Chapter 17

Temperature and Thermal Equilibrium

- **Temperature** is a physical quantity that indicated the “hotness” or “coldness” of an object. It determines the direction of heat flow (it is kinetic energy)
- We say **Two objects are in**
    - **Thermal equilibrium** if they are at the same temperature, which means there is no net flow of energy between them.
- The 0^{th} **Law of Thermodynamics** states that if two systems (A and B) are each in thermal equilibrium with a third system (C), then systems A and B are in thermal equilibrium with each other. This is the principle that allows thermometers to work accurately.

Temperature Scales

To quantify temperature, we use several scales:

- **Celsius Scale (T_C):** This scale defines the freezing point of water as 0°C and the boiling point as 100°C

- **Fahrenheit Scale (T_F):** This scale sets the freezing point of water at 32F and the boiling point at 212F. The conversion formulas are:

$$T_F = \frac{9}{5}T_C + 32^\circ \quad and \qquad T_C = \frac{5}{9}(T_F - 32^\circ)$$

- **Kelvin Scale (T_K):** This is an absolute temperature scale where 0K represents **absolute zero,** the theoretical point of minimum possible energy. The conversion from Celsius is :

$$T_K = T_C + 273.15$$

Thermal Expansion

- Most materials expand when heated and contract when cooled because the average distance between atoms increases with temperature.
- **Linear Expansion:** This refers to the change in an object's length (ΔL) , the formula is:

$$\Delta L = \alpha L_0 \Delta T$$

Here, L_0 is the initial length, ΔT is the temperature, and α is the coefficient of linear expansion

- **Volume expansion :** This refers to the change in an object's volume (ΔV). The formula is:

$$\Delta V = \beta V_0 \Delta T$$

Here, V_0 is the initial volume and β is the coefficient of the volume expansion. For solid materials, the relationship between the coefficient is approximately:

$$\beta = 3\alpha$$