Chapter-6

HEAT TRANSFER

STUDY NOTES

HEAT:

Heat is a form of energy which gives the sensation of warmth. The sum total kinetic energy of all the vibrating molecules of a matter is heat energy.

Temperature –The degree of hotness or coldness of a body is called temperature.

The differences between heat and temperature are as follows:

Heat	Temperature
The sum total kinetic energy of all the vibrating molecules of a matter is heat energy.	The degree of hotness or coldness of a body is called temperature.
Heat is measured by using calorie meter.	Temperature is measured by using thermometer.

The differences between clinical and simple thermometer are as follows:

Clinical thermometer	Lab thermometer
The thermometer used to measure the human body temperature is called clinical thermometer.	The thermometer which is used to measure the temperature of different chemicals, solvents and reagents is called laboratory thermometer.
The stem is graduated from 35^{o}C to 42^{o}C.	The stem is graduated from -10^{o}C to 110^{o}C.
It has construction in its stem.	It doesn't have construction in its stem.
It is prismatic in shape.	It is round and cylindrical in shape.

Thermometer:

An instrument or device which is used for measuring temperature of a body is called thermometer.

Types of thermometer:

Clinical thermometer:

The thermometer used to measure human body is called clinical thermometer.

Maximum minimum thermometer:

This is used to measure the maximum and minimum temperature.

Role of index in minimum and maximum thermometer:

The role of index in minimum and maximum thermometer is to enable to record the maximum day temperature to be read on the scale when the temperature rises during day time. And when the temperature falls at night, index gives the minimum temperature.

Laboratory thermometer:

A laboratory thermometer is a tool used in laboratories to measure temperature with a high level of accuracy. It can be partially or fully immersed in the substance being measured. A laboratory thermometer is recognizable by its long stem with a silver bulb at the end.

Mercury and alcohol:

- The advantages of using Mercury instead of alcohol are as follows:
- Mercury is good conductor of heat but alcohol is bad conductor of heat.
- It expands and contracts in a uniform rate but alcohol's expansion rate is not uniform.
- It is opaque, bright, and silvery in colour which makes it easy to find the level in very fine capillary tube but alcohol is colourless so, it should be coloured before use.
- Alcohol wets the wall of capillary tube. Hence, the rise or fall of alcohol in the capillary tube is not clean and smooth.
- The function of mercury in the maximum and minimum thermometer is to enable the steel index to indicate the minimum temperature at night and the function of alcohol in minimum and maximum thermometer is to enable the steel index to indicate the maximum day temperature.

Role of index in minimum and maximum thermometer:

The role of index in minimum and maximum thermometer is to enable to record the maximum day temperature to be read on the scale when the temperature rises during day time. And when the temperature falls at night, index gives the minimum temperature.

Conductors and insulators

Types of conductors

Type	Definition	Examples
Good conductors	• The substances which allow heat to pass through them faster are called good conductors.	• Metals. • Mercury. • All good conductors of electricity a good conductors of heat, except mic
Bad conductors or insulators	• The substances which do not allow heat to pass through them easily are called poor or bad conductors. • The higher the specific heat of a substance, the less conducting is the material.	• Non-metals like glass, wood, cloth, wax. • Solids like ebonite and asbestos. • All liquids except mercury.

Examples to illustrate good and bad conductors

- In winter, a piece of iron on being touched by hand appears cooler than a piece of wood.
- In summer, if a wooden chair and an iron chair both are kept in sun, and are touched, the iron chair appears to be warmer than the wooden chair.

What is heat?

- Heat is a form of energy.
- It is the energy of random motion of molecules constituting the body.

  The S.I. unit of heat is joule J.

  The other units of heat are calorie (cal) and kilocalorie (kcal).

  1 cal = 4.186 J ∼.
- Heat always flows from a body at a higher temperature to a body at a lower temperature.
- For example, if hot water is mixed with cold water, heat flows from hot water to cold water.

Difference between heat and temperature

Heat	Temperature
Heat is a form of energy. It produces the sensation of warmth.	Temperature is the degree of hotness or coldness of a bo
It is a measure of the total energy content of the molecules in an object.	It is a measure of the average kinetic energy of the molecules in an object.
It is the cause.	It is the effect.
It's S.I. the unit is joules and CGS unit is ergs.	It is measured in °C or °F.

Heat Transfer in Matter (Conduction and Convection)

Definition of Conduction

- Conduction is a process of heat transfer in solids.
- In this process, heat is transferred from particle to particle of the solid, without the actual movement of the particles.
- For example, heating of a metal rod by conduction.

Explanation of conduction

- In solid:
  - The atoms of medium do not leave their positions, but they transfer heat energy through their vibrations.
- In metals:

- In addition to the vibrations of atoms, heat is also transferred by the drift of free electrons.
- The rate of conduction by a metal depends directly on the number of free electrons in it.
- Larger the concentration of free electrons in it, more is its rate of conduction.

Convection

Definition:

Convection is a process of transfer of heat by the actual movement of the medium particles.

- In vacuum, heat cannot be transferred by convection.
- By the process of convection, the transfer of heat is always vertically upwards.

How does convection happen

- The medium particles near the source of heat, absorb heat from the source and they start moving faster.
- The medium near the heat source expands and thus becomes less dense.
- It rise up and the medium from the surroundings and above being denser moves to take its place.
- Thus a current is set up in the medium which is called convection current.
- For example, heating of water.

Measurement of heat (MTN)

- The amount of heat gained by a body is directly proportional to its mass i.e. $Q \propto m$.
- The amount of heat gained by a body depends upon the rise in its temperature i.e. $Q \propto t$.
- The quantity of heat absorbed depends upon the nature of the substance of the body.

Specific heat capacity

The quantity of heat required to raise the temperature of unit mass of a substance by $1^{\circ}C$ is called its specific heat capacity.

- It is denoted by S.
- Specific heat capacity = $Q \propto (m \times t)$.
- S.I. unit is J/kg K.

Advantages of high specific heat capacity of water

- Formation of land-breeze and sea-breeze.
- The specific heat capacity of water is 5 times more than that of sand.
- We use water in hot bags for fomentation purposes because it will keep us warmer for a longer period of time.
- Water is used as an effective coolant by letting it flow in pipes around the heated parts of a machine, say, the radiator of a car.
- In cold countries, wine and juice bottles are kept under water to avoid freezing.

Formula

- Heat absorbed by a body = mass of the body × specific heat capacity × rise in its temperature.
- Heat lost by a body = mass of the body × specific heat capacity × fall in its temperature.
- Q = mst.

Heat capacity

The quantity of heat required to raise the temperature of body through $1^{o}C$ is called the heat capacity or the thermal capacity of the body.

- It is usually denoted by C.
- Heat Capacity=Quantity of heat supplied \ Rise in temperature
- S.I. unit is J/K.

Important point

The heat capacity of a body is directly proportional to the amount of substance it contains.

- Doubling the amount of substance of a body doubles its heat capacity.
- Specific heat is defined as the ratio of the heat capacity of a substance to the heat capacity of water.

Principle of calorimetry

The heat given by the hot body is equal to heat taken by the cold body provided no heat is lost or gained from the surroundings that is:
Heat lost by hot body = Heat gained by cold body.

Schematics representation of changes in state of matter

Specific latent heat

The amount of heat required by unit mass of a substance to change its state without any rise in temperature is known as its specific latent heat.

- S.I. unit of specific latent heat is J/kg.
- It is denoted by letter L.
- Latent heat is the heat released or absorbed by a chemical substance during a process that occurs without a change in temperature.
- Q = mL.

Specific latent heat of fusion

- It is denoted by L_f .
- The specific latent of fusion of a substance is the quantity of heat required to convert a unit mass of the substance from solid to liquid state at its melting point without any change in its temperature.

Specific latent heat of vaporisation

- It is denoted by L_v .
- The specific latent of vaporisation of a substance is the quantity of heat required to convert a unit mass of the substance from liquid state to vapour state at its boiling point without any change in its temperature.

Natural consequences of high specific latent heat capacity of ice

- Snow on the mountains do not melt as a whole but melts gradually into water with the heat of the sun.
- Water in lakes and ponds in cold places do not freeze all at the same time.
- Drinks are cooled more effectively by ice pieces at 0°C and not by water at 0°C.

Consequences of high latent heat capacity of steam

- Steam causes more severe burns than boiling water although both are at 100°C.

- Steam is used for running trains or machines because the high amount of heat contained in it turns into mechanical energy.
- Since water has the highest specific latent heat of vaporisation, water from the soil does not evaporate quickly by heat of the sun.

Evaporation and vaporisation

Evaporation	Vaporisation
It takes place at all temperatures.	It takes place only at a fixed temperature which is the boiling point of t liquid.
It is a slow and gradual process.	It is a rapid and violent process.
It takes place only at the surface of the liquid.	It takes place over the entire liquid.
It causes cooling.	It does not produce cooling.