Class XI: Physics
Chapter 11: Thermal Properties of Matter

Key Learning

1. Heat is a form of energy that brings about changes in temperature.

2. Temperature is that quality of an object which determines the sensation of hotness or coldness felt when there is contact with the object.

3. Heat is the transfer of energy between two systems or a system and its surroundings.

4. Heat flows from body at higher temperature to body at lower temperature.

5. Thermometer uses a measurable property that changes with temperature.

6. In constant volume gas thermometer, $P \propto T$

7. When two objects achieve the same temperature and there is no net transfer of heat between then they are in thermal equilibrium.

8. Heat capacity is the quantity of heat required to raise the temperature of a body by one degree. Its unit is joules per kelvin or J K^{-1}

9. The specific heat capacity is the amount of heat required to raise the temperature of 1kg of a substance by one degree. SI unit is joules per kilogram per kelvin or J kg^{-1} $K^{-1}$and the symbol is c.

10. Calorimeter is a device used for heat measurement.

11. In an isolated system, heat lost = heat gained.

12. Matter exists in three states: solid, liquid and gas.

13. Different phases of a substance at a fixed temperature have different internal energies.

14. Latent heat of fusion is the heat required to change unit mass of a substance from solid to liquid at same temperature and pressure.

15. Latent heat of vaporization is the heat required to change unit mass of a substance from liquid to vapor state at same temperature and pressure.

16. The three mechanisms of heat transfer are – Conduction, Convection and Radiation.

17. Radiation is energy transfer through electromagnetic radiation.

18. Newton's law of cooling states that the rate of loss of heat is proportional to the excess temperature over the surroundings.

$$-dQ/dt = k (T_2 - T_1)$$

19. In conduction, heat is transferred between neighbouring parts of a body through molecular collisions, without any flow of matter.

Top Formulae

1. The ideal gas equation connecting pressure (P), volume (V), and absolute temperature (T) is:

$$PV = \mu RT$$

where μ is the number of moles and R is the universal gas constant.

2. If T_C, T_F and T_K are temperature values of body on Celcius scale, Fahrenheit scale and Kelvin scale, then

$$\frac{T_C - 0}{100} = \frac{T_F - 32}{180} = \frac{T_K - 273.15}{100}$$

3. If triple point of water is chosen as the reference point, then

$$T_K = 273.16\left(\frac{P}{P_{tr}}\right)$$

where P: pressure at unknown temperature T

P_{tr} : pressure at triple point.

4. (i) Coeff. of linear expansion, $\alpha = \frac{\Delta L}{L(\Delta T)}$

   (ii) Coeff. of area expansion, $\beta = \frac{\Delta S}{S(\Delta T)}$

   (iii) Coeff. of volume expansion, $\gamma = \frac{\Delta V}{V(\Delta V)}$

5. $\beta = 2\alpha$; $\gamma = 3\alpha$

6. Variation of density with temperature is given by

$$\rho = \rho_0 (1 - \gamma \Delta T)$$

7. The specific heat capacity of a substance is defined by

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

   Where m is the mass of the substance and ΔQ is the heat required to change its temperature by ΔT.

8. The molar specific hear capacity of a substance is defined by

$$C = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$$

   Where μ is the number of moles of the substance.

9. Change of heat, $\Delta Q = m\ s\ \Delta T$, where c is specific heat of the substance.

10. Molar specific heat of substance, C = m x s,

11. In the method of mixtures,

    Heat gained = Heat lost

    i.e. mass × specific heat × rise in temperature

    = mass×sp. heat×fall in temperature

12. For Change of state, $\Delta Q = mL$ where L is latent heat of the substance

13. $C_P - C_v = \frac{R}{J}$, where $R = \frac{PV}{T}$ =gas constant for one gram mole of the gas.

14. For mono-atomic gases, $C_v = \frac{3}{2}R$; $C_p = \frac{5}{2}R$

15. For diatomic gases, $C_v = \frac{5}{2}R$, $C_p = \frac{7}{2}R$

16. For tri-atomic gases (non linear molecule), $C_v = 3\ R$, $C_p = 4\ R$

17. For tri-atomic gases (linear molecule) $C_p, = \frac{7}{2}R$, $C_p = \frac{9}{2}R$

18. Rate of conduction of heat, $\frac{\Delta Q}{\Delta t} = KA\frac{\Delta T}{\Delta x}$

    Where $\frac{\Delta T}{\Delta x}$ = temperature gradient = rate of fall of temperature with distance, A = area of the hot surface, K = coefficient of thermal conductivity.

19. If heat so conducted is used in changing the state of m gram of the substance, then $\Delta Q = mL = KA\left(\frac{\Delta T}{\Delta x}\right)\Delta t$, where L is latent heat of the substance.

20. If heat so conducted is used in increasing the temp. of the substance through range $\Delta\theta$, then $\Delta Q = sm\Delta\theta = KA\left(\frac{\Delta T}{\Delta x}\right)\Delta t$