Chapter =09

Thermal Properties of Matter

Q1. Differentiate between heat and Temperature

HEAT	**TEMPERATURE**
Heat is the amount of energy in a body.	Temperature is the measure of the intensity of heat.
It can be measure as Total kinetic and potential energy contained by molecules in an object.	It can be measure as Average kinetic energy of molecules in a substance.
Flows from hotter object to cooler object.	Rises when heated and falls when cooled.
Its S.I unit is Joules	Its S.I unit is Kelvin
Its symbol is "Q"	Its symbol is "T"

Q2. Write short note on thermometer

THERMOMETER

Thermometer is a device, used to measure temperature.

FOR EXAMPLE

A clinical thermometer is used to measure the temperature of human body

Thermometers have different scales to measure temperature

There are three scales of temperature

1. Celsius scale (Mostly used for environmental measurements)
2. Fahrenheit scale (Mostly used for clinical measurements)
3. Kelvin scale (Mostly used for industrial measurements)

Q3. Define and give formula of heat capacity

HEAT CAPACITY

Amount of heat required to raise the temperature of a substance through 1°C is called heat capacity of that substance

FORMULA

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

UNIT

Its SI unit is joule per Kelvin ($J\ K^{-1}$).

Q4. Define and give formula of specific heat capacity

SPECIFIC HEAT CAPACITY

Amount of heat required to raise the temperature of 1 kg of a substance through 1°C is called specific heat capacity of that substance

FORMULA

$$c = \frac{\Delta Q}{m\Delta T}$$

UNIT

Its SI unit is joule per kilogram per Kelvin ($J\ kg^{-1}\ K^{-1}$).

Q5. Define heat of fusion, heat of vaporization

HEAT OF FUSION

The heat absorbed by a unit mass of a solid at its melting point in order to convert solid into liquid without change of temperature is called "heat of fusion".

HEAT OF VAPORIZATION

The amount of heat energy required to change the state of a substance from liquid to vapor form, without changing its temperature is called "heat of vaporization".

Q6. Differentiate between evaporization and boiling

EVAPORATION	BOILING
1· It takes place without supply having external heat source.	1· It only takes place without on supply external heat source.
2· It occurs at any temperature below boiling point.	2· It occurs only at certain temperature called "Boiling point".
3· It causes cooling.	3· It do not cause cooling.
4· It is relatively slow.	4· It is relatively fast.
5· It takes place only at the liquid surface.	5· I t takes place throughout the liquid.
6· No formation of bubbles.	6· Bubbles are formed.

Q7. Discus the factor of surface evaporization

FACTORS WHICH INFLUENCING SURFACE EVAPORATION

A. TEMPERATURE:

With the increase in temperature the rate of evaporation also increases.

B. WIND SPEED:

Rate of evaporation also increases with the increase in wind speed.

C. SURFACE AREA OF LIQUID:

Rate of evaporation increases with the increase in surface area of liquid.

D. HUMIDITY:

The rate of evaporation decreases with increase in humidity.

E. NATURE OF LIQUID:

Nature of liquid also effect the rate of evaporation. Liquid with lower boiling point have grater vapor pressure and evaporate more rapidly.

F. SOLUTE CONCENTRATION:

Salty water evaporates more slowly than pure water.

Q8. Define thermal expansion. List down its example.

THERMAL EXPANSION

The expansion of substance on heating is called thermal expansion.

EXAMPLES OF THERMAL EXPANSION.

Expansion in railway tracks in summer.

Expansion in electric wires in summer.

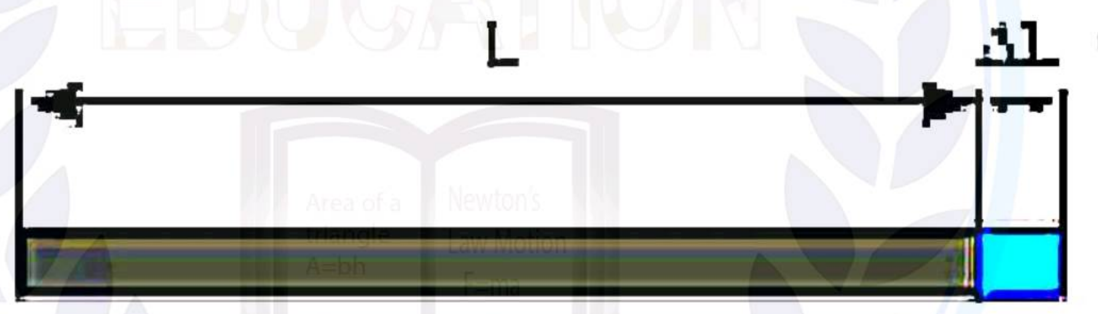
Expansion in bridges in summer.

Q9. Define linear thermal expansion. Derive $\Delta L = \alpha L \Delta T$

LINEAR THERMAL EXPANSION

The expansion in length of a solid object on heating is called linear expansion.

DERIVATION



Suppose a rod of some material with original length L, at initial temperature T, is heated through a certain temperature T', then its length increase and becomes L'.

Therefore,

$$\text{Change in temperature} = \Delta T = T' - T \text{ -------(i)}$$

$$\text{Change in length} = \Delta L = L' - L \text{ ---------------(ii)}$$

It has been experimental proved that change in length is directly proportional to the original length and change in temperature. Therefore

$$\Delta L = (\text{constant})\ L\ \Delta T \text{ -----------------------(iii)}$$

This constant is denoted by α, and is called coefficient of linear expansion. It depends upon the nature of the material.

Therefore equation (iii) can be written as

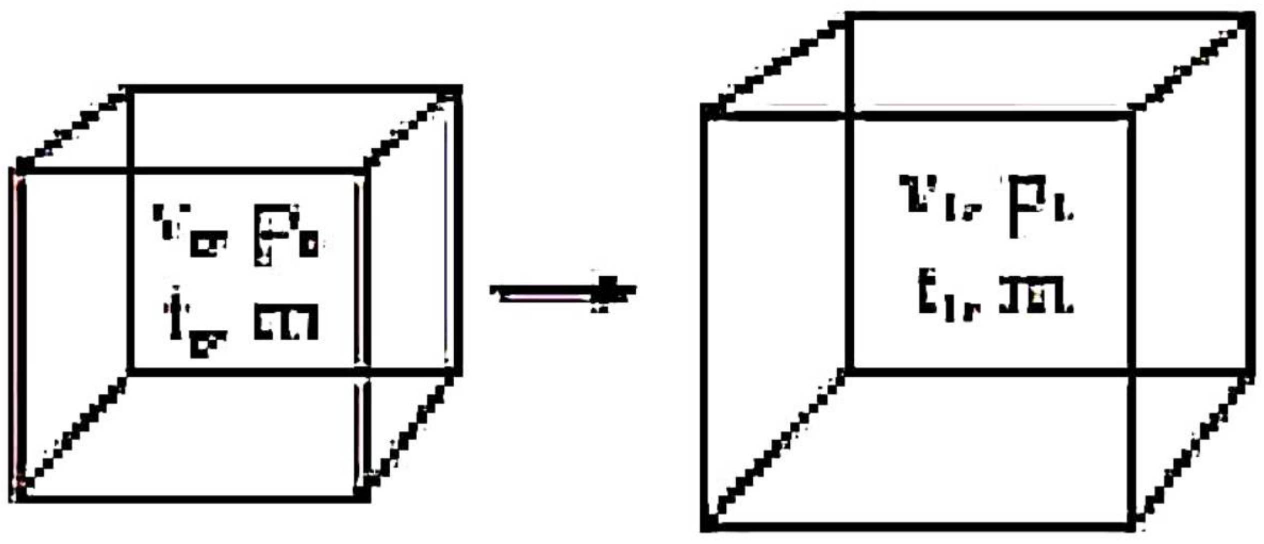
$$\Delta L = \alpha L \Delta T$$

Q10. Define volumetric thermal expansion. Derive $\Delta V = \beta V \Delta T$

VOLUMETRIC THERMAL EXPANSION

The expansion in volume of a solid object on heating is called volume expansion.

DERIVATION



It is three-dimensional expansion as it occurs along the length, width and height of the object. Consider a solid body having volume V, at some initial temperature T. When the body is heated its temperature changes from T to T' and its volume becomes V'.

Therefore,

$$\text{Change in temperature} = \Delta T = T' - T \text{ -------(i)}$$

$$\text{Change in volume} = \Delta V = V' - V \text{ ----------- (ii)}$$

It has been experimentally proved that change in volume is directly proportional to the original volume and change in temperature.

$\Delta V = (\text{constant})\ V\ \Delta T$ ---------(iii)

This constant is denoted by "β" and is called coefficient of volume expansion. It depends upon the nature of material.

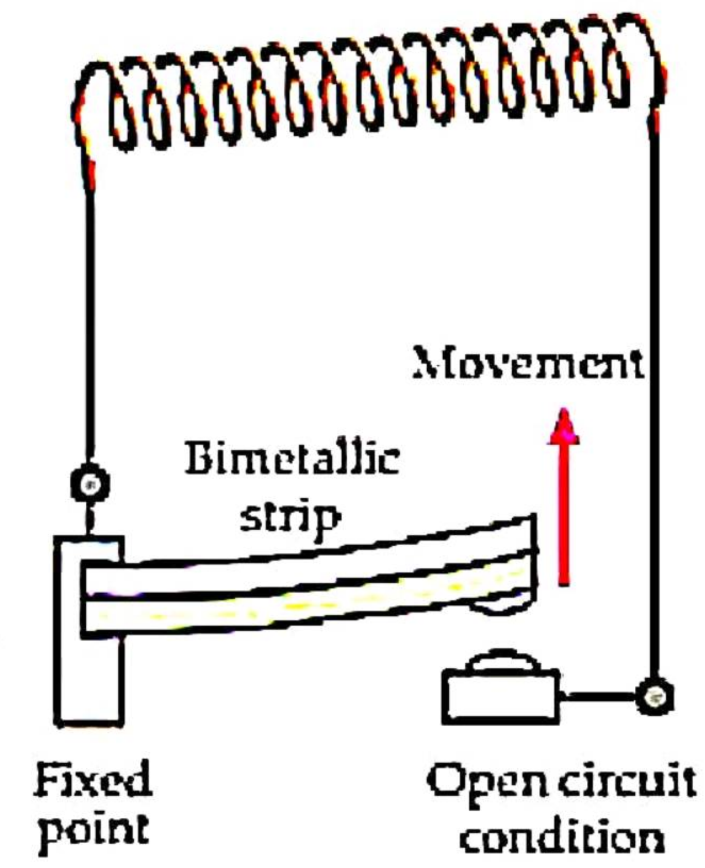
Therefore equation (iii) can be written as:

$$\mathbf{\Delta V = \beta V\ \Delta T}$$

Q11. Write short note on bimetallic thermostat.

BIMETAL THERMOSTAT

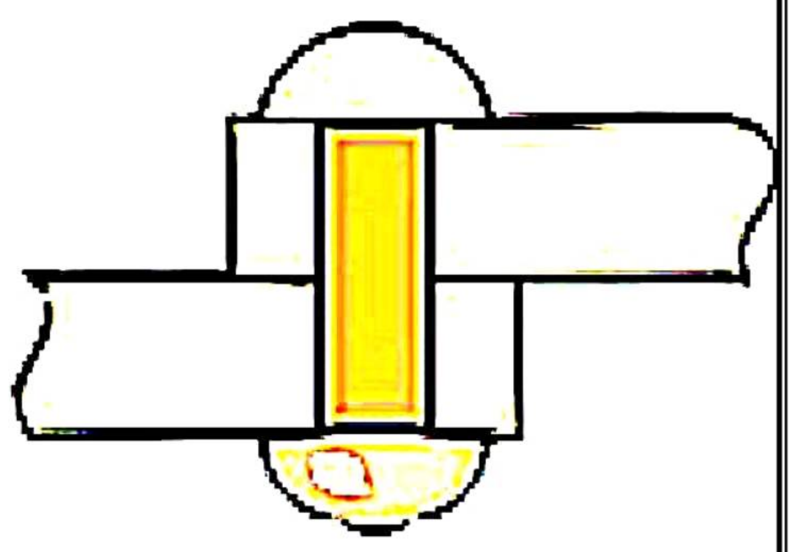
Bimetallic thermostat is used to control temperature of ovens, irons water heaters, refrigerators, air conditioners and so on. It is designed to bend when it becomes hot. Two metals with different coefficient of linear expansion are joined firmly to make it. When it is heated, metal with large value of coefficient of linear expansion more than the other, causing the strip to bend. In this way, it cuts off the current supply. The current supply to the circuit is restored again when it cools down.



Q12. What do you know about Rivets?

RIVETS

Rivets are used in shipbuilding and other industries to join metal plates. A red-hot rivet is passed through holes in two metal plates and hammered until ends are rounded. The rivet contracts on cooling and pulls the two plates tightly together. A metal rim can be fixed on a wooden wheel of a bull cart. The diameter of metal rim is set little bit smaller than the diameter of wooden wheel. The diameter of metal rim increases on heating and can easily be put over the wooden wheel. It contracts on cooling and holds wooden wheel tightly.



Chapter = 09

Numerical Problems

Numerical # 1

Convert 30°C into Kelvin and Fahrenheit Scale.

Data

T = 30°C

T = ? (Kelvin)

T = ? (Fahrenheit)

Solution

°C in to K (+273)

T = 30+273 = 303K

°C in to F: T(F) = 1.8T°C +32

T(F) = 1.8(30) +32

T(F) = 54 + 32

T(F) = 86F

Numerical # 2

Convert 212°F into Celsius and Kelvin.

Data

T = 212F

T = °C = ?

T = K = ?

Solution

F in to °C: T°C = $\frac{T(F)-32}{1.8}$

T°C = $\frac{212-32}{1.8} = \frac{180}{1.8} = 100$°C

K in to °C (–273)

T(K) = 100 – 273 = –173K

Numerical # 3

The temperature of Hyderabad on a hot day is 45 degree Celsius (45°C). What will be its equivalent temperature on Fahrenheit Scale?

Data

T = 45°C

$T = F = ?$

Solution

°C in to F: $T(F) = 1.8T^{o}C + 32$

$T(F) = 1.8 \times 45 + 32$

$T(F) = 81 + 32$

$T(F) = 113F$

Numerical # 4

The thermal energy required to raise the temperature of 50g of water from 40°C to 70°C is 6300 Joules. Calculate the specific heat capacity of water.

Data

$m = 50g = 50 \div 1000 = 0.05$ kg

$T_1 = 40^{o}C$

$T_2 = 70^{o}C$

$\Delta Q = 6300$ j

$C = ?$

Solution

$\Delta Q = mC\Delta T$

$\Delta T = T_2 - T_1 = 70 - 40 = 30^{o}C = 30K$

$6300 = 0.05 \times C \times 30$

$6300 = 1.5C$

$C = \frac{6300}{1.5}$

$C = 4200 \text{ J Kg}^{-1} \text{ K}^{-1}$

Numerical # 5

2kg of copper requires 2050J of heat to raise its temperature through 10°C. Calculate the heat capacity of the sample.

Data

$m = 2$ kg

$\Delta T = 10^{o}C = 10K$

$\Delta Q = 2050$ j

$c = ?$

Solution

$\Delta Q = c\Delta T$

$2050 = c \times 10$

$C = \frac{2050}{10}$

$C = 205\ J\ K^{-1}$

Numerical # 6

An iron block of volume $3m^3$ is heated, so that its temperature changes from 25ºC to 100ºC. If the coefficient of linear expansion of iron is $11 \times 10^{-6}\ ^oC^{-1}$. What will be the new volume of the iron block after heating?

Data

$V_1 = 3m^3$

$T_1 = 20^oC$

$T_2 = 100\ ^oC$

$\alpha = 11 \times 10^{-6}\ ^oC^{-1}$

$V_2 = ?$

Solution

$\Delta T = T_2 - T_1 = 100 - 20 = 80^oC = 80K$

$\beta = 3\alpha$

$\beta = 3 \times 11 \times 10^{-6}$

$\beta = 33 \times 10^{-6}$

$V_2 = V_1(1 + \beta\Delta T)$

$V_2 = 3(1 + 33 \times 10^{-6} \times 80)$

$V_2 = 3(1 + 0.000033 \times 80)$

$V_2 = 3(1 + 0.00264)$

$V_2 = 3(1.00264)$

$V_2 = 3.00792\ m^3$

Numerical # 7

A copper rod 15m long is heated, so that its temperature changes from 30ºC to 85ºC. Find the change in the length of the rod. The coefficient of linear expansion of copper is $17 \times 10^{-6}\ ^oC^{-1}$.

Data

$L_1 = 3m$

$T_1 = 30^oC$

$T_2 = 85\ ^oC$

$\alpha = 17\times10^{-6}\ ^oC^{-1}$

$\Delta L = ?$

Solution

$\Delta T = T_2 - T_1 = 85 - 30 = 55^oC = 55K$

$\Delta L = \alpha L_1 \Delta T$

$\Delta L = 17\times10^{-6} \times 3 \times 55$

$\Delta L = 0.000017 \times 165$

$\Delta L = 0.002805\ m$