Temperature-

It is a relative measure, or indication of hotness or coldness.

Heat –

It is the form of energy transferred between two (or more) systems or a system and its surroundings by virtue of temperature difference.

The SI unit of heat energy transferred is expressed in joule (J) while SI unit of temperature is kelvin (K), and °C is a commonly used unit of temperature.

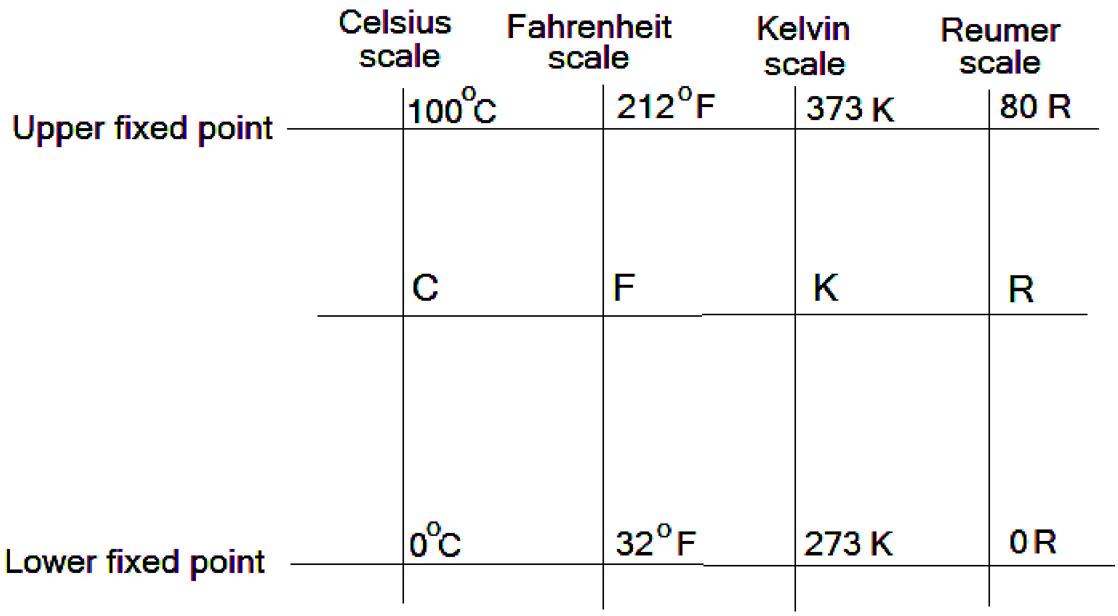
Thermometer-

A measure of temperature is obtained using a thermometer.

The physical properties of materials for the constructing thermometers. Is –

The commonly used property is variation of the volume of a liquid with temperature.

Various scale of measurement of temperature



$$\frac{C-0}{100-0} = \frac{F-32}{212-32} = \frac{K-273}{373-273} = \frac{R-0}{80-0}$$

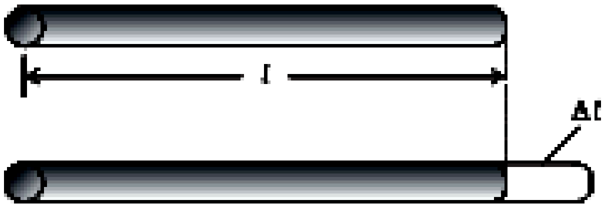
$$\boxed{\frac{C}{5} = \frac{F-32}{9} = \frac{K-273}{5} = \frac{R}{4}}$$

Thermal expansion of solid

It is of three types –

1. Linear expansion
2. Superficial or area expansion
3. Volumetric expansion

Linear expansion



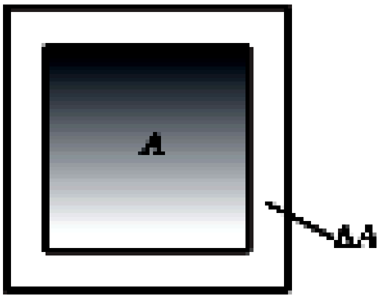
The expansion in length of linear body , due to heating is called linear expansion.

If the substance is in the form of a long rod, then for small change in temperature, ΔT, the fractional change in length, ΔL/L , is directly proportional to ΔT.so,

$$\frac{\Delta L}{L} = \alpha \ \Delta T$$

where **α** is known as the coefficient of linear expansion and is characteristic of the material of the rod.

Superficial or area expansion



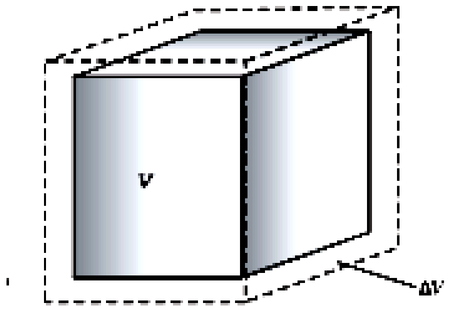
The expansion in surface area of two dimensional body , due to heating is called superficial or area expansion.

If the substance is in the form of a square , then for small change in temperature, ΔT, the fractional change in surface area , ΔS/S , is directly proportional to ΔT.so,

$$\frac{\Delta S}{S} = \beta \, \Delta T$$

where β is known as the coefficient of superficial expansion and is characteristic of the material of the sheet.

Volumetric expansion



The expansion in volume of three dimensional body , due to heating is called volumetric expansion.

If the substance is in the form of a cube , then for small change in temperature, ΔT, the fractional change in volume , ΔV/V , is directly proportional to ΔT.so,

$$\frac{\Delta V}{V} = \gamma \, \Delta T$$

where γ is known as the coefficient of volumetric expansion and is characteristic of the material of the cube .

Relation between α , β and γ

Let us consider a cube of volume V and side L with S as surface area of each face . Let its temperature be increased by ΔT so that

$$\Delta L = \alpha \, L \, \Delta T \text{ ......(1)}$$

$$\Delta S = \beta \, S \, \Delta T \text{.......(2)}$$

$$\Delta V = \gamma \, V \Delta T \text{.......(3)}$$

Where α , β , γ are coefficients linear , superficial and volumetric expansion

(2)=> $\Delta S = (L+\Delta L)^2 - L^2 = L^2 + 2L(\Delta L) + (\Delta L)^2 - L^2 = 2L(\Delta L)$ [neglecting $(\Delta L)^2$]

=> $\beta \, S \, \Delta T = 2L(\alpha \, L \, \Delta T)$

=> $\beta \, L^2 \, \Delta T = = 2L(\alpha \, L \, \Delta T)$ => $\beta = 2\alpha$ **........(4)**

(3)=> $\Delta V = (L+\Delta L)^3 - L^3 = L^3 + 3L^2(\Delta L) + 3L(\Delta L)^2 + (\Delta L)^3 - L^3 = 3L^2(\Delta L)$

neglecting $(\Delta L)^2$ and $(\Delta L)^3$

=> $\gamma \, V \, \Delta T = 3L^2(\alpha \, L \, \Delta T)$

=> $\gamma \, L^3 \, \Delta T = = 3L^2(\alpha \, L \, \Delta T)$ => $\gamma = 3\alpha$ **..........(5)**

From (4) and (5) => $\alpha = \beta/2 = \gamma/3$ .... (6)

SPECIFIC HEAT CAPACITY

The quantity of heat required to warm a given substance depends on its mass, m, the change in temperature, ΔT and the nature of substance.

The change in temperature of a substance, when a given quantity of heat is absorbed or rejected by it, is characterised by a quantity called the heat capacity of that substance.

We define heat capacity, S of a substance as

$$S = \frac{\Delta Q}{\Delta T} \quad \text{...................................... (1)}$$

where ΔQ is the amount of heat supplied to the substance to change its temperature from T to T + ΔT.

The specific heat capacity of the substance is the amount of heat absorbed or rejected to change the temperature of unit mass of it by one unit amount.

If ΔQ stands for the amount of heat absorbed or rejected by a substance of mass m when it undergoes a temperature change ΔT, then the specific heat capacity, of that substance is given by

$$s = \frac{S}{m} = \frac{1}{m}\frac{\Delta Q}{\Delta T} \quad \text{................................ (2)}$$

The specific heat capacity is the property of the substance which determines the change in the temperature of it , when a given quantity of heat is absorbed or rejected by it.

It is defined as the amount of heat per unit mass absorbed or rejected by the substance to change its temperature by one unit.

It depends on the nature of the substance and its temperature.

The SI unit of specific heat capacity is **J kg^{-1} K^{-1}**.

If the amount of substance is specified in terms of moles μ, instead of mass m in kg, we can define heat capacity per mole of the substance by

$$C = \frac{S}{\mu} = \frac{1}{\mu}\frac{\Delta Q}{\Delta T} \quad \text{...................................... (3)}$$

where C is known as molar specific heat capacity of the substance. Like S, C also depends on the nature of the substance and its temperature.

The SI unit of molar specific heat capacity is **J mol^{-1} K^{-1}**.

If the gas is held under constant pressure during the heat transfer, then it is called the molar specific heat capacity at constant pressure and is denoted by C_p.

If the volume of the gas is maintained during the heat transfer, then the corresponding molar specific heat capacity is called molar specific heat capacity at constant volume and is denoted by C_v

1. **Water has the highest specific heat capacity compared to other substances. For this reason water is used as a coolant in automobile radiators as well as a heater in hot water bags.**
2. **Owing to its high specific heat capacity, the water warms up much more slowly than the land during summer and consequently wind from the sea has a cooling effect. Now, you can tell why in desert areas, the earth surface warms up quickly during the day and cools quickly at night.**

CALORIMETRY

A system is said to be isolated if no exchange or transfer of heat occurs between the system and its surroundings. When different parts of an isolated system are at different temperature, a quantity of heat transfers from the part at higher temperature to the part at lower temperature.

Principle of caloriemetry

The heat lost by a body at higher temperature is equal to the heat gained by another at lower temperature.

Calorimetry means measurement of heat.

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, provided no heat is allowed to escape to the surroundings.

Calorimeter –

It is a device in which heat measurement can be made

It consists a metallic vessel and stirrer of the same material like copper or alumiunium. The vessel is kept inside a wooden jacket which contains heat insulating materials like glass wool etc. The outer jacket acts as a heat shield and reduces the heat loss from the inner vessel. There is an opening in the outer jacket through which a mercury thermometer can be inserted into the calorimeter.

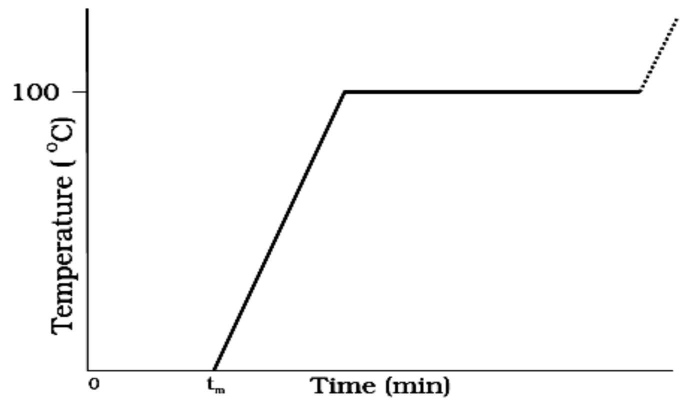
CHANGE OF STATE

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

A transition from one of these states to another is called a change of state.

The changes can occur when the exchange of heat takes place between the substance and its surroundings.

Variation of temperature versus time showing the changes in the state of ice on heating



The change of state from solid to liquid is called **melting** .

The change of state from liquid to solid is called **fusion.**

melting point –

The temperature at which the solid and the liquid states of the substance in thermal equilibrium with each other is called its melting point.

1. It is characteristic of the substance.
2. It also depends on pressure.
3. The melting point of a substance at standard atmospheric pressure is called its **normal melting point**.

Regelation-

This phenomenon of refreezing is called regelation.

How effect of pressure on melting helps in skating ?

Skating is possible on snow due to the formation of water below the skates. Water is formed due to the increase of pressure and it acts as a lubricant.

Vaporisation-

The change of state from liquid to vapour (or gas) is called vaporisation.

Boiling point –

The temperature at which the liquid and the vapour states of the substance coexist is called its boiling point.

The boiling point increases with increase in pressure and decreases with decrease in pressure.

The cooking is difficult on hills. At high altitudes, atmospheric pressure is lower, reducing the boiling point of water as compared to that at sea level.

On the other hand, boiling point is increased inside a pressure cooker by increasing the pressure. Hence cooking is faster.

The boiling point of a substance at standard atmospheric pressure is called its **normal boiling point**.

Sublimation-

The change from solid state to vapour state without passing through the liquid state is called sublimation, The substance is said to sublime.

Dry ice (solid CO_2) sublimes, so also iodine.

During the sublimation process both the solid and vapour states of a substance coexist in thermal equilibrium.

Latent heat –

The amount of heat per unit mass transferred during change of state of the substance is called latent heat of the substance for the process .

The heat required during a change of state depends upon the heat of transformation and the mass of the substance undergoing a change of state.

Thus, if mass m of a substance undergoes a change from one state to the other, then the quantity of heat required is given by $Q = m L$ or $L = Q/m$ ....(1)

where L is known as latent heat and is a characteristic of the substance.

Its SI unit is J kg^{-1}.

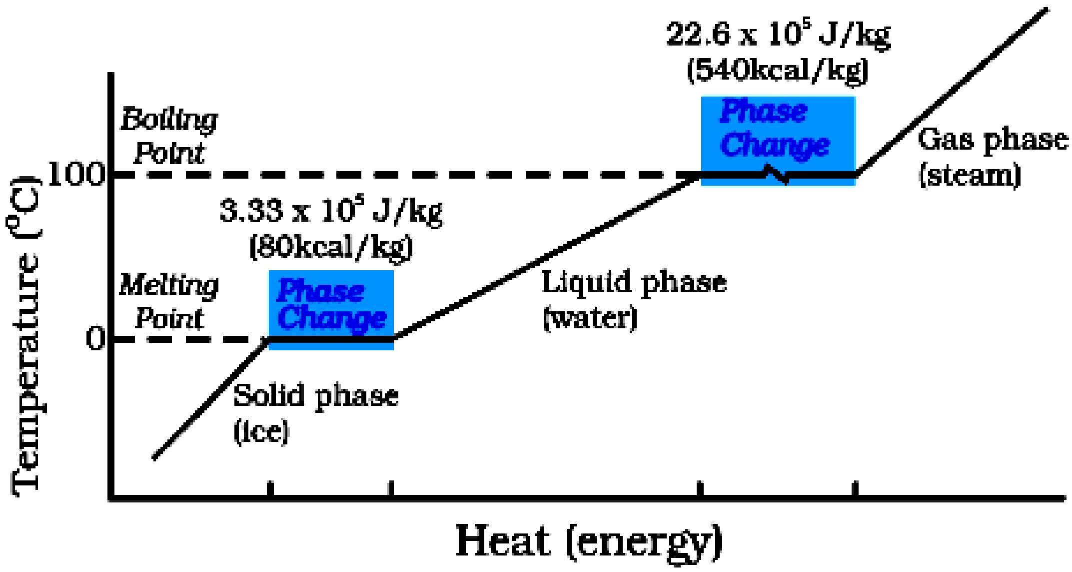
The value of L also depends on the pressure. Its value is usually quoted at standard atmospheric pressure.

The latent heat for a solid-liquid state change is called the **latent heat of fusion (L_f).**

The latent heat for a liquid-gas state change is called the **latent heat of vaporisation (L_v).**

These are often referred to as the heat of fusion and the heat of vaporisation.

Variation of temperature Vs heat energy for water



1. For water, the latent heat of fusion and vaporisation are $L_f = 3.33 \times 10^5$ J kg^{-1} and $L_v = 22.6 \times 10^5$ J kg^{-1}
2. 3.33×10^5 J of heat are needed to melt 1 kg of ice at 0 °C, and 22.6×10^5 J of heat are needed to convert 1 kg of water to steam at 100 °C.
3. So, steam at 100 °C carries 22.6×10^5 J kg^{-1} more heat than water at 100 °C.
4. This is why burns from steam are usually more serious than those from boiling water.