Chapter 7

Heat

Recall the experiments you did in Class 7 with the glasses 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 word “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 colder than the wooden piece.

- What could be the reason for this change in coldness?
- Does it has any relation to the transfer of heat energy from our body to 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 '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 transfer of heat energy takes place between systems?
- Does transfer of heat happen in all situation?
- What are the conditions for occurrence of transfer of heat energy?

Let us find

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 is continued till both bodies attain 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 hotness or coldness 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 same temperature.

Heat

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

Let us find

Activity 2

Take two cups and filled 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 note book. Keep it in hot water. Observe changes in mercury level. Note the reading.

- What change did you notice in mercury level?

- Did mercury level increase or decrease?

Now place the thermometer in cold water and observe changes in mercury level.

Did mercury level decrease or increase?

We know that bodies in contact achieve thermal equilibrium due to transfer of heat energy. When you kept thermometer in hot water you will observe that there is raise in mercury level. This happens because heat has transferred from hotter body (hot water) to cold body (mercury in thermometer). Similarly I second case you will observe that mercury level comes down from its 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 transist that is transferred from body at higher temperature to 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 state 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 increase 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 Celsius

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

Note: Temperature measured in 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 the 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 the motion.

As the speed of motion particles (grain of food) in the water of both bowls is different, we can say that they have different kinetic energies.Thus we conclude that the average kinetic energy of molecules / particles of the hotter body is larger 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 molecule of that body.

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

Activity 4

Take water in a jar and heat it to 60°C. Take a cylindrical transparent glass jar and fill half of it with the 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 holes of the lid in such a way that bulb of the one thermometer lies inside the water and other lies inside the coconut oil as shown in the figure 1.

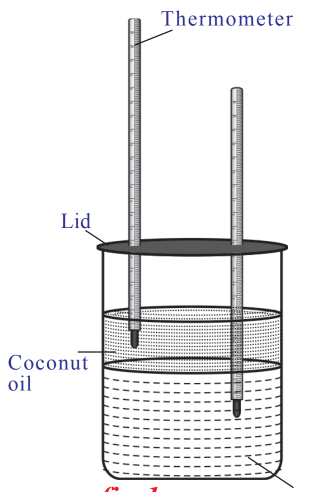

fig-1:

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 with discussion we have in above activities?

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

Heat is the energy that is transferred from hotter to colder body. Temperature is a quantity that decides which body is hotter and which is colder. So temperature decides direction of heat (energy) flow, whereas heat is the energy itself that flow.

SPECIFIC HEAT

Activity 5

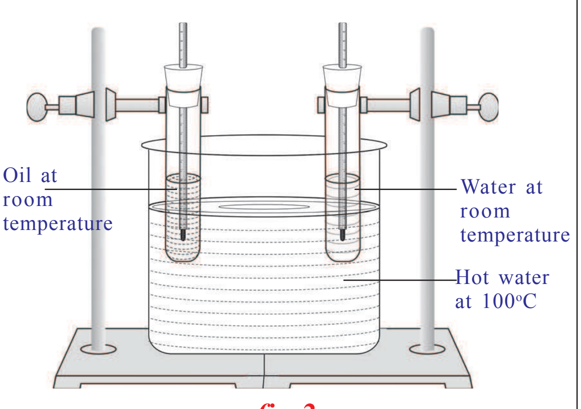

fig-2:

Take a large jar with water and heat it up to 100°.Take two identical boiling test tubes with single-holed corks and fill them, one with 50gm of water and the other with 50gm of oil. Insert two thermometers through holes of the corks, one each in two test tubes. Now clamp them to a retort stand and place them in the jar of hot water as shown in the figure 2.

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

- In which material does the temperature rise quickly?
- 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 kept in the water of same temperature for the same interval of time.

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

- Why does this happen?

We conclude that the *rise in temperature depends on the nature of the material.*

Activity 6

Take 250 ml of water in one beaker (a small beaker) and 1 litre of water in another beaker (a large beaker), and note down their initial temperature using a thermometer (initial temperatures of them should be equal). Now heat both beakers till their temperature of water in two beakers rises by 90 ^{0}C from their initial temperatures. Note down the heating times required to rise temperature of water by 90 ^{0}C in each beaker.

- When do you need more time?

You will notice that you need more time to rise temperature by 90 ^{0}C for water in larger beaker when compared to water in small beaker that means you need to supply more heat energy for water in larger beaker than water in small beaker for same change in temperature.

For same change in temperature the amount of heat absorbed by a body is directrly 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. Note the temperature changes (ΔT) for every two minutes.

- What do you notice?

You will notice that the change in temperature rise with time, 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

$Q \propto m\Delta T$ (as $Q = ms\Delta T$)

Where 's' is a constant for a given material. This constant is called "Specific heat" of substance.

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

Substance	Specific heat	
	In cal/g-0C	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

The specific heat of a material is the amount of heat required to rise the temperature of unit mass of the material by a unit.

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

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

1 cal/g- = 1 kcal /kg-K
= 4.2 x J/kg-K
= 4.2 KJ/kg-K (Here K=10^3)

We have seen that the rise in temperature depends on nature of the material; hence the specific heat of the material depends on its nature. If the specific heat is high the rise in temperature is low. It gives us an idea of degree of 'reluctant' of a material to rise in temperature.

- Why is the specific heat different for different materials?

Let us find.

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

This sharing will vary from material to material. The rise in temperature is high for a material, if the maximum share of heat energy is spent in increasing its linear kinetic energy. This sharing of heat energy of the system (body or material) also varies with temperature .That is why the specific heat is different for different material.

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 substance to a certain level 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 masses 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 much rise in temperature due to high specific heat capacity 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 large percentage of water. (water has greater specific heat).

3. The samosa seems to be cool but it is hot when we eat it because the curry inside 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 reach to the same temperature. If you pour the water from these two beakers into a larger beaker, what do you expect the temperature of the mixture to be? Measure the temperature of mixture.

- What do you notice?
- What could be the reason for the fact you noticed?

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

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

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

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

Let us find.

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 first sample is equal to the heat gained by the other sample 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 mixture using a thermometer?

Principle of method of mixtures:

When two bodies or more bodies at different temperatures are brought into thermal contact, then net heat is lost by the hot bodies is equal to net heat gain 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 solid:

Lab Activity 1

Aim: To find the specific heat of given solid.

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

Procedure: The mass of the calorimeter along with stirrer is determine by common balance. One third of the volume of the calorimeter is filled with water and its mass is measured as .

The calorimeter is placed in the wooden box and temperature is measured using thermometer.

Lead pieces is placed in steam heater they are heated to a temperature is quickly transferred in to calorimeter, with minimum loss of heat. Contents in the calorimeter are stirred well and then resultant temperature is noted .

Since there is no loss of heat to surroundings, we can assume that the entire heat lost by the solid is transferred to the calorimeter and water to reach the final temperature. The mass of the calorimeter along with contents is measured as m_3.If , and are the specific heats of the calorimeter, solid pieces and water respectively.

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

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

$$S_s = \frac{[m_1S_c+(m_2-m_1)S_w]\,(T_3-T_1)}{(m_3-m_1)(T_2-T_3)}$$

Knowing the specific heat capacities of we can calculate the specific heat of the solid pieces.

EVAPORATION

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

- Where does the water go?

Similarly, when floor of the room is washed with water, the water on the floor dries within minutes.

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

Let us see.

Activity 8

Take a small amount of spirit in a cup (make sure there is no flame near it). Pour a few drops on your palm.

- 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 the 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 kept under the ceiling fan disappear. Where as you will find some spirit in the dish that kept in closed room?

- What could be the reason for this change?

To answer above questions you need to understand the process of evaporation. Let us consider second situation activity – 8. The molecules of spirit that kept in petri dish continuously move with random speeds in various directions. As a result these molecules collide with others molecules.

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

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

During the process of evaporation the energy of the molecules inside the liquid slows 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 see the reason for faster evaporation of spirit under the fan. If air is blown over the liquid surface in an open pan the number of returning molecules 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 for the spirit in petri dish that kept under ceiling fan evaporates quickly when compared to that kept in closed room. You will notice clothes dry faster when a wind is blowing.

It means that the temperature of the 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 a work?

When we work our bodies produce heat. 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.

CONDENSATION

Activity 9

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

- What do you observe?
- 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 glass tumbler which is cool; then the molecules of air lose their kinetic energy which leads to lower the temperature and they get converted into droplets.

The energy lost by the water molecule in air will be given to the molecules of 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 warming process.

"Condensation" can also be defined as the phase change from gas to liquid that at the surface of the liquid".

Let us examine a situation:

You feel warm after you finish your bath under the shower on hot day. In the bathroom, the number of vapour molecules per unit volume is greater than number of vapour molecules per unit volume outside the room. 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 vapour molecules in air is humid. The amount of water vapour present in air is called the *humidity* of air.

DEW AND FOG

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

- How these water droplets are formed?

Let us find.

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

If the temperature falls further, the whole atmosphere in that region contain maximum 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 on 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 continuously?

BOILING

Activity 10

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

- Did you see any rise or fall in level of the surface of the water, taken in a transparent glass 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. At 100°C no further rise of temperature of water is seen. At 100 ^{0}C, though supply heat continues we can observe a lot of bubbling at the surface of water at this 100°C temperature. 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 (on the bottom and walls of the vessel). Evaporation of water molecules from surrounding liquid occurs in to these bubbles, and they become filled with saturated vapour, whose pressure increase as we increase 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 of these bubbles rise rapidly to the surface and collaps 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.

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

- Are the process 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, no matter how long we continue to heat it. The temperature remains 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 was started, no further rise temperature seen though supply of heat continues.

- Where does the supplied heat energy 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 is required to change 1gr of liquid to gas at constant temperature is called latent heat of vapourization.

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

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

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.

- Why does the 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 thermometer. Now start heating the beaker keeping on a burner. Observe changes in the reading of thermometer for every 1 minute till the ice completely melts and gets converted into water.

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

You will observe that the temperature at beginning is below $0\,^0$Cand it goes on changing till it reaches 0^0C. 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 temperature is called melting point.

- How much 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 which requires heat energy Q to change 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, ghee converts 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 it converts from liquid phase to solid phase?

We know that the water that is kept in a refrigerator converts in to solid ice. You know that 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 losingsome energy from it 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.

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 should not come out of it. Put the bottle into the deep freezer for a few hours. Take it out from the fridge and you will observe the glass bottle after a few hours.

- What do you observe?
- 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 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, 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 capacity of a material is the amount of heat required to rise the temperature of unit mass of the material by or unit.

  $S=Q/m\Delta t$
- Principle is the process of escaping of molecules from the surface of a liquid at any temperature 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.

Improve your learning

1. What would be the final temperature of a mixture of 50g of water at 200C temperature and 50g of water at 400C 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 H2O condenses? Explain. 6. Answer these. (AS1)
   a) How much energy is transferred when 1gm of boiling water at 1000C condenses to water 1000C?
   b) How much energy is transferred when 1gm of boiling water at 1000C cools twice water 00C?
   c) How much energy is transferred when 1gm of water at 00C freezes to ice at 00C?
   d) How much energy is transferred when 1gm of steam at 1000C turns to ice 00C?
7. Explain the procedure of finding specific heat of solid experimentally. (AS1)
8. Covert 200C into Kelvin scale.(AS1)

9. Your friend is notable to differentiate between evaporation and boiling. What questions do you ask to make him 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 rate of evaporation of 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 with 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 above experience. (AS4)
14. Collect the information about working of geyser and prepare a report. (AS4)
15. How do you appreciate the role higher specific capacity value of water in stabilising atmospheric temperature during winter and summer seasons? (AS6)
16. Suppose that to 1l of water is heated for a certain time to rise and its temperature by 20C. If 2l of water for the same time, by how much will its temperature rises? (AS7)
17. What role does specific heat capacity play in a watermelon to keep it cool for long time after removing it from a fridge on a hot day? (AS7)
18. If you are chilly outside the shower stall, why do you feel warm after the bath if you stay in bathroom? (AS7)
19. Assume that heat is being supplied continuously to the ice at -50C. You know that ice melts at 00C and boils at 1000C. Continue the heating till it starts boiling. Note the temperature for every minute. Draw a graph between temperature and heat using the values you get. What do you understand from the graph. Write the conclusions. (AS5)

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 suffocation 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 450C. then the temperature of C is ____________ [ ]

   a) 450C b) 500C c) 400C d) any temperature

4. The temperature of a steel rod is 330K. Its temperature in 0C is _________ [ ]

   a) 550C b) 570C c) 590C d) 530C

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) 00C b) 1000C c) 1100C d) -50C

7. When ice melts, its temperature [ ]

   a) remains constant b) increases c) decreases d) cannot say