CHAPTER

10 Thermal Properties of Matter

Temperature

- (1) $T_C = \frac{5}{9}(T_F - 32)$ (2) $T = T_C + 273.15$

  (3) $T_F = \frac{9}{5}T - 459.67$

  where T, T_C, T_F, stand for temperature readings on Kelvin scale, Celsius scale, Fahrenheit scale respectively.

Thermal expansion

- (1) $\alpha = \frac{\Delta L}{L\Delta T}$

  (2) $\beta = \frac{\Delta A}{A\Delta T}$

  (3) $\gamma = \frac{\Delta V}{V\Delta T}$

  where ΔL, ΔA, ΔV represent the change in length, change in area and change in volume respectively, due to a change in temperature ΔT. Here L, A and V stand for original length, original area, original volume respectively. α, β and γ denote coefficients of linear, area and volume expansions.
- $\alpha = \beta/2 = \gamma/3$
  or $\alpha : \beta : \gamma = 1 : 2 : 3$
- Thermal stress $\left(\frac{F}{A}\right) = Y\alpha\Delta T$

Heat Capacity or thermal capacity

- $Q = mc\,\Delta T$
  where Q is the heat required to raise the temperature by ΔT of a substance of mass m and of specific heat c.

Latent Heat

- $Q = \text{mL}$
  where Q is the amount of heat required for changing the phase of pure substance of mass m and L is the latent heat of the substance.
- The amount of heat required to change the phase (state) of a unit mass of a substance without any change in its temperature and pressure is called its latent heat. This is referred as the latent heat of fusion (L_F) when the phase change is from solid to liquid ; and latent heat of vaporisation (L_v) when the phases change is from liquid to gas.

Heat Transfer

- (1) $Q = \frac{kA(T_1 - T_2)t}{x}$; $H = kA\left(\frac{T_1 - T_2}{L}\right)$

  where Q is the amount of heat that flows in time t across the opposite faces of a rod of length x and cross-section A. T_1 and T_2 are the temperatures of the faces in the steady state and k is the coefficient of thermal conductivity of the material of the rod.

  (2) $Q = -kA\left(\frac{dT}{dx}\right)t$

  where ($dTldx$) represents the temperature gradient.

  (3) $\text{H} = \frac{dQ}{dt} = -\text{kA}\left(\frac{dT}{dx}\right)$

  H is called the heat current.

Radiation

It is a method of heat transmission in which heat travels directly from one location to another without the use of a medium.

- This radiation of heat energy takes the form of EM waves.
- These radiators are emitted as a result of their temperature, similar to how a red-hot iron or a filament lamp emits light.
- Everybody both radiates and absorbs energy from its surroundings. The amount of energy absorbed is proportional to the color of the body.
- Black-body radiation is the thermal electromagnetic radiation emitted by a black body within or surrounding a body in thermodynamic equilibrium with its environment (an idealized opaque, non-reflective body). It has a specific spectrum of wavelengths that are inversely related to intensity and are only affected by the body's temperature, which is assumed to be uniform and constant for the sake of calculations and theory.
- Reflectance (r), absorbtance (a) and transmittance (t)

  (1) $r = \frac{Q_1}{Q}$ (2) $a = \frac{Q_2}{Q}$ (3) $t = \frac{Q_3}{Q}$

  where Q_1 is the radiant energy reflected, Q_2 is the radiant energy absorbed and Q_3 is the radiant energy transmitted through a surface on which Q is the incident radiant energy. Further r, a and t denote reflectance, absorbtance and transmittance of the surface.

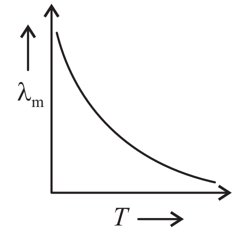
So, $r + a + t = 1$

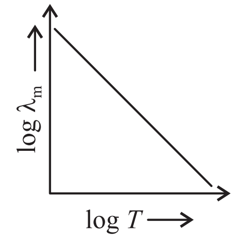
Stefan's Law of Radiation

Stefan's Law states that the radiated power density of a black body is directly related to its absolute temperature T raised to the fourth power.

Wien's displacement law

- $\lambda_m T = b$ = constant where b is Wien's constant and has value 2.89×10^{-3} m – K.





- "Newton's Law of Cooling" says that the rate of cooling of a body is proportional to the excess temperature of the body over its surroundings:

$$\frac{dQ}{dt} = -k(T_2 - T_1)$$

where T_1 is the temperature of the surrounding medium and T_2 is the temperature of the body.