	INDIAN SCHOOL AL WADI AL KABIR	
Class: XI	**Department of Science 2022 – 23** **Subject: Physics**	**Note:** **A4 FILE FORMAT**
Handouts: Chapter 11	**Chapter: THERMAL PROPERTIES OF MATTER**	

Temperature: It is an indication or a relative measure of hotness or coldness of matter.

SI unit: kelvin (K)

Heat: It is a form of energy transferred between two or more systems and its surroundings by virtue of temperature difference.

SI unit: joule (J) or calorie.

1 cal = 4.186 J ≈ 4.2 J

One calorie is the amount of heat required to raise the temperature of 1 gram of water through 1°C (i.e. from 14.5°C to 15.5°C).

Measurement of temperature: Thermometer is an instrument which is used to measure the temperature of a body.

Centigrade Scale: In the Celsius scale of temperature, the melting point of ice under standard pressure is 0^oc and boiling point of water under standard pressure is 100^oc. The space between 0^oc and 100^oc is divided into 100 equal intervals.

Fahrenheit Scale: The melting point of ice and boiling point of water under standard pressure are 32^oF and 212^oF respectively. The space between 32^oF and 212^oF is divided into 180 equal intervals.

Relation between centigrade and Fahrenheit scale:

$$t_c = (5/9)(t_F - 32)$$

where t_c is centigrade temperature and t_F is Fahrenheit temperature.

To convert temperature in degree Celsius (t_c) to temperature in kelvin (T) just add 273.15. Thus

$$\mathbf{T = t_c + 273.15}$$

Thermal Expansion: The increase in size of a body due to increase in the temperature is called thermal expansion.

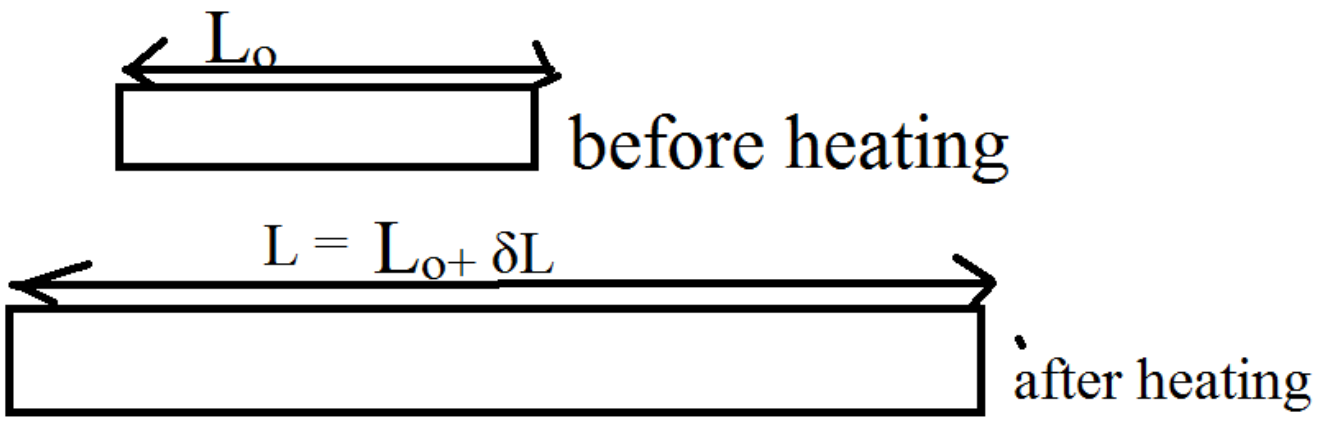
There are three types of expansion in solids. They are

Linear expansion

Area expansion

Volume or cubical expansion

***LinearExpansion*:**



When a solid is heated its length increases then the expansion is called linear expansion. Consider a rod of length L_0, when the rod is directly heated, the increase in its length ΔL is proportional to its original length L_0 and change in temperature ΔT

$$\text{i.e. } L - L_0 \; \alpha \; L_0 \; \Delta T$$

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

$$L = L_0 \, (1 + \alpha \, \Delta T)$$

$$\alpha = (L - L_0) / L_0 \, \Delta T$$

where α is the coefficient of linear expansion.

Area Expansion: When a solid is heated its area increases then the expansion is called superficial or area expansion.

$$A = A_0 \, (1 + \beta \, \Delta T)$$

$$\beta = (A - A_0) / A_0 \, \Delta T$$

where β is called as the coefficient of area expansion.

Volume Expansion: When a substance is heated its volume increases then its expansion is called cubical or volume expansion.

$V = V_0 (1+ \gamma \Delta T)$

$\gamma = (V - V_0) / V_0 \Delta T$

Where γ is called as the coefficient of volume or cubical expansion.

RELATION among α, β AND γ:

Let us consider a cube of side 1 m each, and heated from 0 K to 1K.

As per linear expansion,

new length $l = 1 + \alpha$, new width, $b = 1 + \alpha$ new height, $h = 1 + \alpha$

Relation between α and β:

We have, $A = A_0 [1+ \beta \Delta T]$

$l \times b = l_0 \times b_0 [1+ \beta \Delta T]$

$l \times b = 1 \times 1[1+ \beta (1 - 0)]$

$(1 + \alpha)(1 + \alpha) = (1+ \beta)$

$(1 + \alpha)^2 = (1+ \beta)$

$1 + \alpha^2 + 2\alpha = (1+ \beta)$

$1 + 2\alpha = (1+ \beta)$ (α is very small hence α^2 is neglected)

$2\alpha = \beta$ and $\alpha = \frac{\beta}{2}$

Relation between α and γ:

We have, $V = V_0 [1+ \gamma \Delta T]$

$l \times b \times h = l_0 \times b_0 \times h_0 [1+\gamma \Delta T]$

$(1 + \alpha)(1 + \alpha)(1 + \alpha) = 1 \times 1 \times 1[1+\gamma(1 - 0)]$

$(1 + \alpha)^3 = (1+ \gamma)$

$1 + \alpha^3 + 3\alpha + 3\alpha^2 = (1+ \gamma)$

$1 + 3\alpha = (1+ \gamma)$ (α is very small hence α^3 and α^2 are neglected)

$3\alpha = \gamma$ and $\alpha = \frac{\gamma}{3}$

Relation between β and γ:

As we have, $\alpha = \frac{\beta}{2}$ and $\alpha = \frac{\gamma}{3}$

$\frac{\beta}{2} = \frac{\gamma}{3}$

$3\beta = 2\gamma$

Relation among α, β and γ:

As we have, $\alpha = \frac{\beta}{2}$ and $\alpha = \frac{\gamma}{3}$

$\alpha = \frac{\beta}{2} = \frac{\gamma}{3}$,

6 α = 3β = 2γ

α:β:γ = 1:2:3

SPECIFIC HEAT CAPACITY:

It is defined as the quantity of heat required to raise the temperature of unit mass of the substance through one kelvin.

When heat is supplied to a substance its temperature increases, and the amount of heat(ΔQ) supplied is directly proportional to the mass(m) of the body and temperature raised(ΔT).

i.e., $\Delta Q \propto m$ and $\Delta Q \propto \Delta T$

$\Delta Q \propto m\Delta T$

$\Delta Q = sm\Delta T$

Here, 's' is a constant of proportionality and is called specific heat capacity or simply specific heat of the material of the substance

Equation of specific heat of solid is given by $s=\Delta Q/m\Delta T$

The SI unit of specific heat s is J kg^{-1} K^{-1} and cgs unit is cal/g/°c or cal/g/K.

Specific heat of water = 1 cal/g/°c = 4186 J kg^{-1} K^{-1} = 4.2 x 10^3 J kg^{-1} K^{-1}

Specific heat of ice = 0.5 cal/g/°c = 2093 J kg^{-1} K^{-1} = 2.1 x 10^3 J kg^{-1} K^{-1}

Specific heat of steam = 0.47 cal/g/°c

Molar Specific Heat: Heat required to raise the temperature of one mole of substance through one kelvin.

i.e; $C=\Delta Q/n\Delta T$ where n =m/M is the number of moles of the gas having molecular weight M.

SI UNIT: J/mol/K

Heat Capacity: The quantity of heat required to raise the temperature of a certain quantity of a substance through one kelvin.

Heat capacity=ms= $\Delta Q/\Delta T$

SI UNIT: J/K

Molar Specific heat at constant pressure (C_p): It is defined as the quantity of heat required to raise the temperature of one mole of the gas through one kelvin keeping pressure constant.

Molar Specific heat at constant volume (C_v): It is defined as the quantity of heat required to raise the temperature of one mole of the gas through one kelvin keeping volume constant.

CALORIMETRY:

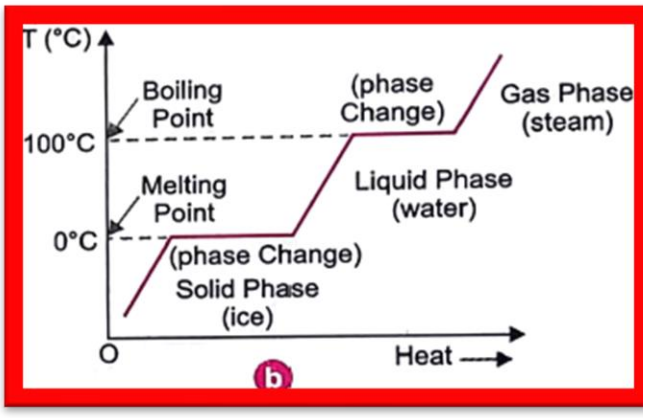
It deals with the measurement of heat energy.

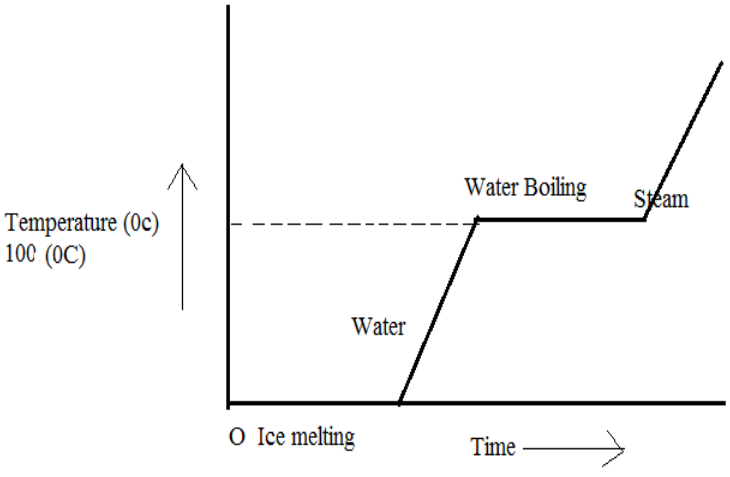
Principle: "In thermal equilibrium, the heat lost by the hot substance is equal to the heat gained by the cold substance".

Calorimeter: It is a device used to measure the amount of heat energy lost or gained by a substance.

It is in the form of a cylindrical copper vessel provided with a copper stirrer. The vessel is enclosed in a wooden box lined with a material which is bad conductor of heat. Using this device, it is not only possible to calculate the heat lost or gained but also to determine specific heat and latent heat of solids and liquids.

CHANGE OF STATE:





A transition from one of the state to another is called change of state.

The change of state from solid to liquid is called ***melting*** and from liquid to solid is called ***fusion***. The temperature at which the solid state and the liquid state of a substance are in thermal equilibrium with each other is called ***melting point***.

The change of state from liquid to vapour is called ***vaporisation***. The temperature at which the liquid state and the vapour state of the substances co-exist in thermal equilibrium is called ***boiling point***.

Eg; when ice at 0^oc taken in a vessel is heated slowly at normal pressure, the ice melts. The temperature remains constant at 0^oc. when this water in the vessel is further heated, the temperature increases till it reaches 100^oc. At 100^oc, water boils and converts into steam. The temperature remains constant at 100^oc until all the water is vaporised.

When pressure increases, the boiling point of a liquid increases. Hence, inside a pressure cooker, water boils at a temperature much higher than 100^oc. Therefore, cooking is faster in a pressure cooker. At high altitudes such as mountain peaks, the pressure is lower and water boils at a temperature lower than 100^oc. Therefore, cooking will be slower at high altitudes. The variation of the temperature of water with time as it continuously heated is as shown in the following graph

Regelation: The phenomena in which ice m elts when pressure is increased and again freezes when pressure is removed. This is called as regelation.

Eg: skating on ice surface is possible due to formation of water layer below the skates. This water acts as lubricant for skating process.

Sublimation: The change from solid state to vapour state without passing through the liquid state is called sublimation.

Eg: Dry ice and iodine undergo sublimation.

LATENT HEAT: When a substance changes its state from solid to liquid or from liquid to gas by the absorption of heat energy, no change is observed in the temperature of substance. So the heat supplied during the change of state is called latent heat.

The expression for latent heat is given by

$$\mathbf{Q=mL \text{ or } L=Q/m}$$

SI UNIT: J/kg

Where L is the latent heat, m is the mass of the substance undergoes a change from one state to the other and Q is the heat required to the substance.

Types of Latent heat:

Latent heat of fusion (L_f): The quantity of heat required to convert unit mass of a solid at its melting point completely into liquid without change of temperature is called latent heat of fusion.

Latent heat of fusion of ice is 33600 J/Kg

Latent heat of vaporisation (L_v): The quantity of heat required to convert unit mass of a liquid at its boiling point completely into vapour without change of temperature is called latent heat of vaporisation.

The latent heat of vaporisation of water is 2.25×10^6 J/Kg.

HEAT TRANSFER:

There are three different modes in which heat is transferred. These are conduction, convection and radiation.

Conduction: It is a process of heat transfer in solids from a point of higher temperature to a point of lower temperature, without the actual movement of the particles of the solid.

Convection: It is a process in which heat is transmitted from a place of higher temperature to a place of lower temperature by the bodily movement of heated particles.

Following phenomena are based on thermal convection:

Land and sea breezes: Land absorbs heat from the sun more rapidly than water. Further on account of its lower specific heat. Land is raised to a higher temperature than the sea water. Thus, during the day, land is hotter than the sea. As a result, cold air from the sea blows towards the land. This is called sea breeze. At night, land cools more rapidly than sea and the land is at lower temperature than the sea. Therefore, air blows from the land towards the sea is called land breeze.

Radiation: It is a process of transmission of heat from one place to another without the aid of any intervening medium. Heat radiation from a body on account of its temperature is called thermal radiation.

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