XVI. Fick's One-dimensional diffusion Equations:

Fick's one-dimensional diffusion equations describe the diffusion of particles in a medium due to a concentration gradient. The equations are based on Fick's laws of diffusion and are used to model the rate at which particles move.

1. Fick's First Law (Steady-State diffusion):

First law in Fick's equation states that the flux of particles diffusing through a medium is proportional to the concentrating gradient. In one dimension, it can be mathematically expressed as;

$$\boxed{J = -D \frac{\partial C}{\partial x}}$$

where;

- J is the diffusion flux (amount of substance per unit area per unit time).

- D is the diffusion co-efficient (or diffusivity) of the medium (units: m^2/s).
- $\frac{\partial C}{\partial x}$ is the concentration gradient in the x-direction.

The negative sign indicates that diffusion occurs from regions of higher concentration to regions of lower concentration.

2. Fick's Second Law (Non-Steady-State diffusion):

Ficks Second law describes the time-dependent change in concentration, assuming that the concentration gradient can vary over time.

The one dimensional form of Fick's Second law is given by:

$$\boxed{\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2}}$$ where;

- $\frac{\partial C}{\partial t}$ is the rate of change of concentration with respect to time.
- $\frac{\partial^2 C}{\partial x^2}$ is the 2nd derivative of concentration with respect to position. (representing the curvature of the concentration Profile).
- D is the diffusion coefficient.

Interpretation:

- Ficks first law applies when the concentration profile does not change with time, ie., Steady-state conditions.

- Fick's Second law is used for non-steady state conditions, where the concentration profile changes with time.

Applications:

(i) Drug delivery Systems: Fick's law model how drugs diffuse from formulations into the body, guiding controlled-release designs.

(ii) Gas Exchange in Biological Systems: They explain oxygen and carbon-dioxide diffusion in lungs and tissues, crucial for respiratory function.