaporation**
  - Surface area → If increases, evaporation rate increases
  - Temperature → If increases, evaporation rate increases
  - Humidity → If increases, evaporation rate decreases
  - Wind speed → If increases, evaporation rate increases

- **Evaporation cause cooling –** The particles take the latent heat from body and evaporate causing the body to feel cool.

- Boiling is the phenomenon in which a liquid changes to vapour at a constant temperature on heating.
- Boiling point of a liquid is the fixed temperature at which the change from liquid state to gaseous state occurs without further increase in temperature.
- The boiling point of a liquid is directly related to pressure i.e. it increases with increase in pressure and decreases with decrease in pressure.
- **Evaporation Versus Boiling**

Evaporation	Boiling
It takes place at all temperatures	It takes place at fixed temperature known as boiling point of liquid
It is a surface phenomenon	It is a bulk phenomenon
It is a slow process	It is a rapid process
The surface molecules absorb heat from their surroundings	The heat absorbed by molecules is supplied externally

All substances expand on heating.

The order of expansion of solid, liquid and gas is:

Gas > Liquid > Solid

- Due to expansion of solids, rail tracks have spaces in them and electric wires are kept loosen
- Due to the expansion of air, hot air balloon moves up

Expansion of Solids

When a solid is heated, it expands.

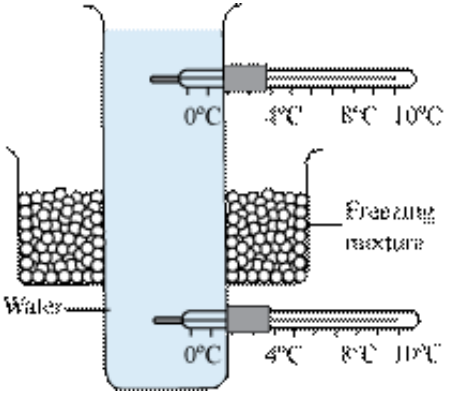
Type of expansion	Amount of expansion	Coefficient of expansion
Cubical Expansion	$V_t = V_0 (1+ \gamma \Delta t)$	γ = Coefficient of volume expansion
Superficial expansion	$A_t = A_0 (1+\beta \Delta t)$	β = Coefficient of area expansion

Linear expansion	$L_t = L_0 (1 + \alpha \Delta t)$	α = Coefficient of linear expansion

Application of thermal expansion—Riveting, bimetallic strips, thermostat, space between railway lines

Expansion of liquids

- **Hope's experiment** proves anomalous expansion of water.



1. Lower thermometer reading— Stops at 4°C
2. Upper thermometer reading— Falls till 0°C
3. This happens because on cooling, water decreases in volume and sinks down whereas warmer water expands and rises up.

Water shows compression when cooled and has maximum dsensity at 4°C, below 4°C water expands and its density increase.

Expansion of Gases

- Increase in volume for different gases for the same rise in temperature is same.

Apart from raising the temperature of the substance, heat has additional effects as well.

Expansion of solids on heating

On heating, generally solids expand in all directions, i.e. in its volume. So, it is also known as cubical expansion or volume expansion.

Advantages of expansion of substances on heating:

1. **Bimetallic strips** are used as heat-operated switches in circuits of automatic equipments, like iron box, fire alarms, microwave oven, etc.

2. Many thermometers work on the principle of expansion of liquids.

3. Expansion of gases is useful in automobile engines.

Disadvantages of expansion of solids by heating and their solutions-

1. **Breaking of thick glass tumbler by pouring boiling water into it-** If boiling water is poured into a thick glass tumbler, it cracks immediately. The heat from the boiling water expands the inner wall of the glass but it is not transferred to the outer wall. Thus, the outer wall fails to expand and this uneven expansion breaks the glass.

Similarly, the thick glass tumbler cracks when ice is put in it.

Thus, a very thin glass tumbler with low expansion capacity (like pyrex or borosilicate) should be chosen.

2. Narrow spaces are left between small stretches of **cemented roads** so that they do not bend and cause problem to vehicles and people.

3. The **metal pipelines** used to transfer hot water or molten liquid in industries are provided with metal loops at regular intervals. So, the expansion of pipeline causes the size of the loop to increase slightly and prevent the pipe from breakage.

4. The **iron tyres of cart wheels** are made a little smaller than their wooden wheels in order to prevent them from expanding in summers and loosening of the tyres.

5. **Railway tracks** are made up of steel, leaving small spaces in between them in order to prevent the tracks from bending and derailing trains. The spaces get closer in summers and wider in winters and prevent the rail from bending.

6. The **telegraph wires** between two poles are never strongly tightened as they sag in summer and get tightened in winters.