14. Measurement and Effects of Heat

- The measure of degree of hotness of a substance is called its temperature.
- The device that is used to measure the temperature of a substance is called thermometer.
- Thermometers are of two types - clinical (used for measuring temperature of human body) and laboratory (used for measuring temperature of common objects).
- The temperature range of clinical thermometer is 37- 42 °C and that of laboratory thermometer is -10 ^{o}C to +110 ^{o}C. The unit for temperature is °C.
- The normal temperature of human body is 37 °C or 98.6 °F.
- There are three commonly scales used in temperature
- Celsius scale of temperature
- Fahrenheit scale of temperature
- Kelvin scale of temperature
- Kelvin is the SI unit of temperature.
- The SI unit of heat is joule (J)
- Other common units of heat are calorie (cal) and kilocalorie (kcal).
- 1 kcal = 1000 cal
- 1 cal = 4.2 J

Specific Heat

- The quantity of heat required to raise the temperature of unit mass of a substance by 1°C
- Unit of Specific Heat—In SI systems—Joules per kilogram per degree—J/kg °C or J/kg-K

In CGS systems—Joules per gram per degree—J/g °C or J/g-K

Heat capacity or thermal capacity

The amount of heat energy required by an object to raise its temperature by 1 ^{o}C is known as its hear capacity. Thus,

Heat Capacity, C'=Amount of heat energy suppliedRise in temperature=HΔθr

Relationship between heat capacity and specific heat capacity

Heat capacity, C'=Mass, m×Specific heat capacity, C

Formula for transfer of heat

$Q = m \times C \times t$

Where,

m = Mass

C = Specific heat

t = Rise in temperature

Q = Heat gained

Heat of Capacity

- Amount of heat required to raise the temperature of a body by 1°C.

Principle of Calorimetry

- When a hot object is brought in contact with a cold object, the heat lost by the hot object is equal to the amount of heat gained by the cold object, provided there is no heat lost to the surroundings.

- 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.

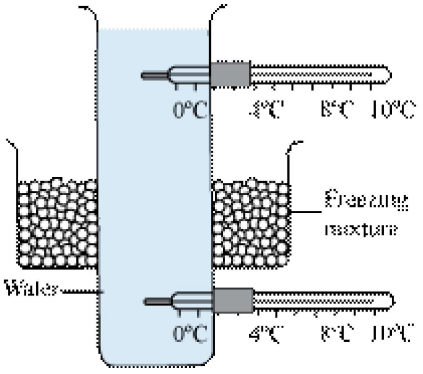
Expansion of Solids

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.