7. Thermal Expansion

- Temperature is the measure of hotness or coldness of a body.
- Heat is the form of energy transfer from one body to another due to their temperature difference.
- Thermometers are used for measuring temperature.
- Ice point and steam point are used as lower and upper fixed points for measurement.
- Conversion of temperature from one scale to another:

$$K = 273 + C$$
$$F = 32 + \frac{9}{5}C$$

- Boyle's law and Charles' law are combined into a single relationship,

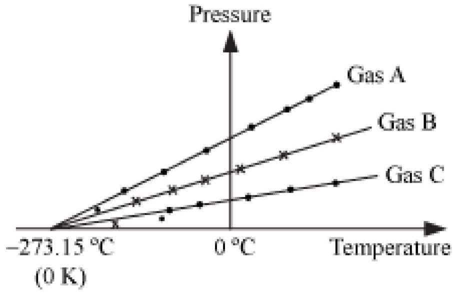
$$\frac{PV}{T} = \text{constant} \qquad \text{(Ideal gas law)}$$

- General form which can be applied to any quantity of gas:

$$\frac{PV}{T} = \mu R \text{ [Ideal gas equation]}$$

k – Universal gas constant (8.31 J $mol^{-1}K^{-1}$)

- Absolute Temperature



- The absolute minimum temperature of ideal gas is inferred by extrapolating the straight line to the axis. The temperature is −273.15°C, which is called absolute zero.
- Absolute zero is the foundation of the Kelvin temperature scale or absolute scale temperature. On this scale, −273.15°C is taken as the zero point i.e., 0 K.

Thermal Expansion of solids

- Linear expansion → $L = L_0(1 + \alpha\Delta T)$

L_0 → Original length, L → Length after expansion,

Get More Learning Materials Here : CLICK HERE www.studentbro.in

$\Delta T \rightarrow$ Change in temperature, $\alpha \rightarrow$ Coefficient of linear expansion

- Superficial expansion $\rightarrow S = S_0 (1 + \beta \Delta T)$

$S_0 \rightarrow$ Original area, $S \rightarrow$ Area after expansion,

$\Delta T \rightarrow$ Change in temperature, $\beta \rightarrow$ Coefficient of superficial expansion

- Cubical expansion $\rightarrow V = V_0 (1 + \gamma \Delta T)$

$V_0 \rightarrow$ Original volume, $V \rightarrow$ Volume after expansion

$\Delta T \rightarrow$ Change in temperature, $\gamma \rightarrow$ Coefficient of cubical expansion

elationship between the three coefficients of expansion of a body

- $\frac{\alpha}{1} = \frac{\beta}{2} = \frac{\gamma}{3}$ or $6\alpha = 3\beta = 2\gamma$

Specific heat capacity (*s*)

- $s = \frac{1}{m} \frac{\Delta Q}{\Delta T}$

$m \rightarrow$ Mass of the solid

$\Delta T \rightarrow$ Increase in temperature

$\Delta Q \rightarrow$ Quantity of heat supplied

- SI unit is J $mol^{-1}K^{-1}$
- The specific heat capacity of water is high, so it is used as a coolant in automobiles.

Molar specific heat capacity (*C*)

$$C = \frac{1}{n} \frac{dQ}{dt}$$

Where,

$C \rightarrow$ Molar specific heat capacity

Get More Learning Materials Here : CLICK HERE www.studentbro.in

n →Number of moles

- Heat transfer at constant pressure is called molar specific heat capacity at constant pressure (C_p).
- Heat transfer at constant volume is called molar specific heat capacity at constant volume (C_v).
- Relation between C_p and C_v

$$C_p - C_v = R$$

C_p → Specific heat at constant pressure

C_v →Specific heat at constant volume

R → Gas constant

Calorimetry

- **Principle of calorimetry :** When a body at higher temperature is brought in contact with another body at lower temperature, the heat lost by the hot body is equal to the heat gained by the colder body.
- **Calorimeter :** A device used for heat measurement is called a calorimeter.

- Determination of Specific Heat by a Calorimeter
  - According to calorimetry principle,

$$(m_1 + w)(t - t_1) = s.m_2(t_2 - t)$$

$$\therefore s = \frac{(m_1 + w)(t - t_1)}{m_2(t_2 - t)}$$

where,

m_1 = Mass of water

t_1 = Initial temperature of the water and the calorimeter

w = Water equivalent of the calorimeter and the stirrer

m_2 = Mass of the substance

s = Specific heat of the substance

t_2 = Temperature of the substance

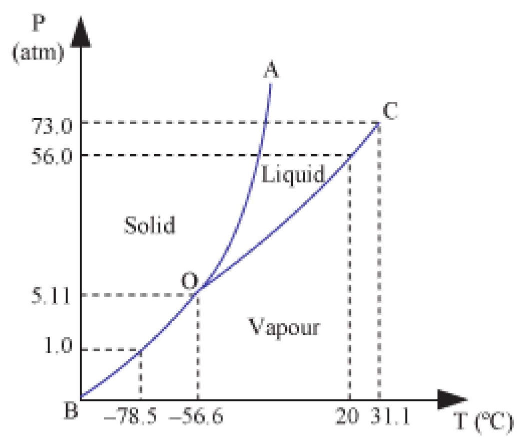
Get More Learning Materials Here : CLICK HERE www.studentbro.in

t = Common temperature of the mixture

- Temperature at which the solid and liquid states of a substance are in thermal equilibrium with each other is called its melting point.

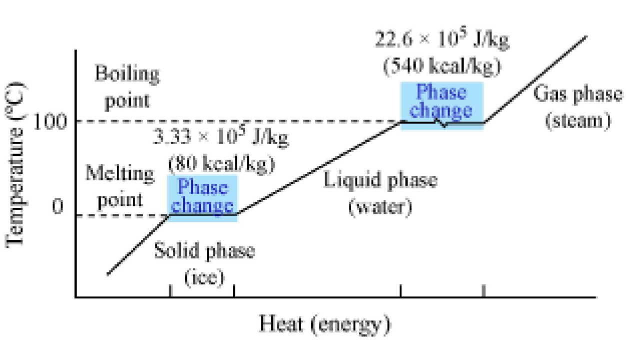
- Temperature at which the liquid and vapour states of a substance co-exist is called its boiling point.

- Temperature and pressure at which the fusion curve, vaporisation curve and sublimation curve meet, and all the three phases coexist, is called the triple point.



- Latent heat is the amount of heat energy required to change the state of a unit mass of a substance from solid to liquid or from liquid to vapour, without a change in temperature.

- A plot of temperature versus heat energy for a quantity of water is shown in the figure.

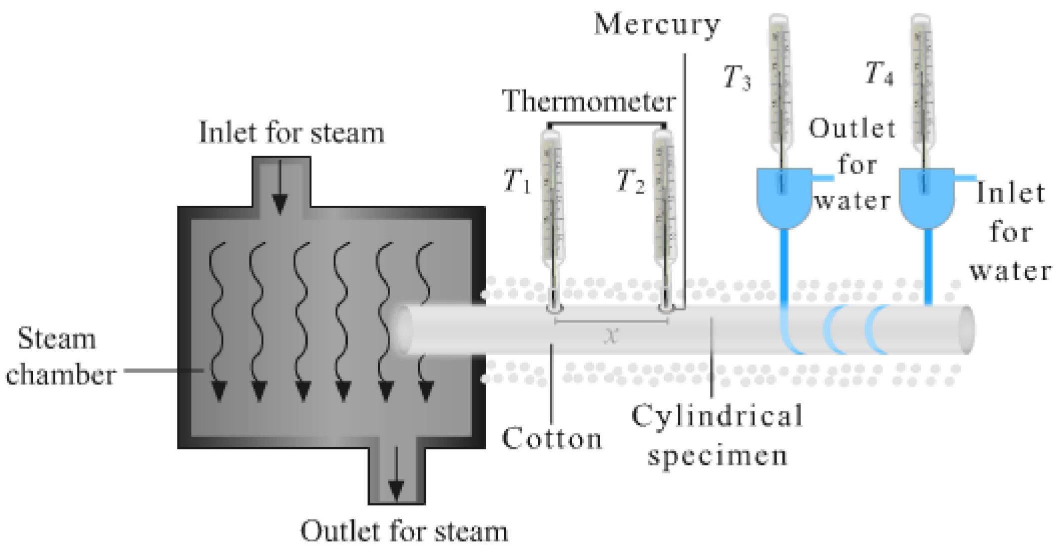


Get More Learning Materials Here : CLICK HERE www.studentbro.in

- Conduction is the mechanism of transfer of heat between two adjacent parts of a body because of their temperature difference without the actual movement of the particles from their equilibrium positions.
- For a bar of length L and uniform cross-sectional area A with its ends maintained at temperatures T1 and T2, (T1>T2) the rate of flow of heat H is:

H equals K A fraction numerator T subscript 1 minus T subscript 2 over denominator L end fraction ,
where K is the thermal conductivity of bar

- Thermal conductivity – Metals have high thermal conductivity whereas non-metals and gases have low thermal conductivity
- Applications
    - Cooking pots have copper coating. Copper helps in uniform distribution of heat over the bottom of a pot as it is a good conductor.
    - Concrete roof gets warm during summer. Therefore, a layer of hay (bad conductor) forms an insulating layer and the heat transfer through the ceiling into the roof is prohibited.
- Searle's experiment is used to determine the thermal conductivity of an unknown specimen using Searle's apparatus. The apparatus is shown below.



K=mC(T3-T4)xA(T1-T2)dt

- **Convection:** is the process in which heat is transferred from one point to another by the actual movement of the material particles from a region of high temperature to a region of lower temperature.
- Medium is required for convection.

- **Radiation** is the process in which heat is transferred by means of electromagnetic waves.
- No medium is required for radiation.

- **Newton's Law of cooling**

Get More Learning Materials Here : CLICK HERE www.studentbro.in

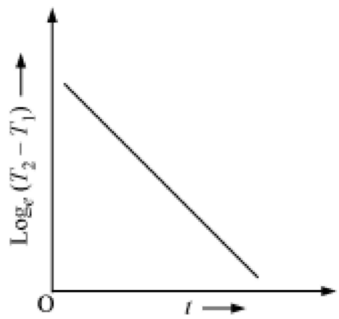
$$\frac{dQ}{dt} = -k(T_2 - T_1)$$

$k \rightarrow$ Thermal conductivity

$T_1 \rightarrow$ Temperature of the surrounding medium

$T_2 \rightarrow$ Temperature of the body

- Rate of heat loss, dQdt=msdT2dt
- If we plot a graph between t and $\log_e (T_2 - T_1)$, then we obtain a straight line having slope K and making an intercept C on Y-axis.



Newton's law of cooling

Get More Learning Materials Here : CLICK HERE www.studentbro.in