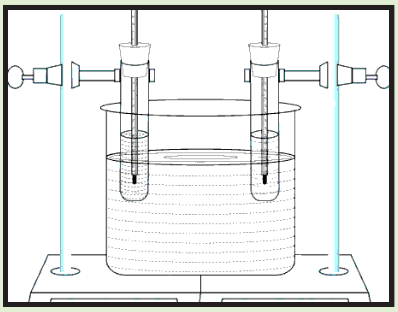
Chapter

1

Heat



Recall the experiments you did in Class 7 with the glass tumblers containing of cold water, lukewarm water and hot water. We understood that 'hot' and 'cold' are relative terms and that heat was a form of energy. We use the terms "Temperature and Heat" to describe these observations. These words, technically, have special meanings. In order to understand their meanings let us do some activities

Activity 1

Take a piece of wood and a piece of metal and keep them in a fridge or ice box. After 15 minutes, take them out and ask your friend to touch them.

- Which is colder? Why?

When we keep materials in a fridge, they become cold i.e., they lose heat energy. The iron and wooden pieces were kept in the fridge for the same period of time but we feel that the metal piece is colder than the wooden piece.

- What could be the reason for this difference in coldness?
- Does it have any relation to the transfer of heat energy from our body to the object?

When you touch the metal or wooden piece, you feel that they are cold. This means that heat energy is being transferred from your finger to the pieces. When you remove your finger, you don't get a feeling of 'coldness'. This means that when heat energy flows out of your body you get the feeling of 'coldness' and when heat energy enters your body you get a feeling of 'hotness'. You can test this by bringing your finger near the flame of a matchstick!

So, if you feel that the metal piece is 'colder' than the wooden piece, it must mean that more heat energy flows out of your body when you touch the metal piece as compared to the wooden piece. In other words, the 'degree of coldness' of the metal piece is greater than that of the wooden piece.

The conventional definition of temperature is "the degree of hotness or coldness".

We say that the metal piece is at a lower 'temperature' as compared to the wooden piece, when they are taken out of the fridge.

- Why does transfer of heat energy take place between objects ?
- Does transfer of heat take place in all situations?
- What are the conditions for transfer of heat energy?

Let us find out

Thermal equilibrium-heat and temperature

When two bodies are placed in thermal contact, heat energy will be transferred from the 'hotter' body to the 'colder' body. This transfer of heat energy continues till both bodies attain the same degree of hotness (or) coldness. At this stage, we say that the bodies have achieved 'thermal equilibrium'. Thus, the state of thermal equilibrium denotes a state of a body where it neither receives nor gives out heat energy.

If you are not feeling either hot or cold in your surroundings, then your body is said to be in thermal equilibrium with the surrounding atmosphere. Similarly, the furniture in the room is in thermal equilibrium with air in the room. So we can say that the furniture and the air in the room are at the same temperature.

Heat

- What is temperature?
- How can you differentiate it from heat?

Let us find out

Activity 2

Take two cups and fill one of them with hot water and another with cold water. Now take a laboratory thermometer, observe the mercury level in it and note it in your book. Keep it in hot water. Observe changes in the mercury level. Note the reading.

- What change did you notice in the reading of the thermometer? (mercury level)?

- Did the mercury level increase or decrease?

Now place the thermometer in cold water and observe changes in the mercury level. Did the level decrease or increase?

We know that bodies in contact achieve thermal equilibrium due to transfer of heat energy. When you kept the thermometer in hot water you observe that there is a rise in mercury level. This happens because heat got transferred from the hotter body (hot water) to the colder body (mercury in thermometer). Similarly in the second case you will observe that the mercury level comes down from its initial level because of the transfer of heat from mercury (hotter body) to water (colder body). Thus we define heat as follows:

"Heat is a form of energy in transit, that flows from a body at higher temperature to a body at lower temperature."

The steadiness of the mercury column of the thermometer indicates that flow of heat between the thermometer liquid (mercury) and water, has stopped. *Thermal equilibrium* has been attained between the water and thermometer liquid (mercury). The thermometer reading at thermal equilibrium gives the "temperature". Thus 'temperature' is a measure of thermal equilibrium.

If two different systems, A and B in thermal contact, are in thermal equilibrium individually with another system C(thermal contact with A and B), will the systems A and B be in thermal equilibrium with each other?

We know that if A is in thermal equilibrium with C, they both have the same temperature. Similarly, B and C have the same temperature. Thus A and B will have the same temperature and would therefore be in thermal equilibrium with each other. (A,B and C are in thermal contact).

The SI unit of heat is Joule (J) and CGS unit is calorie (cal).The amount of heat required to raise the temperature of 1gram of water by 1^0C is called calorie.

1cal = 4.186 Joules

The SI unit of temperature is Kelvin (K). It can also be expressed as degree Celsius (^{0}C).

0^0C = 273K

- How would you convert degree Celsius to Kelvin?

Temperature in Kelvin = 273+Temperature in degree Celsius

Add 273 to the value of temperature in degree Celsius to get the temperature on the Kelvin scale.

Note: Temperature measured on Kelvin scale is called absolute temperature.

Temperature and Kinetic energy

Activity 3

Take two bowls one with hot water and second with cold water. Gently sprinkle food colour on the surface of the water in both bowls .Observe the motion of the small grains of food colour.

- How do they move?
- Why do they move randomly?
- Why do the grains in hot water move more rapidly than the grains in cold water?

You will notice that the grains of food colour jiggle (move randomly). This happens because the molecules of water in both bowls are in random motion. We observe that the jiggling of the grains of food colour in hot water is more when compared to the jiggling in cold water.

We know that bodies possess kinetic energy when they are in motion.

As the speed of motion of particles (grain of food colour) in the bowls of water is different, we can say that they have different kinetic energies.Thus we conclude that the average kinetic energy of molecules / particles of a hotter body is greater than that of a colder body. So we can say that the temperature of a body is an indicator of the average kinetic energy of molecules of that body.

"The average kinetic energy of the molecules is directly proportional to the absolute temperature"

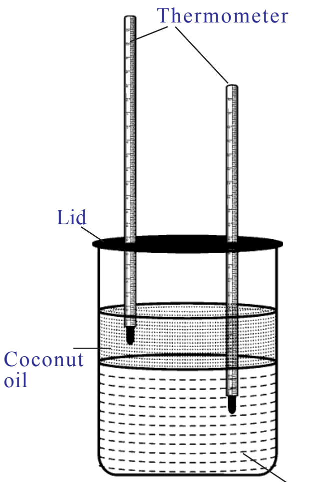


fig-1

Activity 4

Take water in a container and heat it to 60°C. Take a cylindrical transparent glass jar and fill half of it with this hot water. Very gently pour coconut oil over the surface of the water. (Take care that the water and oil do not mix). Put a lid with two holes on the top of the glass jar. Take two thermometers and insert them through the holes of the lid in such a way that bulb of the one thermometer lies only inside the water and other lies only inside the coconut oil as shown in figure 1.

Now observe the readings of the two thermometers. The reading of the thermometer kept in water decreases, while, at the same time, the reading of the thermometer kept in oil increases.

- Why does this happen?

Because the average kinetic energy of the molecules of oil increases, while the average kinetic energy of the molecules of water decreases. In other words, the temperature of oil increases while the temperature of water decreases.

- Can you say that the water loses energy?

From the above discussion it is clear that, water loses energy while oil gains energy; because of the temperature difference between the water and oil. Thus some heat energy flows from water to oil. This means, the kinetic energy of the molecules of the water decreases while the kinetic energy of the molecules of oil increases.

- Can you now differentiate between heat and temperature based on the discussion we made of the above activities?

With activities 2, 3 and 4 we can differentiate heat and temperature as follows:

Heat is the energy that flows from a hotter to a colder body. Temperature is a quantity that denotes which body is hotter and which is colder. So temperature determines *direction of heat (energy) flow*, whereas heat is the *energy* that flows.

Specific Heat

Activity 5

Take a large jar with water and heat it up to 80°C.Take two identical boiling test tubes with single-holed corks. One of them is filled with 50g of water and the other with 50g of oil, both at room temperature. Insert two thermometers through holes of the corks, one each into two test tubes. Now clamp them to a retort stand and place them in a jar of hot water as shown in figure 2.

Observe the readings of thermometers every three minutes .Note the readings in your notebook.

- In which test tube does the temperature rise quickly?

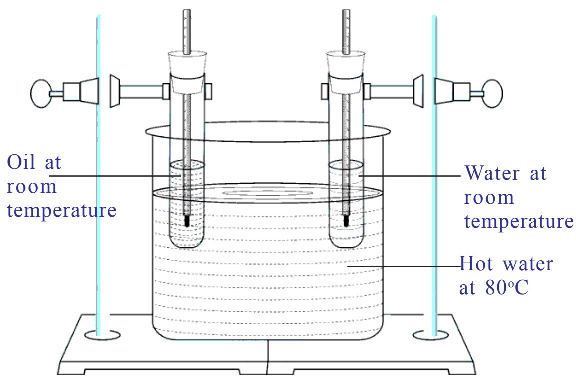


fig-2

- Are the amounts of heat given to the water and oil same? How can you assume this?

We believe that the same amount of heat is supplied to water and oil because they are kept in the jar of hot water for the same interval of time.

We observe that the rate of rise in temperature of the oil is higher than that of the rise in temperature of the water.

- Why does this happen?

We conclude that the rate of rise in temperature depends on the nature of the substance.

Activity 6

Take 250 ml of water in one beaker (a small beaker) and 1 litre of water in another beaker (a larger beaker), and note down their initial temperature using a thermometer (initial temperatures should be the same). Now heat both beakers till the temperature of water in the two beakers rises to 60 ^{0}C. Note down the heating times required to raise the temperature of water to 60 ^{0}C in each beaker.

- Which beaker needed more time?

You will notice that you need more time to raise the temperature of water in the larger beaker when compared to water in the small beaker. That means you need to supply more heat energy to water in a larger beaker (greater quantity of water) than water in a small beaker for same change in temperature.

For same change in temperature the amount of heat (Q) absorbed by a substance is directly proportional to its mass (m)

⇨ $Q \propto m$ (when ΔT is constant) ……………..(1)

Now take 1 litre of water in a beaker and heat it over a constant flame. Note the temperature changes (ΔT) for every two minutes.

- What do you notice?

You will notice that the change in temperature rise with time is constant, that means, for the same mass (m) of water the change in temperature is proportional to amount of heat (Q) absorbed by it.

⇨ $Q \propto \Delta T$ (when 'm' is constant) …………….(2)

From equation (1) and (2), we get

$Q \propto m\Delta T$ ⇨ $Q = mS\Delta T$

Where 's' is a constant for a given substance. This constant is called "specific heat" of the substance.

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

The specific heat of a substance is the amount of heat required to raise the temperature of unit mass of the substance by one unit.

- How much heat energy is required to raise the temperature of unit mass of substance by 1°C ?

CGS unit of specific heat is cal/g-°C and SI unit of it is J / kg - K

1 cal/g- °C = 1 kcal /kg-K

$= 4.2 \times 10^3$ J/kg-K

Substance	Specific heat	
	In cal/g-°C	In J/kg-K
Lead	0.031	130
Mercury	0.033	139
Brass	0.092	380
Zinc	0.093	391
Copper	0.095	399
Iron	0.115	483
Glass(flint)	0.12	504
Aluminum	0.21	882
Kerosene oil	0.50	2100
Ice	0.50	2100
Water	1	4180
Sea water	0.95	3900

We have seen that the rise in temperature depends on the nature of the substance; hence the specific heat of a substance depends on its nature. If the specific heat is high, the rate of rise (or fall) in temperature is low for same quantity of heat supplied. It gives us an idea of the degree of 'reluctance' of a substance to change its temperature.

- Why is the specific heat different for different substances?

Let us find out.

We know that the temperature of a body is directly proportional to the average kinetic energy of particles of the body.The molecules of the system (body or substance) have different forms of energies such as linear kinetic energy, rotational kinetic energy, vibrational energy and potential energy between molecules. The total energy of the system is called *internal energy* of the system. When we supply heat energy to the system the heat energy given to it will be shared by the molecules among the various forms of energy.

This sharing will vary from substance to substance. The rise in temperature is high for a substance, if the maximum share of heat energy is utilised for increasing its linear kinetic energy. This sharing of heat energy of the system also varies with temperature .That is why the specific heat is different for different substances.

If we know the specific heat of a substance, we can determine how much heat (Q) is needed to raise the temperature of a certain mass of the substance through certain degrees by using the equation $Q = mS\Delta T$

Applications of Specific heat capacity

1. The sun delivers a large amount of energy to the Earth daily. The water sources on Earth, particularly the oceans, absorb this energy for maintaining a relatively constant temperature. The oceans behave like heat "store houses" for the earth. They can absorb large amounts of heat at the equator without appreciable rise in temperature due to high specific heat of water.. Therefore, oceans moderate the surrounding temperature near the equator. Ocean water transports the heat away from the equator to areas closer to the north and south poles. This transported heat helps moderate the climates in parts of the Earth that are far from the equator.

2. Water melon brought out from the refrigerator retains its coolness for a longer time than any other fruit because it contains a large percentage of water. (water has greater specific heat).

3. A samosa appears to be cool outside but it is hot when we eat it because the curry inside the samosa contains ingredients with higher specific heats.

Method of mixtures

Activity - 7

Situation – 1: Take two beakers of the same size and pour 200 ml of water in each of them. Now heat the water in both beakers till they attain the same temperature. If you pour this water from these two beakers into a larger beaker, what temperature could you expect the mixture to be? Measure the temperature of the mixture.

- What do you observe?
- What could be the reason for the fact you observed?

Situation – 2: Now heat the water in one beaker to 90°C and the other to 60°C . Mix the water from these beakers in a larger beaker.

- What will the temperature of the mixture be?
- Measure temperature of the mixture. What did you notice?
- Can you give reasons for the change in temperature?

Situation – 3: Now take 100 ml of water at 90°C and 200 ml of water at 60°C and mix the two.

- What is the temperature of the mixture?
- What difference do you notice in the change of temperature?

Let us find out.

Let the initial temperatures of the samples of masses m_1 and m_2 be T_1 and T_2 (the higher of the two temperatures is called T_1, the lower is called T_2). Let T be the final temperature of the mixture.

The temperature of the mixture is lower than the temperature of the hotter sample but higher than the temperature of the colder sample. This means that the hot sample has lost heat, and the cold sample has gained heat.

The amount of heat lost by the hotter sample Q_1 is $m_1S(T_1 - T)$.

The amount of heat gained by the cooler sample Q_2 is $m_2S(T - T_2)$.

Since heat lost by the hotter sample is equal to the heat gained by the cooler sample (assuming no loss of heat) i.e $Q_1 = Q_2$

which can be written as $m_1S(T_1 - T) = m_2S(T - T_2)$

which can be simplified to $T = (m_1T_1 + m_2T_2)/(m_1 + m_2)$

You will notice the temperatures of mixtures in situation – 2 and situation – 3 are not equal.

- Can you guess the reason for this?
- Can we find temperature of the mixture using a thermometer?

Principle of method of mixtures

When two or more bodies at different temperatures are brought into thermal contact, then net heat lost by the hot bodies is equal to net heat gained by the cold bodies until they attain thermal equilibrium. (If heat is not lost by any other process)

Net heat lost= Net heat gain

This is known as principle of method of mixtures.

Determination of Specific heat of a solid

Lab Activity 1

Aim: To find the specific heat of given solid.

Material required: calorimeter, thermometer, stirrer, water, steam heater, wooden box and lead shots.

Procedure: Measure the mass of the calorimeter along with stirrer.

Mass of the calorimeter, m_1 = ...

Now fill one third of the volume of calorimeter with water. Measure its mass and its temperature.

Mass of the calorimeter plus water, m_2 = ...

Mass of the water, $m_2 – m_1$ =

Temperature of water in calorimeter, T_1 = ...

Note: Calorimeter and water are at same temperature.

Take a few lead shots and place them in hot water or steam heater. Heat them upto a temperature 100°C. Let this temperature be T_2.

Transfer the hot lead shots quickly into the calorimeter (with minimum loss of heat). You will notice that the mixture settles to a certain temperature after some time.

Measure this temperature T_3 and mass of the calorimeter along with contents (water and lead shots).

Mass of the calorimeter along with contents, m_3 = ...

Mass of the lead shots, $m_3 - m_2$ = ...

Since there is no loss of heat to surroundings, we can assume that the entire heat lost by the solid (lead shots) is transferred to the calorimeter and water to reach the final temperature.

Let the specific heats of the calorimeter, lead shots and water be S_c, S_l and S_w respectively. According to the method of mixtures, we know;

Heat lost by the solid = Heat gain by the calorimeter + Heat gain by the water

$$(m_3 - m_2)\, S_l(T_2 - T_3) = m_1\, S_c(T_3 - T_1) + (m_2 - m_1)\, S_w(T_3 - T_1)$$

$$S_l = \frac{[m_1 S_c + (m_2 - m_1) S_w]\,(T_3 - T_1)}{(m_3 - m_2)(T_2 - T_3)}$$

Knowing the specific heats of calorimeter and water, we can calculate the specific heat of the solid (lead shots).

Evaporation

When wet clothes dry, you will notice that water in the clothes disappears.

- Where does the water go?

Similarly, when the floor of a room is washed with water, the water on the floor disappears within minutes and the floor becomes dry.

- Why does water on the floor disappear after some time?

Let us see.

Activity 8

Take a few drops of spirit on your palm using a droper.

- Why does your skin become colder?

Take a few drops of spirit (say 1 ml) in two petri dishes (a shallow glass or plastic cylindrical lidded dish used in the laboratory) separately. Keep one of the dishes containing spirit under a ceiling fan and switch on the fan . Keep another dish with its lid closed. Observe the quantity of spirit in both dishes after 5 minutes.

- What do you notice?

You will notice that spirit in the dish that is kept under the ceiling fan disappears, where as you will find some spirit left in the dish that is kept in the lidded dish.

- What could be the reason for this change?

To answer the above questions, you need to understand the process of evaporation. The molecules of spirit that is kept in petri dish, continuously move with random speeds in various directions. As a result these molecules collide with other molecules.

During the collision they transfer energy to other molecules. When the molecules inside the liquid collide with molecules at the surface, the molecules at the surface acquire energy and may fly off from the surface.

Some of these escaping molecules may be directed back into liquid when they collide with the particles of air. If the number of escaping molecules is greater than the number returned, then the number of molecules in the liquid decreases. Thus when a liquid is exposed to air, the molecules at the surface keep on escaping from the surface till the entire liquid disappears into air. This process is called *evaporation.*

During the process of evaporation, the energy of the molecules inside the liquid decreases and they slow down. They transfer this energy to escaping molecules during the collisions.

"The process of escaping of molecules from the surface of a liquid at any temperature is called evaporation"

Let us determine the reason for faster evaporation of spirit kept under the fan. If air is blown over the liquid surface in an open pan or perti dish, the number of molecules returned is reduced to a large extent. This is because any molecule escaping from the surface is blown away from the vicinity of the liquid. This increases the rate of evaporation. This is the reason why the spirit in petri dish, that is kept under ceiling fan evaporates quickly when compared to that kept closed. You will notice that clothes dry faster when a wind is blowing.

It means that the temperature of a system falls during evaporation.

Evaporation is a surface phenomenon.

We can also define evaporation as "the change of phase from liquid to gas that occurs at the surface of the liquid". It is a cooling process, because the particles of liquid continuously give up their energy to the particles that are escaping from the surface.

Let us look at the following example.

- Why do we sweat while doing work?

When we do work, we spend our energy mostly in the form of heat energy from the body. As a result the temperature of the skin becomes higher and the water in the sweat glands starts evaporating. This evaporation cools the body.

Rate of evaporation of a liquid depends on its surface area, temperature and amount of vapour already present in the surrounding air.

- Does the reverse process of evaporation take place?
- When and how does it take place?

Let us find out.

Condensation

Activity 9

Place a glass tumbler on the table. Pour cold water up to half its height.

- What do you observe on the outer surface of the tumbler?
- Why do water droplets form on the outer side of the glass?

We know that the temperature of surrounding air is higher than the temperature of the cold water.

Air contains water molecules in the form of vapour.

When the molecules of water in air, during their motion, strike the surface of the glass tumbler which is cool; they lose their kinetic energy which lowers their temperature and they get converted into droplets.

The energy lost by the water molecules in air is gained by the molecules of the glass tumbler. Hence the average kinetic energy of the glass molecules increases. In turn the energy is transferred from glass molecules to the water molecules in the glass.

In this way, the average kinetic energy of water molecules in the tumbler rises. Hence we can conclude that the temperature of the water in glass increases. This process is called '*condensation*'. It is a warming process.

Condensation can also be defined as "the phase change from gas to liquid".

Let us examine a situation:

You feel warm after you finish your bath under the shower on a hot day. In the bathroom, the number of vapour molecules per unit volume is greater than the number of vapour molecules per unit volume outside the bathroom. When you try to dry yourself with a towel, the vapour molecules surrounding you condense on your skin and this condensation makes you feel warm.

Humidity

Some vapour is always present in air. This vapour may come from evaporation of water from the surfaces of rivers, lakes, ponds and from the drying of wet clothes, sweat and so on. The presence of vapour molecules in air is said to make the atmosphere humid. The amount of water vapour present in air is called *humidity*.

Dew and Fog

In early morning, during winter, you might have noticed that water droplets form on window panes, flowers, grass etc.

- How are these water droplets formed?

Let us find out.

During winter nights, the atmospheric temperature goes down. The surfaces of window-panes, flower, grass etc, become still colder. The air near them becomes saturated with vapour and condensation begins. The water droplets condensed on such surfaces are known as *dew*.

If the temperature falls further, the whole atmosphere in that region contains a large amount of vapour. So the water molecules present in vapour condense on the dust particles in air and form small droplets of water. These droplets keep floating in the air and form a thick mist which restricts visibility. This thick mist is called *fog*.

- Does the temperature of the water rise continuously if heat is supplied to it continuously?

Boiling

Activity 10

Take a beaker of water, keep it on the burner .Note the readings of thermometer for every 2 minutes.

- Did you see any rise or fall in the level of the surface of the water, in the beaker? Why?
- Does the temperature rise continuously?
- When does the rise in temperature of water stop?

You will notice that, the temperature of the water rises continuously, till it reaches 100°C. Beyond 100°C no further rise of temperature of water is seen. At 100 ^{0}C, though supply of heat continues, the temperature does not increase further. We also observe a lot of bubbling at the surface of water at 100^{0}C. This is what we call *boiling* of water

- Why does this happen?

Water is a solution, there are many impurities dissolved in it including some gases. When water or any liquid is heated, the solubility of gases it contains reduces. As a result, bubbles of gas are formed in the liquid (at the bottom and on walls of the vessel). Evaporation of water molecules from the surrounding causes these bubbles, to become filled with saturated vapour, whose pressure increases as we increase the temperature of the liquid by heating. At a certain temperature, the pressure of the saturated vapour inside the bubbles becomes equal to the pressure exerted on the bubbles from the outside (this pressure is equal to the atmospheric pressure plus the pressure of the layer of water above the bubble). As a result, these bubbles rise rapidly to the surface and collapse at the surface releasing vapour present in bubbles into air at the surface. This process of converting the liquid into vapour (gas) continues as long as you supply heat. This appears as boiling of water for us.

"Boiling is a process in which the liquid phase changes to gaseous phase at a constant temperature at a given pressure." This temperature is called boiling point of the liquid.

- Are the processes of evaporation and boiling the same?

As you have seen in activity – 8 and 10, the boiling of a liquid differs essentially from evaporation. Note that evaporation takes place at any temperature, while boiling occurs at a definite temperature called the boiling point. Let us recall your observation in activity – 10 that, when boiling process starts, the temperature of the liquid cannot be raised further, no matter how long we continue to heat it. The temperature remains constant at the boiling point until all of the liquid has boiled away.

In activity – 10, you have noticed that, while heating the water in the beaker, the temperature of water rises continuously till it reaches 100 ^{0}C. But once boiling got started, no further rise of temperature is seen though supply of heat continues.

- Where does the heat energy supplied go?

This heat energy is used to change the state of water from liquid to vapour (gas). This is called *latent heat of vapourization.*

The heat energy required to change 1gm of liquid to gas at constant temperature is called latent heat of vapourization.

Consider a liquid of mass 'm' that requires heat energy of 'Q' calories to change from its state from liquid phase to gas phase. Then ***Latent heat of vaporization*** is **Q/m**. Latent heat of vaporization is denoted by '**L**'.

CGS unit of latent heat of vaporization is cal/gm and SI unit is J/kg.

The boiling point of water at constant atmospheric pressure (1atm) is 100°C or 373K and Latent heat of vaporization of water is 540 cal/gm.

Let us now consider the transformation of ice into water.

- Why does an ice cube get converted into water?

Melting

Activity 11

Take small ice cubes in a beaker. Insert the thermometer into ice cubes in the beaker. Observe the reading of the thermometer. Now start heating the beaker keeping it on a burner. Observe changes in the thermometer reading every 1 minute till the ice completely melts and gets converted into water.

- What changes do you notice in the reading of thermometer as time passes by?
- Does the temperature of the ice change during the process of melting?

You will observe that the temperature of ice at the beginning is equal to or below 0^{o}C. If the temperature of ice is below 0^{o}C, it goes on changing till it reaches 0^{0}C. When ice starts melting, you will notice no change in temperature though you are supplying heat continuously.

- Why does this happen?

The heat energy supplied to the ice increases the internal energy of the molecules of the ice. This increase in internal energy of molecules weakens the bonds as well as breaks the bonds between the molecules (H_2O) in the ice. That is why the ice (in solid phase) becomes water (in liquid phase).This process takes place at a constant temperature 0°C or 273K. This temperature is called *melting point.* This process of converting solid into a liquid is called "***Melting***".

The temperature of the ice does not change during melting because the heat energy given to the ice is totally utilized in breaking the bonds between the water molecules.

The process in which solid phase changes to liquid phase at a constant temperature is called melting. This constant temperature is called melting point.

- How much heat energy is required to convert 1gm of ice to liquid?

The Heat energy required to convert 1gm of solid completely into liquid at a constant temperature is called *Latent heat of fusion.*

Consider a solid of mass m. Let heat energy Q be required to change it from the solid phase to liquid phase. The heat required to change 1gm of solid into liquid is Q/m.

Latent heat of fusion L = Q/m. The value of Latent heat of fusion of ice is 80cal/gm

Freezing

You might have observed coconut oil and ghee getting converted from liquid state to solid state during winter season.

- What could be the reason for this change?
- What happens to water kept in a refrigerator?
- How does it get converted from liquid phase to solid phase?

We know that the water that is kept in a refrigerator converts to solid ice. You know that initial temperature of water is more compared to the temperature of ice. It means that during the process of conversion from liquid to solid, the internal energy of the water decreases so that it becomes a solid ice. This process is called *freezing.*

"The process in which the a substance in liquid phase changes to solid phase by losing some of its energy is called *freezing*."

Freezing of water takes place at 0°C temperature and at one atmospheric pressure.

- Are the volumes of water and ice formed with same amount of water equal? Why?

Let us find out.

Activity 12

Take small glass bottle with a tight lid .Fill it with water completely without any gaps and fix the lid tightly in such a way that water does not come out of it. Put the bottle into the deep freezer of a refrigerator for a few hours. Take it out from the fridge and you will observe that the glass bottle breaks.

- Why did the glass bottle break?

We know that the volume of the water poured into the glass bottle is equal to the volume of the bottle. When the water freezes to ice, the bottle is broken .This means that the volume of the ice should be greater than the volume of the water filled in the bottle.

In short, we say that water 'expands' (increases in volume) on freezing!

Thus the density of ice is less than that of water and this explains why ice floats on water.

Key words

Temperature, Heat, Thermal equilibrium, Specific heat, Evaporation, Condensation, Humidity, Dew, Fog, Boiling, Latent heat of vaporization, Melting, Freezing.

What we have learnt

- If two different systems, A and B, (thermal contact) are in thermal equilibrium individually with another system C, then the systems A and B are in thermal equilibrium with each other.
- The average kinetic energy of the molecules is directly proportional to the absolute temperature.
- The specific heat of a substance is the amount of heat required to raise the temperature of unit mass of the substance by one unit.

  $S=Q/m\Delta t$
- The process of escaping of molecules from the surface of a liquid at any temperature is called evaporation and it is a cooling process.
- Condensation is the reverse process of evaporation.
- Boiling is the process in which the liquid phase changes to gaseous phase at a constant temperature and constant pressure.

Improve your learning

1. What would be the final temperature of a mixture of 50g of water at 20°C temperature and 50g of water at 40°C temperature? (AS1)
2. Explain why dogs pant during hot summer days using the concept of evaporation? (AS1)
3. Why do we get dew on the surface of a cold soft drink bottle kept in open air? (AS1)
4. Write the differences between evaporation and boiling? (AS1)

5. Does the surrounding air become warm or cool when vapour phase of H_2O condenses? Explain.
6. Answer these. (AS1)
   a) How much energy is transferred when 1gm of boiling water at 100°C condenses to water at 100°C?
   b) How much energy is transferred when 1gm of boiling water at 100°C cools to water at 0°C?
   c) How much energy is released or absorbed when 1gm of water at 0°C freezes to ice at 0°C?
   d) How much energy is released or absorbed when 1gm of steam at 100°C turns to ice at 0°C?
7. Explain the procedure of finding specific heat of solid experimentally. (AS1)
8. Covert 20°C into Kelvin scale.(AS1)
9. Your friend is asked to differentiate between evaporation and boiling. What questions could you ask to make him to know the differences between evaporation and boiling? (AS2)
10. What happens to the water when wet clothes dry? (AS3)
11. Equal amounts of water are kept in a cap and in a dish. Which will evaporate faster? Why? (AS3)
12. Suggest an experiment to prove that the rate of evaporation of a liquid depends on its surface area and vapour already present in surrounding air. (AS3)
13. Place a Pyrex funnel with its mouth-down in a sauce pan full of water, in such a way that the stem tube of the funnel is above the water or pointing upward into air. Rest the edge of the bottom portion of the funnel on a nail or on a coin so that water can get under it. Place the pan on a stove and heat it till it begins to boil. Where do the bubbles form first? Why? Can you explain how a geyser works using this experience. (AS4)
14. Collect information about working of geyser and prepare a report. (AS4)
15. Assume that heat is being supplied continuously to 2kg of ice at -5°C. You know that ice melts at 0°C and boils at 100°C. Continue the heating till it starts boiling. Note the temperature every minute. Draw a graph between temperature and time using the values you get. What do you understand from the graph. Write the conclusions. (AS5)
16. How do you appreciate the role of the higher specific heat of water in stabilising atmospheric temperature during winter and summer seasons? (AS6)
17. Suppose that 1*l* of water is heated for a certain time to rise and its temperature by 2°C. If 2*l* of water is heated for the same time, by how much will its temperature rise? (AS7)
18. What role does specific heat play in keeping a watermelon cool for a long time after removing it from a fridge on a hot day? (AS7)
19. If you are chilly outside the shower stall, why do you feel warm after the bath if you stay in the bathroom? (AS7)

Fill in the blanks

1. The SI unit of specific heat is_____________
2. _____________ flows from a body at higher temperature to a body at lower temperature.
3. _____________ is a cooling process.
4. An object 'A' at 10 ^{0}C and another object 'B' at 10K are kept in contact, then heat will flow from _________ to ___________.
5. The latent heat of fusion of ice is _____________.
6. Temperature of a body is directly proportional to _____________.
7. According to the principle of method of mixtures, the net heat lost by the hot bodies is equal to _____________ by the cold bodies.
8. The sultryness in summer days is due to _____________.
9. ____________ is used as a coolant.
10. Ice floats on water because _____________.

Multiple choice questions

1. Which of the following is a warming process [ ]
   a) Evaporation b) condensation c) boiling d) all the above
2. Melting is a process in which solid phase changes to [ ]
   a) liquid phase b) liquid phase at constant temperature
   c) gaseous phase d) any phase
3. Three bodies A, B and C are in thermal equilibrium. The temperature of B is 45^{o}C. then the temperature of C is ___________ [ ]
   a) 45^{o}C b) 50^{o}C c) 40^{o}C d) any temperature
4. The temperature of a steel rod is 330K. Its temperature in ^{o}C is ________ [ ]
   a) 55^{o}C b) 57^{o}C c) 59^{o}C d) 53^{o}C
5. Specific heat S = [ ]
   a) $Q/\Delta t$ b) $Q\Delta t$ c) $Q/m\Delta t$ d) $m\Delta t/Q$
6. Boiling point of water at normal atmospheric pressure is _________ [ ]
   a) 0^{o}C b) 100^{o}C c) 110^{o}C d) -5^{o}C
7. When ice melts, its temperature [ ]
   a) remains constant b) increases
   c) decreases d) cannot say