10. THERMAL PROPERTIES OF MATTER

THERMAL EXPANSION

Tendency of matter to change its shape, area and volume is said to be thermal expansion.

Relationship between Coefficient of Linear expansion, areal expansion and volume expansion:-

$$\alpha = \frac{\beta}{2} = \frac{\gamma}{3} \text{ or } \alpha : \beta : \gamma = 1 : 2 : 3$$

Linear Expansion

(1) Expansion in only one direction or dimension,

(2) $\Delta L \propto L_o$, $\Delta L \propto \Delta T$

$\Delta L = \alpha L_o \Delta T$

α is coeff. of Linear expansion

$L = L_o (1 + \alpha \Delta T)$

Superficial/ Areal expansion

(1) Expansion of solids in two dimension.

(2) $A = A_o(1 + \beta \Delta T)$,

β - coefficient of areal expansion,

A_o = initial area of plate.

$\beta = 2\alpha$

α = Coeff. of Linear expension

Volume Expansion

(1) Three dimensional expansion of solids.

(2) $V = V_o (1 + \gamma \Delta T)$

γ = Coeff. of volume expansion,

V_o = initial volume of the solid.

HEAT

(1) Heat is the form of energy.

(2) Transferred from higher temp. to the lower temp.

(3) measured in calorie or joule.

TEMPERATURE

(1) Quantity which measured the degree of hotness or coldness of a body is called Temperature.

(2) S.I. unit is Kelvin (K)

CALORIMETRY

Heat loss by hot body = Heat gain by cold body

$$m_1c_1(T_1 - T) = m_2c_2(T - T_2)$$

$$T = \frac{m_1c_1T_1 + m_2c_2T_2}{m_1c_1 + m_2c_2}$$

T is equilibrium Temperature.

Case – 1 : If material of body is same ($c_1 = c_2$)

$$T = \frac{m_1T_1 + m_2T_2}{m_1 + m_2}$$

Case – 2 : If mass of bodies are equal, $m_1 = m_2 = m$,

$$T = \frac{c_1T_1 + c_2T_2}{c_1 + c_2}$$

Case – 3 : If bodies are of same material and equal masses

$$T = \frac{T_1 + T_2}{2}$$

Thermal Stress

The expansion or contraction occurs in solids due to change in temperature develops compressive stress.

$$\sigma_{thermal} = Y \alpha \Delta\theta$$

Y - Young modulus, α - Coeff. of Thermal exp, $\Delta\theta$ - temp. difference.

Heat Capacity or Thermal Capacity

Amount of heat supplied to an object to produce a unit change in its temperature.

$$\text{Heat Capacity} = \frac{dQ}{dT}$$

S.I. unit is joule per kelvin (J/K)

Molar Specific Heat

(1) Amount of heat required to raise the temperature of 1 mole of a gas by 1°C.

(2) $c = \frac{1}{n}\frac{dQ}{dT}$

n = number of moles,

(3) S.I. unit is J/mol-K

Specific Heat

(1) Amount of heat required to raise the temperature of unit mass of substance by unity.

(2) $C = \frac{1}{m}\frac{dQ}{dT}$

(3) Unit is J/kg-K

Thermal expansion in Liquid

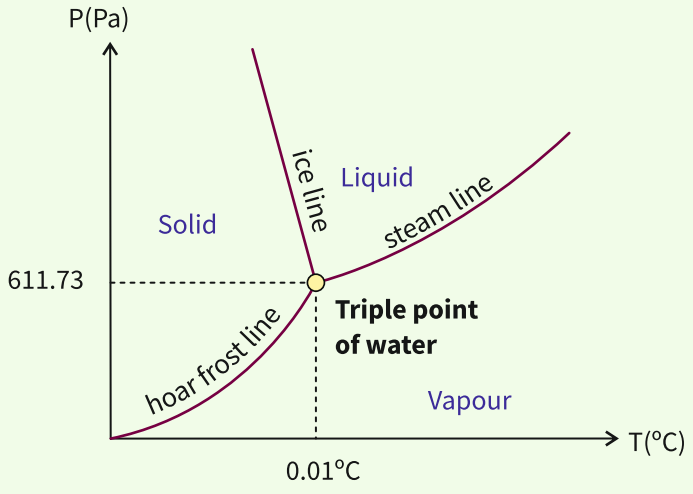
The change in volume of liquid relative to vessel;

$$\Delta V_{app} = \gamma_{app} V \Delta T$$

γ_{app} - apparent Coeff of volume expansion.

Volumetric Coefficients in Liquids

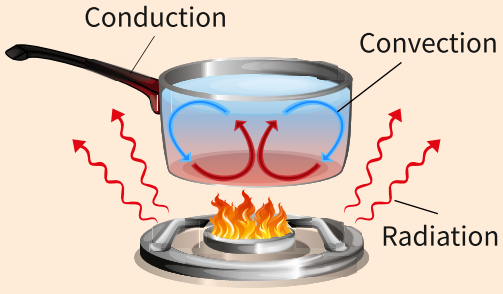
Coefficient of apparent expansion	Coefficient of real expansion
$\gamma_{app} = \frac{\Delta V_{app}}{V \times \Delta T}$	$\gamma_r = \frac{\Delta V_r}{V \times \Delta T}$



Triple Point of Water

HEAT TRANSFER

Transfer of heat energy from a body at higher temperature to a lower temperature.



LATENT HEAT

Amount of Heat required to change unit mass of a substance from one phase to the other at constant temperature.

$$L = \frac{Q}{m}$$

L = Latent heat, m = mass of substance

S.I unit of L : JKg^{-1}

Conduction

(1) Heat will flow from hot end to the cold end by means of oscillation of particles but particles do not leave their original position.
(2) Medium is necessary.
(3) Rate of heat transfer is slow

Latent Heat of fusion

- The amount of heat required to change 1 kg mass of substance from solids to liquid or vice – versa.
- $\mathbf{Q = mL_f}$
- L_f = Latent heat of fusion.

Latent heat of vaporisation

- The amount of heat required to change 1kg mass of substance from liquid to vapor or vice – versa.
- $\mathbf{Q = mL_v}$
- L_v = Latent heat of vaporization.

Convection

(1) Heat is carried by mobile particles from the body.
(2) Rate of heat transfer is slow in free convection and high in forced Convection.

Radiation

Radiation is a mode of heat transfer in which the heat is transfer from one place to another without heating of intervening medium. It is the fastest mode of heat transfer.