

Heat:- Heat is the agent which produces in us the sensation of warmth and makes bodies hot. It is form of energy. The part of thermal energy which flows from one body to the other due to temperature difference is called heat.

Nature of heat:-

- (a) The weight of a body remains the same whether it is heated or cooled.
- (b) Heat flows from higher to lower temperature
- (c) In any exchange of heat, heat lost by the hot body is equal to the heat gained by the cold body.
- (d) Substances generally expand when heated
- (e) A certain amount of heat known as latent heat is required to change the state of a body from solid to liquid or from liquid to gas without any change in temperature.

Thermal Energy:- In accordance to dynamical theory of heat the sum total of translational, vibrational and rotational energies of the molecules of a system is called the thermal energy of the system .

Unit of Heat:-

- (a) Calorie (cal):- It is the amount of heat required to raise the temperature of 1 gram of water through 1°C.
- (b) Kilocalorie (kcal):- It is the amount of heat required to raise the temperature of 1 kilo gram of water through 1°C.

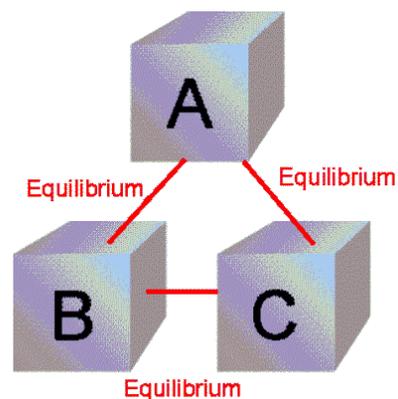
Temperature:- It is defined as the degree of hotness of a body.

Zerth Law of Thermodynamics:-

It states that the two systems (A and B) which are separately in equilibrium with a third system (C) must also be in equilibrium with each other.

Absoluter Zero of Temperature:-

- (a) Charle's law:- $V_t = V_0(1 + t/273)$
- (b) Gay Lussac's law:- $P_t = P_0(1 + t/273)$



(c) Absolute zero of temperature is defined as the temperature at which a gas has zero volume and exerts zero pressure. It is that temperature at which molecular motion ceases.

$$(d) C \propto \sqrt{T}, C = \sqrt{c_1^2 + c_2^2 + \dots + c_n^2} / n$$

Absolute gas scale or absolute scale of temperature:- It is that scale of temperature whose zero (i.e. 0°K) = -273°C

A centigrade degree is exactly equal to the absolute or Kelvin's degree.

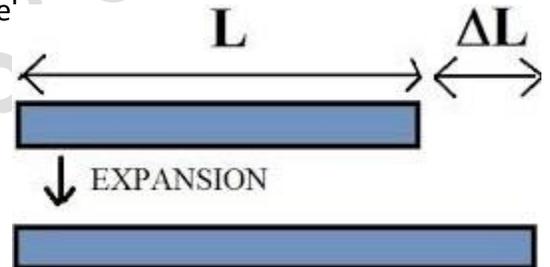
Conversion of temperature from one scale to another:-

$$C/100 = (K-273)/100 = (F-32)/180 = R_e/80 = (R_\alpha-492)/180$$

Here C , K , F , R_e and R_α are respectively, the temperatures of same both on centigrade, Kelvin, Fahrenheit, Reaumer and Rankin scale, respective'

$$F = [(9/5)C] + 32$$

$$K = C + 273$$



Linear Expansion (longitudinal expansion):-

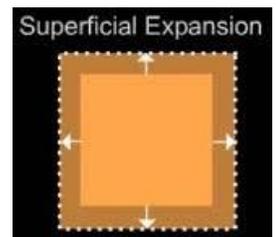
When the expansion due to heating takes place only along one direction, the expansion is said to be one dimensional and linear.

Coefficient of linear expansion (α):- Coefficient of linear expansion of the material of a rod is defined as the change in length per unit length, at 0°C , per degree centigrade rise of temperature.

$$\alpha = l_t - l_0 / l_0 t$$

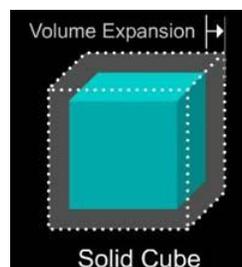
Expansion in two dimensions (Superficial expansion):-

When the thermal expansion of a body is confined to a plane, it is to be two dimensional expansion or superficial expansion.



Coefficient of superficial expansion (β):- It is defined as the change in area of the surface per unit area at 0°C , per degree centigrade rise of temperature.

$$\beta = S_t - S_0 / S_0 t$$



Expansion in three dimensions (Cubical expansion/volume expansion):- When thermal expansion of the body takes place in space, it is said to be three dimensional expansion or cubical expansion.

Coefficient of cubical expansion (γ):- Coefficient of cubical expansion is defined as the change in volume per unit volume, at 0°C , per degree celsius rise of temperature.

$$\gamma = \frac{V_t - V_0}{V_0 t}$$

Relation between expansion coefficients:-

(a) Relation between α and β :-

$$\beta = 2\alpha$$

(b) Relation between α and γ :-

$$\gamma = 3\alpha$$

(c) Relation between β and γ :-

$$\gamma = \frac{3}{2} \beta$$

(d) $\alpha : \beta : \gamma = 1:2:3$

Thermal expansion of liquids:-

(a) Co-efficient of apparent expansion (γ_a):- The coefficient of apparent expansion of a liquid is defined as the apparent (or observed) increase in volume, per unit volume of the liquid at 0°C per degree celsius rise of temperature.

$$\gamma_a = \frac{\text{apparent increase in volume}}{\text{original volume at } 0^\circ\text{C}} \times (\text{rise of temperature})$$

(b) Co-efficient of real expansion (γ_r):- The coefficient of real expansion of a liquid is defined as the real increase in volume, per unit volume of the liquid at 0°C per degree centigrade rise of temperature.

$$\gamma_r = \frac{\text{real increase in volume}}{\text{original volume at } 0^\circ\text{C}} \times (\text{rise of temperature})$$

Work and Heat:-

Whenever heat is converted into work or work into heat, the quantity of energy disappearing in one form is equivalent to the quantity of energy appearing in the other.

$$W \propto H \text{ or } W = JH$$

Joule's mechanical equivalent of heat is defined as the amount of work required to produce a unit quantity of heat.

$$J = W/H$$

$$\text{Value of } J:- J = 4.2 \times 10^7 \text{ erg cal}^{-1} = 4.2 \text{ J cal}^{-1}$$

Specific heat capacity or specific heat (c):-

Specific heat capacity of a material is defined as the amount of heat required to raise the temperature of a unit mass of material through 1°C.

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

$$\text{Unit:- kcal kg}^{-1}\text{K}^{-1} \text{ or } \text{J kg}^{-1}\text{K}^{-1}$$

$$\text{Dimension:- } M^0L^2T^{-2}K^{-1}$$

Molar specific heat capacity(C):-

Molar specific heat capacity of a substance is defined as the amount of heat required to raise the temperature of one gram molecule of the substance through one degree centigrade.

$$(a) C = Mc \text{ (Here } M \text{ is the molecular weight of the substance)}$$

$$(b) C = 1/n (dQ/dT)$$

Heat Capacity or Thermal Capacity:-

It is defined as the amount of heat required to raise the temperature of body through 1°C.

$$Q = mc\Delta T$$

$$\text{If } \Delta T = 1^\circ\text{C, } Q = \text{heat capacity} = mc$$

$$\text{Unit:- kcal K}^{-1} \text{ or } \text{JK}^{-1}$$

Water Equivalent:-

Water equivalent of a body is defined as the mass of water which gets heated through certain range of temperature by the amount of heat required to raise the temperature of body through same range of temperature.

$$w = mc$$

Water equivalent of a body is equal to the product of its mass and its specific heat.

Latent Heat:- When the state of matter changes, the heat absorbed or evolved is given by: $Q = mL$. Here L is called the latent heat.

(a) Specific latent heat of fusion (L_f):-

Specific latent heat of fusion of a substance is defined as the amount of heat required to convert 1 gram of substance from solid to liquid state, at the melting point, without any change of temperature.

(b) Specific latent heat of vaporization (L_v):- Specific latent heat of vaporization of a substance is defined as the amount of heat required to convert 1 gram of liquid into its vapours at its boiling point without any rise of temperature.

Dimensional formula:- $M^0L^2T^{-2}$

Unit:- $kg\ cal\ kg^{-1}$ or $J\ kg^{-1}$

Triple point of water = 273.16 K

Absolute zero = 0 K = -273.15°C

For a gas thermometer, $T = (273.15) P/P_{\text{triple}}$ (Kelvin)

For a resistance thermometer, $R_e = R_0[1 + \alpha\theta]$

| S. No. | Physical quantity | Symbol | Dimensions | Units | |
|--------|-------------------|--------|----------------------------|---------|------------|
| | | | | SI | CGS |
| 1. | Heat | Q | $[ML^2T^{-2}]$ | Joule | calorie |
| 2. | Specific-heat | c | $[L^2T^{-2}q^{-1}]$ | J/kg K | cal/gm C° |
| 3. | Molar sp. heat | C | $[ML^2T^{-2}q^{-1}m^{-1}]$ | J/mol K | cal/mol C° |
| 4. | Latent heat | L | $[L^2T^{-2}]$ | J/kg | cal/gm |
| 5. | Thermal capacity | Tc | $[ML^2T^{-2}q^{-1}]$ | J/K | cal/C° |
| 6. | Water-equivalent | W | $[M]$ | kg | gm |