Unit - 9

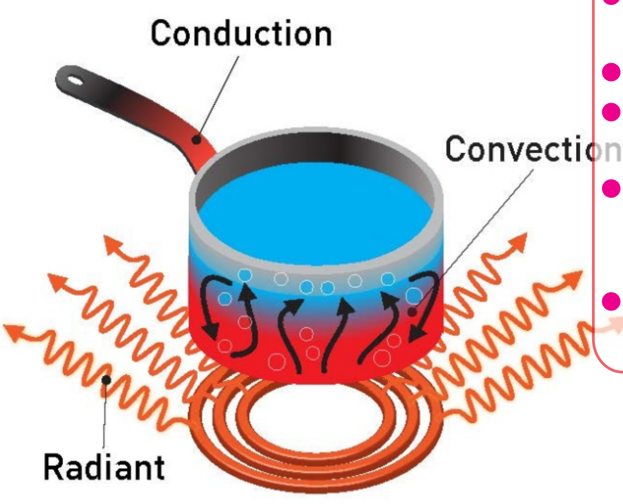
THERMAL PROPERTIES OF MATTER

The properties of matter which change with the change in temperature are called "Thermal properties". Materials change their states due to change in their temperature, cause by the addition or removal of heat. Like for example, water changes from liquid to gas 'steam' due to addition of heat or to solid 'ice' due to removal of heat. The process of evaporation, boiling, freezing, thermal expansion (liner and volumetric) are all happens due to the change in temperature of the substance. Thus changes in temperature caused by the addition or removal of heat play very important role in our daily life.

Students Learning Outcomes (SLOs)

After learning this unit students should be able to:

- Differentiate between heat and temperature
- Define the terms heat capacity and specific heat capacity with SI unit
- Describe one everyday effect due to relatively large specific heat of water
- Describe heat of fusion and heat of vaporization (as energy transfer without a change of temperature for change of state)
- Describe experiments to determine heat of fusion and heat of vaporization of ice and water respectively by sketching temperature-time graph on heating ice.
- Explain the process of evaporation and the difference between boiling and evaporation.
- Explain that evaporation causes cooling
- List the factors which influence surface evaporation
- Define thermal expansion
- Describe qualitatively the thermal expansion of solids (linear and volumetric expansion)
- List and explain some of the everyday applications and consequences of thermal expansion
- Explain the thermal expansion of liquids (real and apparent expansion)



The objective of this unit is to create critical logical thinking among the students, so that they can observe and analyze the physical quantities and changes taking place in their surroundings.

- How does water in our surrounding helps us to maintain the temperature of environment?
- Why different liquids heat up in different manner at same time an same temperature?
- What is the importance of specific heat in everyday life?
- How evaporation takes place and its affects on the surroundings?
- What happen when temperature of solids and liquids increases?
- How does physical state of matter changes from one state to other?
- Why wet clothes take more time to dry out in cloudy day?
- What is the role of thermal expansion in our daily life?

Do You Know!

Heat transfers in three ways
i. Conduction
ii. Convection
iii. Radiation

9.1 HEAT AND TEMPERATURE

Heat

Fig 9.1 (a)
Heat

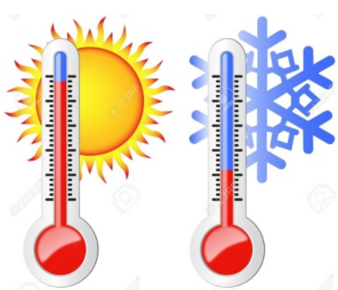


Fig 9.1 (b)
Temperature

Mostly we think that heat and temperature are the same, however, this is not true, they are related with each other, but are different concepts; Fig 9.1(a, b).
Heat is a form of energgy. Where as temperature is flow of heat.
For Example: A hot cup of tea is placed on table, after some time the tea in the cup becomes cold because surrounding temperature is lower than that of the hot tea. Hence heat flows from hot cup to the surrounding. Therefore heat and temperature can be stated as:

Heat	Temperature
It is the form of energy which transfers from hot body to cold body as a result of difference of temperature between them. As heat is form of energy. Therefore its SI unit is joule. Its other unit is calorie.	It is a degree of hotness of a body. It determines the direction of flow of heat from one body to the other body. SI unit of temperature is Kelvin. Its other units are Celsius and Fahrenheit.

Thermometer

Thermometer is a device, used to measure temperature.

For example;

A clinical thermometer is used to measure the temperature of human body (Fig 9.2).

Fig 9.2
Clinical thermometer

Thermometers have different scales to measure temperature.

There are three scales of temperature (Fig 9.3).

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

These three scales of temperature are interconvertible. Therefore temperature measured in Celsius scale can be converted into Kelvin and Fahrenheit scales as follows:

Conversion of temperature from Celsius scale to Kelvin scale

$$K = {}^{\circ}C + 273$$

Conversion of temperature from Celsius scale to Fahrenheit scale

$$^{\circ}F = 1.8^{\circ}C + 32$$

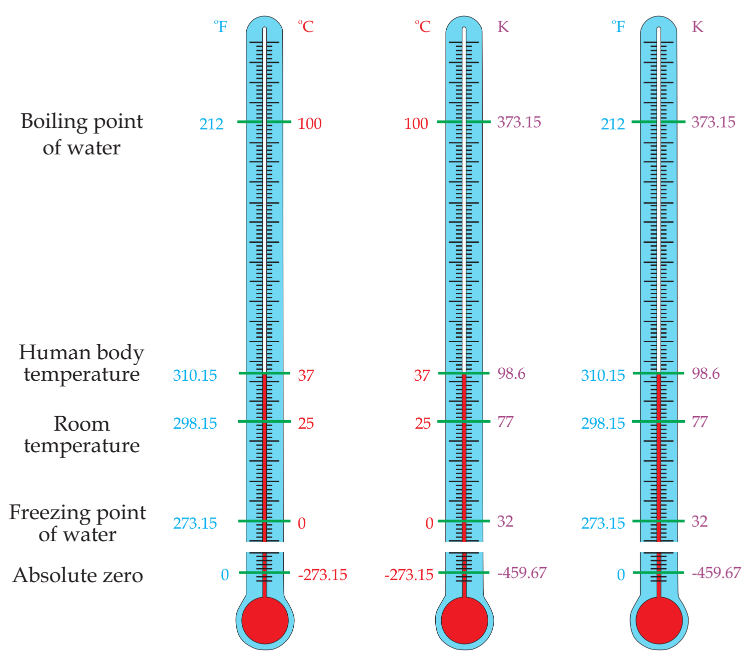


Fig 9.3
The three scales of thermometer

Do You Know!

The temperature of a small cup of tea might be the same as the temperature of a large cup of tea , but the large cup of tea gas more amount of heat because it has more tea has amount of thus more total thermal energy.

Do You Know!

Specific heat of water is 4200 $Jkg^{-1} K^{-1}$.
Boiling point of water is 100°C

Worked Example 1

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

Step 1: Write down known quantities and quantities to be found.

$$°C = 45°$$

$$°F = ??$$

Step 2: Write down formula and rearrange if necessary

$°F = 1.8°C + 32$

Step 3: Put values in formula and calculate

$°F = 1.8 \times 45 + 32$

$°F = 113°$

Hence, the equivalent temperature in Fahrenheit scale is 113°F.

Self Assessment Questions:

Q1: Differentiate between heat and temperature.

Q2: Why we can not tell temperature of a body by teaching it?

Q3: Explain different scales used in thermometers to measure the temperature

9.2 SPECIFIC HEAT CAPACITY

Heat Capacity

Heat capacity is a term in physics that describe how much heat is added to a substance to raise its temperature by 1°C.

Mathematically $C = \frac{Q}{\Delta T}$ where Q = amount of heat absorbed and ΔT is change in temperature.

Heat capacity depends upon the nature of material. For example Two beakers contain equal masses of water and oil are heated by the same gas burner for three

Substance	Specific heat capacity (J/(kg.°C))
Water	4.18×10^3
Ethyl alcohol	2.46×10^3
Ice	2.1×10^3
Aluminum	9.2×10^2
Glass	8.4×10^2
Iron	4.5×10^2
Copper	3.8×10^2
Sliver	2.4×10^2
Lead	1.3×10^2

Table 9.1
Specific Heat Capacity of different substances.

minutes. Then it is observed that the temperature of oil may rise twice than water.

Specific Heat Capacity

When comparing the heat capacity of different substances, we are actually talking about their specific heat capacity.

Hence specific heat capacity can be defined as:

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.

Equation of specific heat capacity 'c' is as under:

$$c = \frac{C}{m} = \frac{1}{m}\left(\frac{Q}{\Delta T}\right)$$

$$c = \frac{\Delta Q}{m\Delta T} \text{ ....(9.1)}$$

Where "c" is constant which depends upon the nature of material of the body. This constant is called as specific heat capacity or specific heat. Its SI unit is joule per kilogram per Kelvin (**$Jkg^{-1}K^{-1}$**).

Table 9.1 shows the specific heat capacity of different substances of common use.

Effects due to large specific heat of water

We know that water has a large specific heat, due to this quality it plays an important role in everyday life.

- The large amount of water in oceans and lakes help to maintain the temperature ranges in their surroundings.
- Water with coolant is used to reduce the temperature of engine through radiator of vehicle.
- Water also help to maintain our body temperature.

Do You Know!

Water has very high specific heat, while the sand has relatively low specific heat, therefore the sand heats up very quickly with little energy.

Worked Example 2

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.

Step 1: Write down known quantities and quantities to be found.

$T_1 = 40°C$

$T_2 = 70°C$

$\Delta T = T_2 - T_1 = 70°C - 40°C = 30°C = 30K$

$\Delta Q = 6300J$

$m = 50g = 0.05\,kg$

$c = ?$

Step 2: Write down formula and rearrange if necessary

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

Step 3: Put values in formula and calculate

$$c = \frac{6300J}{0.05kg \times 30K}$$

$$c = 4200Jkg^{-1}K^{-1}$$

Hence, specific heat of water is $c = 4200Jkg^{-1}K^{-1}$.

Do You Know!

Soil has specific heat capacity of 810 $Jkg^{-1}K^{-1}$, which is about 5 times less than that of water.

Self Assessment Questions:

Q4: Define specific heat capacity.

Q5: Write down the factors on which specific heat capacity depends.

Q6: Write examples of specific heat capacity from daily life experience.

9.3 Heat of fusion and heat of vaporization

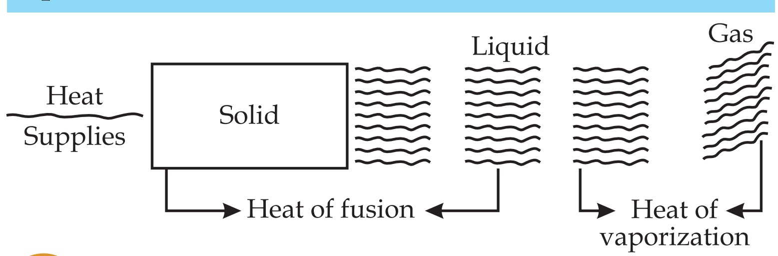
Heat of fusion

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

When a beaker filled with water placed on a burner to boil, the temperature of water gradually raises until it reaches 100°C. At this temperature it starts to boil, that is to say that bubbles of vapor formed at the bottom and start to raise to the surface and then escape in the form of steam. At this stage the temperature of water (liquid) and of water vapors (gas) is same. Thus the heat energy which is required to convert water from liquid to vapor state is know as "heat of vaporization". Therefore heat of vaporization is defined as:

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".



Do You Know!

- The heat of fusion for water at 0°C is approximately 334 Joules per gram.
- The heat of vaporization for water at 100^{0}C is about 2230 Joules per gram.

Activity

Encourage students to take solid ice pieces in a container and supply heat through burner, and observe the process of heat of fusion in class/lab.

Experiments given below determine latent heat of fusion and latent heat of vaporization of ice and water respectively by sketching temperature-time graph of heating ice. This experiment has two parts

(i) Conversion of ice into water.

(ii) Conversion of water into steam.

(i) Convert Ice (Solid) into Water liquid

Experiment

Take a container and place it on a stand as shown in; Fig 9.4. Put small pieces of ice in the container. Suspend a thermometer in the container to measure the temperature. Take a stop watch to measure accurate time at different stages. Now place the container on the burner. The ice will start melting after absorbing heat. The temperature will remain same up to 0°C until all the ice melts. Note the time t_1 and t_2, which the ice takes to melt completely into water at 0°C. Supply heat continuously to water at 0°C, again note the time, Its temperature will start to increase. Note the time, which water in container takes to reach its boiling point at 100°C from 0°C. Draw a temperature-time graph as shown in graph 9.1. Calculate the heat of fusion of ice from the data using the graph.

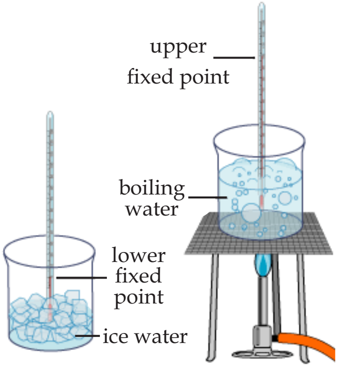
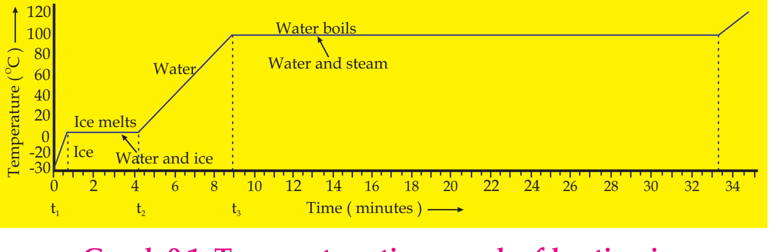


Fig 9.4
Heating ice experiment



Graph 9.1. Temperature-time graph of heating ice

Experiment

(ii)Convert Water (Liquid) into steam (Gas)

It is continuity of previous experiment; Fig 9.5. The container now contains boiling water we continue to supply heat to water, till all the water convert into steam. Note the time during which water in container completely changed into steam at its boiling point, using the temperature-time graph no 9.1 calculate the heat of vaporization of water.

Table 9.2 shows heat of fusion and vaporization of different elements.

Self Assessment Questions:

Q7: Why does the temperature not increase when ice is heated at $0^{\circ}C$?

Q8: Why does the temperature not increase when water is heated at $100\,^{\circ}C$? Explain.

9.4 EVAPORATION PROCESS

It is our common observation that wet clothes dry in sun due to the evaporation. The water in the wet cloth takes heat energy from sun and get evaporated. Similarly the water taken from the sea is kept under the sun for a long period of time leading to the evaporation of the water molecules and as a result the common salt is formed, which is left as remnants in this whole process. We mostly notice that water placed in a pot, disappear slowly. It is because of evaporation process

The process in which the water changes from liquid to gas or vapor form is known as "evaporation".

Difference between boiling point and evaporation

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 causes cooling.
4. It is relatively slow.	4. It is relatively fast.
5. It takes place only at the liquid surface.	5. It takes place throughout the liquid.
6. No formation of bubbles.	6. Bubbles are formed.

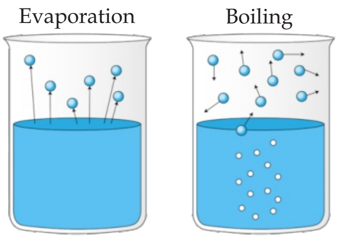


Fig 9.5
Difference between evaporation and boiling

Figure 9.5 demonstrates the difference between evaporation and boiling. The table 9.3; shows the freezing and boiling points of some important solvents.

Solvent	Freezing point (°C)	Boiling Point (°C)
Water	0.0	100
Acetic acid	17.0	118.1
Benzene	5.5	80.2
Chloroform	-63.5	61.2
Ethanol	-114.7	78.4

Table 9.3 Freezing and boiling points of different solvents

Evaporation causes cooling

When evaporation occurs, the molecules of water with greater Kinetic energy escape from its surface. So the molecules of water with lower Kinetic energy are left behind. This results in a decrease in the temperature of water. Hence, evaporation causes cooling.

You feel cold when come out directly under a heavy wind after taking bath. This is due to the reason

Fig 9.6
Evaporation causes cooling

that water molecules with greater Kinetic energy escape from your skin surface, while the molecules with lower Kinetic energy are left behind. This lowers the temperature of water at your skin and you feel cold.

Some liquids have low boiling point due to which they change from liquid to vapor very easily at ordinary temperature, these liquids are called 'volatile liquids'.

For Example methylated ether has low boiling point. If little amount of methylated spirit is taken on our hand it evaporates rapidly and our hand feel instantly cold. To change spirit from liquid to vapor it requires latent heat which is obtained from our hand thus our hand losses heat and we feel cool.

Water also causes the hand to become cold but it is not felt as spirit. The water has high boiling point then spirit so it evaporates slowly at the temperature of our hand and hence it does not cause the cooling effect.

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.

Self Assessment Questions:

Q9: Define evaporation and factors influencing evaporation process.

Q10: Differentiate between boiling and evaporation.

Q11: What is the freezing point of ethanol in Celsius scale?

9.5 THERMAL EXPANSION

Most solid materials expand on heating and squeeze on cooling because on heating the kinetic energy of their molecules increases. Therefore changes take place in shape, area and volume of the substances with the change in temperature. This is called "thermal expansion", defined as:

The expansion of substance on heating is called thermal expansion.

Examples of thermal expansion

- Expansion in railway tracks in summer; Fig 9.7(a).
- Expansion in electric wires in summer; Fig 9.7(b).
- Expansion in bridges in summer; Fig 9.7(c), etc.

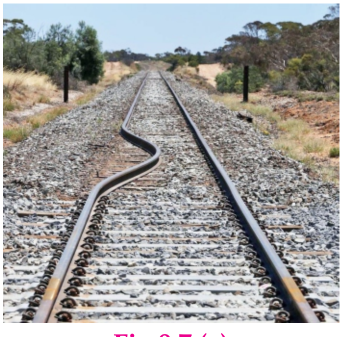


Fig 9.7 (a)
Thermal expansion

Fig 9.7 (b)
Thermal expansion

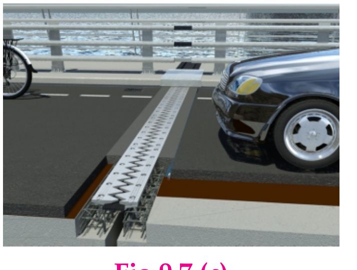
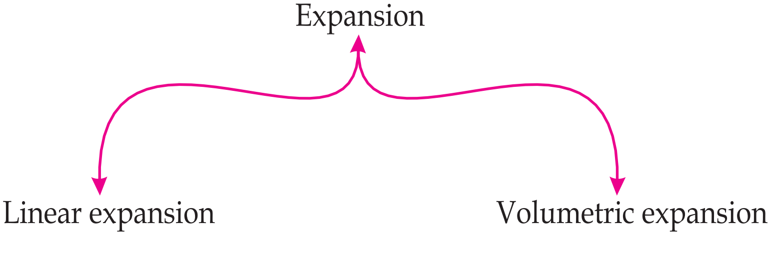


Fig 9.7 (c)
Thermal expansion

Expansion of Solid

The molecules of solid materials vibrate at their mean positions. So, when a solid is heated, its molecules vibrate with greater amplitudes due to increase in their kinetic energy. As a result the solid expands its length and volume.



Linear Expansion

Fig 9.8
Linear expansion

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

It is one dimensional expansion as it occurs only along the length of the object; Fig 9.8.

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

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

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

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

ΔL = (constant) $L \Delta T$ -----------------------(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

$$\Delta L = \alpha L \Delta T \text{---------------------(9.2)}$$

Do You Know!

The co-efficient of volume expansion of liquids greater than solids.

Volumetric Expansion

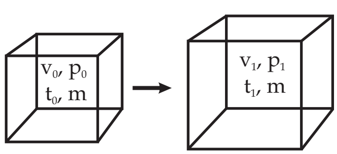


Fig 9.9
Volumetric expansion

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

It is three dimensional expansion as it occurs along the length, width and height of the object (Fig 9.9). 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.

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

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:

$$\Delta V = \beta V\ \Delta T \text{ .... (9.3)}$$

NOTE:

As linear expansion occurs in one dimension, where as volume expansion occurs in three dimensions. Hence, coefficient of volume expansion "β" is three times than coefficient of linear expansion "α":

Therefore:

$$\beta = 3\alpha \text{..........(9.4)}$$

Substance	Coefficient of expansion per degree centigrade
Aluminum	25×10^{-6}
Brass or Bronze	19×10^{-6}
Brick	9×10^{-6}
Copper	17×10^{-6}
Glass (Plate)	9×10^{-6}
Glass (Pyrex)	3×10^{-6}
Ice	51×10^{-6}
Iron or Steel	11×10^{-6}
Lead	29×10^{-6}
Quartz	0.4×10^{-6}
Silver	19×10^{-6}

Table 9.4

The coefficients of linear expansion of different substances.

Application and Consequences of thermal expansion

Thermal expansion of solids is useful in some situations of daily life and in some situations it creates problems:

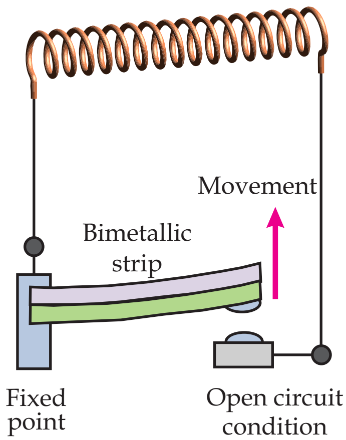


Fig 9.10
Bimetalic Thermostat

Applications

Bimetal thermostat

Bimetallic thermostat (Fig.9.10) 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.

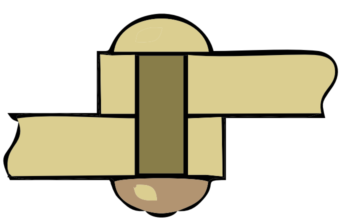


Fig 9.11 Rivet

Rivets

Rivets(Fig.9.11) 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(Fig.9.12) 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.

Fig 9.12
Wooden Wheel

i. Car Radiator Coolant

Engine coolant is used in car radiator in place of pure water because water has greater volume expansion it can expand enough to damage the engine or radiator.

ii. Mercury in Thermometer

Mercury expands on heating and contracts on cooling. It do not stick to the walls of thermometer. Therefore Mercury is placed in long sealed capillary tube in thermometer. Change in the temperature is measured by the position of mercury in capillary tube which has calibrated marks with °F, °C or K scale.

iv. Rail Tracks

The rail tracks are made up of metals and hence they expand in summer due to hot weather. Hence, small gaps are left at the joints of sections of tracks; Fig 9.13. This allows the tracks to expand safely. If these gaps are not left between the tracks, the tracks buckled and train would be de-tracked (derailed).

Fig 9.13
Gaps between Rail Tracks

Real and Apparent expansion of liquids

Consider a flask, filled with water up to level "a". The flask is placed on a burner, as shown below in; Fig 9.14.

Heat start to flow through the flask to water. So, the flask expand first. Due to expansion of flask, the level of water falls from point "a", level L_1 to point "b", level L_2. So, when water get heated, it start to expand from a point "b" beyond its original level.

Thus expansion of water appear from level "L_1" point "a" to level "L_3" point "c" is called "apparent expansion of water". But in real sense, the water on heating has expanded from level "L_2" point "b" to level "L_3" point "c" which is the "real expansion of water".

Real expansion = L_2 to L_3 i.e from point "b" to "c", as shown in; Fig 9.14.

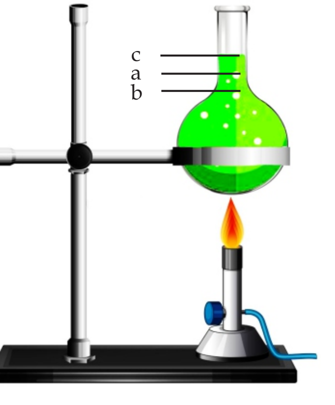


Fig 9.14
Real and Apparent expansion of liquids

Worked Example 3

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

Step 1: Write down known quantities and quantities to be found.

$$L = 15m$$
$$T = 30^{\circ}C$$
$$T' = 85^{\circ}C$$
$$\Delta T = T' - T = 85^{\circ}C - 30^{\circ}C = 55^{\circ}C$$
$$\alpha = 17 \times 10^{-6}\,{}^{\circ}C^{-1}$$
$$\Delta L = ?$$

Step 2: Write down formula and rearrange if necessary

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

Step 3: Put values in formula and calculate

$$\Delta L = 17 \times 10^{-6}\,{}^{\circ}C^{-1} \times 15m \times 55\,{}^{\circ}C$$
$$\Delta L = 0.014m$$

Hence, the change in length of the copper rod is 0.014m.

Self Assessment Questions:

Q12: What is the reason for expansion of solids on heating?

Q13: Explain two types of thermal expansion.

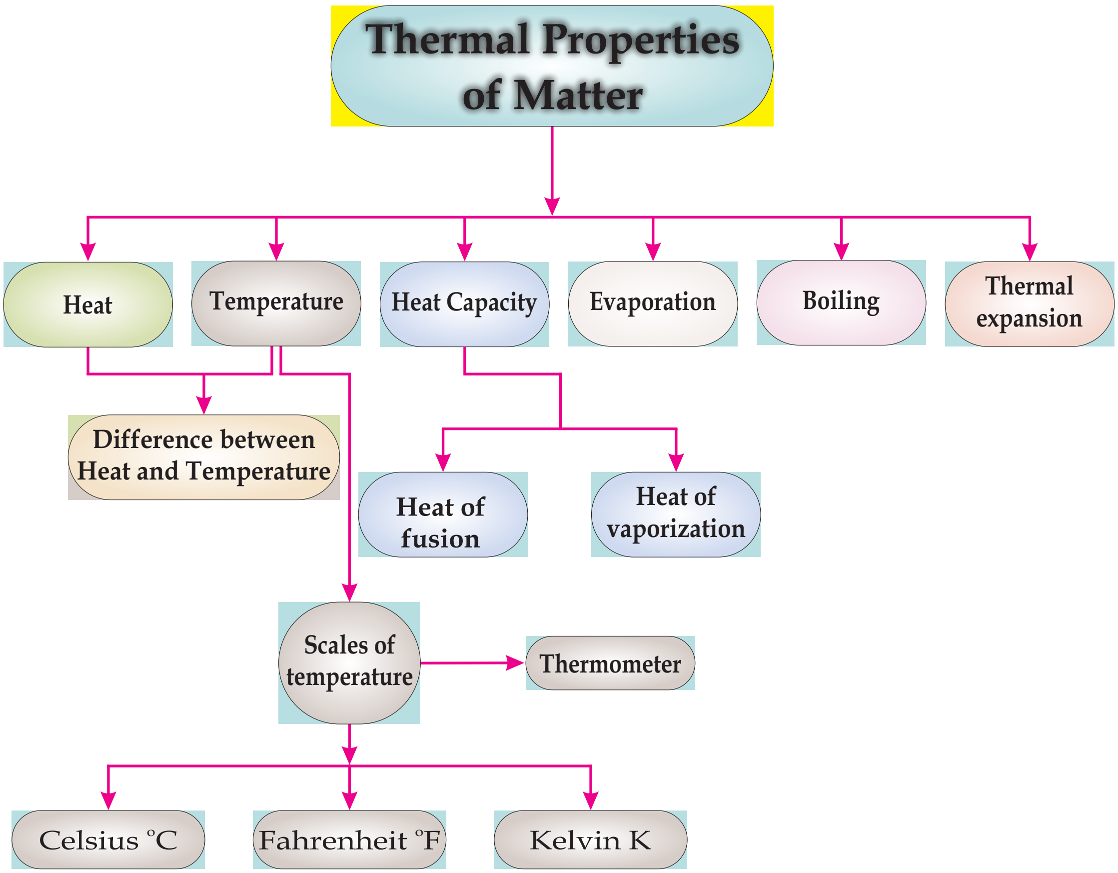
Q14: What is the relation between α and β?

SUMMARY

- Heat is the form of energy and its unit is Joule.
- Degree of hotness or coldness of a body is called as temperature.
- Temperature that determines the direction of transfer of thermal energy is called temperature..
- Three different scales, Celsius , Fahrenheit and are used for quantitative measurement of temperature.
- Temperature on Celsius scale is converted into Kelvin using $K = {}^{\circ}C + 273$.
- Temperature on Celsius scale is converted to Fahrenheit using: $F = 1.8^{\circ}C + 32$.
- Thermal energy transfer required per unit mass to raise the temperature by $1^{0}C$ or 1K is called specific heat capacity.
- The product of mass and specific heat capacity is called thermal capacity or heat capacity of an object.
- Thermal energy transfer required to change the state of a substance from solid to liquid without changing its temperature is called latent heat of fusion..
- Thermal energy transfer required to change the state of a substance from liquid into gas without changing its temperature is called heat of vaporization.
- The process in which liquid changes into gas without any external energy supply is called evaporation.
- Real expansion of water is the sum of apparent expansion of water and volume expansion of flask.

- Temperature, humidity, surface area of liquid, pressure, boiling point and moving air are the factors which affect the evaporation process of a liquid.
- Increase in length or size of a substance on heating is called thermal expansion.
- Increase in the length of a solid, when heated is called linear thermal expansion.
- Increase in volume of a solid, when heated is called volume thermal expansion.
- Volume thermal expansion of a solid depends upon increase in temperature, its original volume and properties of material.
- Increase in volume of a solid after heating is calculated by using $\Delta V = \beta V_0 \Delta T$.

CONCEPT MAP


Thermal Properties of Matter
Heat
Temperature
Heat Capacity
Evaporation
Boiling
Thermal expansion
Difference between Heat and Temperature
Heat of fusion
Heat of vaporization
Scales of temperature
Thermometer
Celsius °C
Fahrenheit °F
Kelvin K

End of Unit Questions

Section (A) Multiple Choice Questions (MCQs)

1. Heat is the form of __________
   a) Pressure b) Weight
   c) Energy d) All
2. Heat capacity is the product of mass and __________
   a) Boiling point b) Freezing point
   c) Energy d) Specific heat of material
3. The amount of heat needed to convert a substance from liquid to gas is called __________
   a) Heat of Vaporization b) Specific heat
   c. latent heat of fusion d) All
4. Thermal energy transfer required per unit mass to increase the temperature by 1^0C or 1 K is called ____
   a) Latent heat of Vaporization
   b) Specific heat capacity
   c) Latent heat of fusion
   d) Thermal capacity
5. A fixed temperature at which a pure liquid boils is called__________.
   a) melting point b) freezing point
   c) boiling point d) Both (a) and (b).
6. The melting point of ice at normal atmospheric pressure is __________.
   a) 0^0C b) 0K
   c) 100^0C d) Both (a) and (b)

7. Thermal energy transfer required to change a solid into liquid without changing its temperature is called __________.
   a) Latent heat of Fusion
   b) latent heat of vaporization
   c) latent heat of boiling
   d) specific heat capacity
8. Thermal energy transfer required to change a liquid into gas without changing its temperature is called
   a) latent heat of freezing
   b) latent heat of vaporization
   c) latent heat of boiling
   d) latent heat of melting
9. Evaporation can occur at __________
   a) freezing point   b) melting point
   c) boiling point   d) all temperatures
10. Rate of evaporation of a liquid can be increased by__________.
   a) increasing humidity
   b) decreasing temperature
   c) increasing its boiling point
   d) decreasing atmospheric pressure
11. Linear thermal expansion of a solid depends upon_______________.
   a) increase in temperature
   b) original length
   c) properties of material
   d) all of these

Section (B) Structured Questions

Heat and Temperature

1. a) Define Heat and write its SI unit.
   b) Why does heat flows from hot body to cold body?
   c) Convert 30° C into Kelvin and Fahrenheit Scale.
2. a) Explain three different scales of temperature along with their main uses.
   b) Differentiate between heat and temperature.
   c) Convert 212°F into Celsius and Kelvin.

Specific Heat Capacity

3. a) Explain specific heat capacity.
   b) How would you find the specific heat of a solid?
   c) How much heat is required to boil 3 kg water which is initially 10° C ?
4. a) Explain the effects of large specific heat of water with examples from our daily life.
   b) 2kg of copper requires 2050J of heat to raise its temperature through 10°C. Calculate the heat capacity of the sample.

Heat of fusion and Heat of vaporization

5. Define heat of fusion with the help of an experiment.
6. Differentiate between heat of fusion and heat of vaporization
7. Demonstrate heat of fusion and heat of vaporization by the help of heating ice graph.

Evaporation Process

8. Explain in detail, why evaporation causes cooling?
9. Differentiate between evaporation and boiling.
10. Write any four factors that influence the surface evaporation.
11. Write down the freezing and boiling points of following
    i) Acetic acid ii) Benzene
    iii) Chloroform iv) Water

Thermal Expansion

12. Why solids increases in size on heating ? Explain.
13. An iron block of volume $3m^3$ is heated, so that its temperature changes from 25°C to 100°C. If the coefficient of linear expansion of iron is 11×10^{-6} $^{\circ}C^{-1}$. What will be the new volume of the iron block after heating ?
14. a) Draw the diagram, showing real and apparent expansion of liquid. Label the diagram properly.
    b) Why small gaps are left at the joints of sections of railway tracks? Explain the phenomenon involved in it.