Heat

UNITS OF HEAT

The branch of science that deals with the measurement of heat is Calorimetry. Units used to measure heat are as follow:

1. C.G.S unit : Calorie(cal)

Calorie: it is defined as heat required raising the temperature of 1 g of water through 1 degree Celsius from 14.5^0C to 15.5^0C.

2. M.K.S unit: 1 Kilo **Calorie (Kcal)** = 1000 Calories.
3. S.I. unit: Joule (J)

The units Calorie and Joule are related as:

1 cal = 4.186 J (or nearly 4.2 J)

TEMPERATURE

Temperature is a quantity which tells the thermal state of a body (i.e., the degree of hotness or coldness of the body). It determines the direction of flow of heat when two bodies at different temperatures are placed in contact. At molecular level, when temperature increases (means body is gaining heat), we say kinetic energy of molecule increases.

THERMOMETERS AND TEMPERATURES SCALE

The sense of touch provides some indication of the temperature of an object but is unreliable. For example, the metal shelf in the refrigerator feels colder than the food sitting on the shelf, even though they are in thermal equilibrium. The metal feels colder because the metal conducts the heat from your hand more efficiently.

THERMOMETERS

Thermometers are instruments that define and measure the temperature of a system. The common thermometer consists of a volume of mercury that expands into a capillary tube when heated. When the thermometer is in thermal equilibrium with an object, the temperature can be read from the thermometer scale.

Three temperature scales are commonly used: Celsius, Fahrenheit, and Kelvin (also called *absolute*). Comparisons of the Celsius and Fahrenheit thermometers are shown in Figure

A degree on Celsius is $\frac{1}{100}th$ part of the interval between the ice point and the steam point.

A degree on Fahrenheit scale is $\frac{1}{180}th$ part of the interval between the ice point and the steam point.

$$1 \text{ centigrade degree} = \frac{9}{5} \text{ Fahrenheit degree}$$

The relation between Fahrenheit scale and Celsius scale is

$$\frac{C}{5} = \frac{F-32}{9}$$

The zero of the absolute scale is the temperature at which the molecular motion ceases and the average kinetic energy of molecules becomes zero. Thus the zero of absolute is not the ice point. Absolute zero is the lowest attainable temperature. No temperature can be less than this temperature. Therefore this scale has no negative temperature.

$$T\,K = 273 + t^{o}C.$$

THERMOMETRY

Thermometry is the branch of science which deals with temperature. The instrument used for measuring the temperature is called a thermometer.

The choice of thermometer depends on

(a) The range of temperature to be measured,

(b) The accuracy required, and

(c) The physical conditions of the substance of which temperature is to be measured.

The construction of a liquid thermometer involves the following three considerations:

(i) Choice of thermometric liquid,

(ii) Calibration of thermometer, and

(iii) Increase of sensitivity of thermometer.

The Thermometric substance is chosen in such a way that the variation in its thermal property is large and uniform in the required range of temperature.

THERMAL EQUILIBRIUM AND ZEROTH LAW

Heat flows from a body at a higher temperature to a body at lower temperature till their temperatures become equal. Two bodies are said to be in thermal equilibrium, if they are at the same temperature.

Zeroth Law: If a system A and a system B are in thermal equilibrium with system C, then system A and system B are also in thermal equilibrium with each other. This is the essence of the Zeroth law.

TYPES OF CHANGES OF STATE AND THE TEMPERATURES AT WHICH THEY OCCUR

Matter can exists in three states- solid, liquid and gases. One state can be converted into another. During the state change temperature of matter remains constant. Let us study the change of one state to another and the temperature at which they occur.

(1) Melting and Melting Point

The conversion of a solid to liquid form is melting. The temperature at which a substance which is being heated begins to melt under normal atmospheric pressure is called its melting point.

(2) Freezing and Freezing Point

The conversion of liquid to solid form is freezing. The temperature at which a liquid rejecting heat begins to solidify under normal atmospheric conditions is called its freezing point.

(3) Vaporization and Boiling Point

The conversion of a liquid to vapour is called vaporization. The temperature at which a liquid receiving heat begins to vaporize under normal atmospheric condition is called its boiling point.

(4) Condensation and Condensation Point

The conversion of a vapour to liquid is called condensation. The water at which a gas rejecting heat begins to liquefy under normal atmospheric conditions is called as condensation point.

(5) Sublimation and Sublimation Point

The conversion of a solid into vapour is called sublimation. The temperature at which a solid vaporize under normal atmospheric conditions is called its sublimation point.

LATENT HEAT (L)

Whenever matter changes one state to another state, heat is absorbed or released by the substance. Heat absorbed or released by the body is called as latent heat.

It was experimentally found that the quantity of heat (Q) absorbed or released is directly proportional to the mass of the substance (m) which changes its state.

$$Q \propto m$$

$$Q = mL$$

Latent heat can therefore be defined as that heat which is absorbed by unit mass of a substance during its change of state without any change of temperature.

Units of Latent Heat

C.G.S	M.K.S	S.I.
$\frac{\text{Calorie}}{\text{gram}} = \frac{\text{cal}}{\text{g}}$	$\frac{\text{Kilo Calorie}}{\text{Kilogram}} = \frac{\text{Kcal}}{\text{Kg}}$	$\frac{\text{Joule}}{\text{Kilogram}} = \frac{\text{J}}{\text{Kg}}$

A substance can have two types of phase change

i. Solid to liquid

ii. Liquid to gas

iii.

For these types of phase change, we define two types of latent heats which are mentioned below in the table:

	Latent heat of fusion(L_F)	Latent heat of vaporization(L_V)
1	Def: the quantity of heat consumed by a unit mass of a substance during its change of state from solid to liquid without change in temperature.	Def. the quantity of heat absorbed by a unit mass of a substance during its state change from liquid to vapour without change in temperature.
2	Latent heat of fusion of ice is 80 cal/gm. It means 1 gram of ice at 0^0C absorbed 80 cal of heat to convert 1 gm of water.	Latent heat of vaporization of water is 540 cal/gm. It means 1 gram of water at 100^0C required 540 cal of heat to convert 1 gm of vapour
3	During the reverse process, means at the time of freezing 1 gm of water releases the same amount of energy (80 cal) to convert into 1 gm of ice at 0^0C.	During the reverse process, means at the time of condensation 1 gm of vapour releases the same amount of energy (540 cal) to convert into 1 gm of water at 100^0C.

EVAPORATION V/S VAPORIZATION

Both evaporation and vaporization involve a change of state from liquid to vapour, but both processes differ from each other in many ways. Following is the difference between them:

	Evaporation	Vaporization
1	It takes place at all temperatures.	It takes place only at some fixed temperatures under the standard conditions.
2	It is a slow process.	It is a fast process.
3	Rate of evaporation depends upon the surface of the liquid, wind speed, humidity and temperature of the surrounding.	It does not depend upon any of these factors.
4	It only occurs at the surface of the liquid	It occurs over the entire mass of the liquid.
5	Evaporation is an endothermic process. This means temperature of the liquid decreases due to evaporation.	It is isothermal process. Temperature of the liquid remains constant.