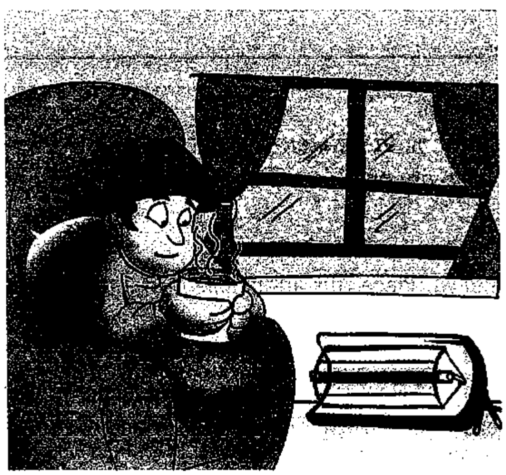
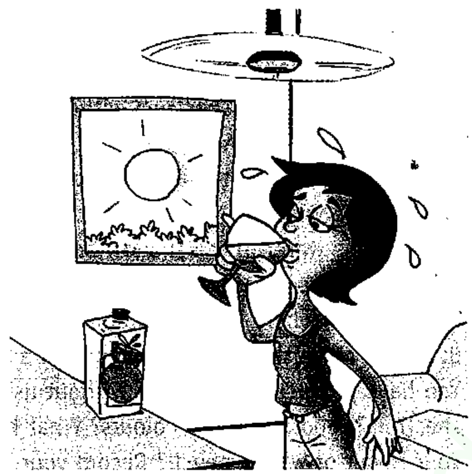
Heat

3

LEARNING OUTCOMES

- Heat: form of energy
- Effects of heat
- Specific heat capacity
- Heat capacity
- Change of state
- Latent heat





FACT FILE

The body temperature of cold-blooded reptiles changes with the temperature of their surroundings. Hence, they are more active in warm and are sluggish in cold environments. On the other hand, the body temperature of warm-blooded mammals and birds does not change with the surrounding temperature. They retain their body temperature by sweating in hot and shivering in cold weather.

When Sumit was feeling very cold during a chilly winter evening, he took a steaming cup of coffee and his body warmed up. When Rashmi was sweating badly on a sunny afternoon, she drank cold orange juice after which she felt cool and refreshed. How did the hot coffee warm up Sumit who was feeling cold? How did Rashmi, who was feeling hot, start feeling cool and refreshed after taking a glass of cold orange juice?

The answer to these questions lies in a term called *heat*. In class 7 you studied how heat is transferred in substances and how it causes expansion in them. Here in this chapter, you will study how heat can change the temperature and state of a substance and how heat gained/lost by a substance can be calculated.

Touch a few things like an ice cube, a freshly cooked chapati, a steaming bowl of soup, a fruit taken from the refrigerator, etc. Are they hot or cold? You will find that the cooked chapati and the bowl of soup are hot, while the ice cube and the fruit are cold.

The degree of hotness or coldness of a substance is determined by a property known as ***temperature****.*

HEAT—FORM OF ENERGY

Just like mechanical energy and chemical energy, heat is also a form of energy. What happens when you boil water on a stove with the lid on? The lid moves because of the energy of the heat. Now, how does this heat energy flow? Heat energy flows between two bodies if there is a difference in temperature between them. Thus, ***heat is a form of energy that is transferred by a difference in temperature***. We must note that the heat energy always flows from a body at high temperature to a body at low temperature.

We know that temperature is a measure of average kinetic energy of molecules. So, we can also say that when there is a difference in the average kinetic energies of two bodies, which are in contact, heat energy flows.

Can you now explain why we feel hot when we touch hot coffee and cold when we touch ice? Hot coffee is at a higher temperature than our body, so when we touch it heat flows from the hot coffee to our body and we feel hot. On the other hand, ice is at a lower temperature than our body, so when we touch ice, heat flows from our body to ice and we feel cold. Thus, we say that heat is a form of energy only when it flows.

Let us understand this with a simple example. In Figure 3.1, two beakers A and B are connected to each other with a pipe. We see that since the level of water in tank A is higher than that in tank B, water flows from tank A to tank B, irrespective of the size of the tank and the quantity of water in it. Once both the tanks attain the same level, there is no more flow of water.

Similarly, heat flows from one body to another only if the temperatures of the two bodies are different. When the two bodies have attained the same temperature, no further flow of heat takes place, and we say that the two bodies have reached *thermal equilibrium*.

You would have learnt in class 7 that all bodies absorb and emit heat radiations all the time. Hence, we can say that there is no net flow of heat energy at thermal equilibrium.

FACT FILE

Heat energy vs. internal energy

The internal energy of a body is the sum of kinetic energy (due to random motion of molecules) and potential energy (due to intermolecular forces) of the molecules in a body. But temperature is only a measure of a body's average internal kinetic energy. The amount of this internal kinetic energy that flows in and out of a body is called heat energy.

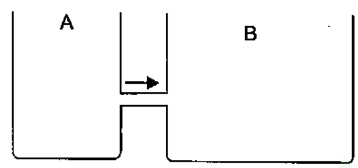


Fig. 3.1 *Flow of water from higher level to lower level*

FACT FILE

Sometimes, heat energy is forcefully made to flow from a region of lower temperature to a region of higher temperature. To do this, we need to supply energy to the system from outside. This outside source of energy is electrical energy. This concept is used in air conditioners and refrigerators.

James P. Joule
(1818–1889)

James Joule was an English physicist. He studied the nature of heat and discovered that heat is a form of energy. The mechanical equivalent of heat is a constant and is designated by the symbol J in honour of James Joule.

Units of heat

Do you remember the SI unit of energy? It is *joules*. Since heat is a form of energy, its unit will be the same as the unit of energy, i.e., joules.

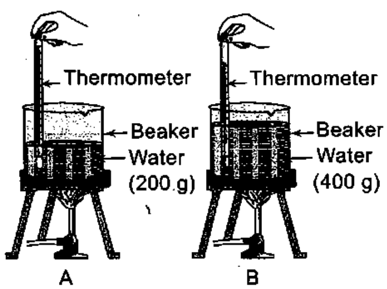
Thus, the *SI unit of heat is joules*. Another important unit of heat is *calorie*. ***One calorie is defined as the amount of heat required to raise the temperature of 1 g of water by 1°C.***

One more unit of heat is called *kilocalorie*, which is defined as the amount of heat required to raise the temperature of 1 kg of water by 1°C.

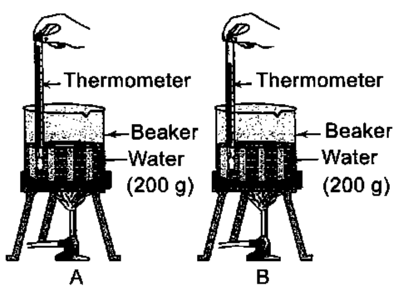
1 kilocalorie = 1,000 calories
The calorie is a bigger unit than joule.
1 calorie = 4.2 joules (J)

Quantity of heat

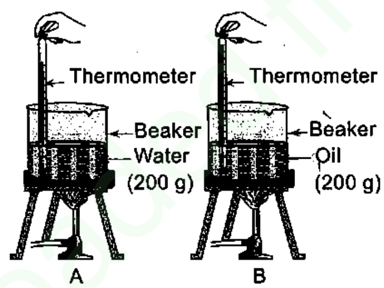
We know that when a body is heated, its temperature increases due to gain of heat, and when a body is cooled, its temperature decreases due to loss of heat. The quantity of heat gained or lost by a body, to increase or decrease its temperature, depends on many factors. Let us observe the following figures to study the factors that affect the amount of heat gained or lost by a body.



When different quantities of water taken in two different beakers are heated uniformly, water in beaker A (200 g) boils faster and takes less time than water in beaker B (400 g). Thus, ***heat energy depends on the mass of the substance***. More the mass taken more will be the heat required, less the mass taken less will be the heat required.



When equal quantities of water in two beakers are heated from room temperature to 50 °C in beaker A and 70 °C in beaker B, the time taken to reach 70 °C is more than the time taken to reach 50 °C. Thus, ***heat energy depends on the change in temperature***. More the temperature change, more will be the heat required.



When equal quantities of water and oil in two different beakers are heated uniformly, oil takes less time to reach a higher temperature than water, Thus, ***heat energy depends on the nature of the substance*** (called the specific heat capacity of the substance).

Thus, we conclude that the heat gained or lost by a body depends on

1. the mass of the body;
2. the rise or fall in temperature of the body; and
3. the nature of the body.

Effect of heat

Take a little water in a pan and heat it for sometime. Can you list the changes that you observe? You will notice that (i) the temperature of the water rises; and (ii) the water changes its state and becomes vapour. Thus, we see that heating a body can have two effects:

1. the body can experience a rise in temperature; and
2. the body can change its state, e.g., from liquid to vapour.

Although you have learnt about four effects of heat in class 7, we will only study the two mentioned above in detail.

SPECIFIC HEAT CAPACITY

We have seen earlier that if equal quantities of water and cooking oil are given the same amount of heat, their temperature goes up by varying degrees. Oil heats up much faster than water, i.e., it requires less heat than water for the same rise in temperature. This difference is because of the *specific heat capacity* of substances, which depends on the nature of the substance.

*The **specific heat capacity** of a substance is defined as the amount of heat required to raise the temperature of unit mass (1 g or 1 kg) of a substance by 1°C.*

The SI unit of specific heat capacity is J/kg °C*. It can also be expressed in J/g °C, when we consider 1 g of that substance. To convert J/g °C to J/kg °C, the value should be multiplied by 1,000.

Table 3.1 shows the specific heat capacities of some substances. From the table, we see that the specific heat capacity of water is more than oil, and that is why it requires more amount of heat to raise its temperature by 1 °C. Thus, substances having high specific heat capacity require more time to increase or to decrease their temperature. We also see that water has the highest specific heat capacity.

* Although the SI unit of temp. is K, the change in temp. in K is the same as the change in °C, so we use °C as a unit instead of K for convenience.

***Table 3.1** Specific heat capacities of some substances*

Substance	Specific heat capacity (J/kg °C)
Mercury	138
Silver	230
Copper	385
Iron	440
Glass	670
Aluminium	920
Air	1,000
Vegetable oil	1,670
Milk	3,393
Water	4,186*

* For calculation basis, the specific heat capacity of water can be taken as 4,200 J/kg °C.

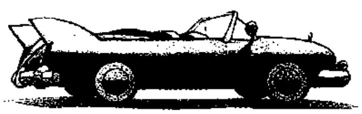
If 4,200 J is needed to raise the temp. of 1 kg of water through 1 °C, then, ...J is needed to raise the temp. of 2 kg of water through 1 °C; and ....J is needed to raise the temp. of 2 kg of water through 10 °C.

This high specific heat capacity of water renders it a lot of advantages. Some of them are shown below.

Plants can be protected from frost if fields are filled with water as wet soil takes a long time to cool. Also, vegetables, fruits, etc. are kept under water in cold countries because water can store large amounts of heat, which prevents the eatables from freezing.

Because of the high specific heat capacity of water, it can store lot of energy for a small temperature rise and so, retain heat for a very long time. Hence, it is used in hot water bottles.

The temperature change of sea water is much less than the temperature change of land. This explains why coastal areas have a cooler summer and a milder winter than inland areas. For the same reason, a swimming pool remains cool even in peak summer.



Since water can absorb large amounts of heat without rising to a high temperature, it can be used as a coolant in car radiators, power stations, and mills and factories to keep the engine and other parts cool.

THINK QUEST

Why does a piece of water melon stay cool for a longer time than sandwiches when both of them are taken out from the refrigerator on a hot day? (*Hint: think of the specific heat capacity of water in a water melon.*)

So far, we have learnt that the amount of heat gained/lost by a body depends on the mass of the body (m), rise/fall in the temperature of the body (ΔT), and the nature or the specific heat capacity of the body (C). Keeping all these together in an equation, the amount of heat gained/lost by a body (Q) is

$$Q = m \times C \times \Delta T$$

or $Q = mC\Delta T$, where ΔT = higher temperature – lower temperature.

Let us see some solved examples based on this formula.

SOLVED EXAMPLES

1. How many joules of energy is needed to raise the temperature of 2 kg of water from 15 °C to 55 °C? Sp. heat capacity of water is 4,200 J/kg°C.
   Mass of water (m) = 2 kg
   Sp. heat capacity of water (C) = 4,200 J/kg°C
   Rise in temperature (ΔT) = 55 – 15 = 40 °C
   Heat energy required (Q) = $m \times C \times \Delta T$
   $Q = 2 \times 4200 \times 40$
   $= 336{,}000$ J
2. How many joules of energy is given out by 500 g of iron, when it is cooled from 400 °C to 30 °C? Sp. heat capacity of iron is 440 J/kg°C.
   Mass of iron (m) = 500 g = 0.5 kg
   Sp. heat capacity of iron (C) = 440 J/kg°C
   Fall in temperature (ΔT) = 400 – 30 = 370 °C

Heat energy required (Q) = $m \times C \times \Delta T$

$Q = 0.5 \times 440 \times 370$

$= 81{,}400$ J

3. If 24,000 J of heat energy is given out by 200 g of oil at 80 °C, what will be the final temperature of oil? Sp. heat capacity of oil is 2,000 J/kg °C.

Mass of oil (m) = 200 g = 0.2 kg

Sp. heat capacity of oil (C) = 2,000 J/kg°C

Heat energy given out (Q) = 24,000 J

We know that,

$$Q = m \times C \times \Delta T$$

Therefore, $\Delta T = \dfrac{Q}{m \times C}$,

Therefore, $\Delta T = \dfrac{2400}{0.2 \times 2000}$,

$\Delta T = 60$ °C

Now, $\Delta T = 80 - x$ (If x is the final temperature)

$60 = 80 - x$

Thus, $x = 80 - 60 = 20$ °C

Conductors and insulators

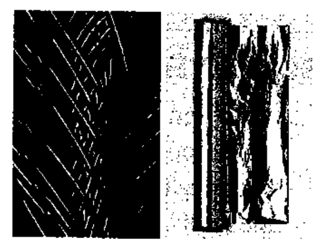
For a substance to gain or lose heat, the heat must travel through the substance; we say that the substance conducts heat.

Do all substances conduct heat easily through them? Think of wood, rubber, etc. Do they conduct heat? No!

*Substances that conduct heat easily through them are called **conductors**.* For example, metals like iron, copper, aluminium, etc. Many metals, in fact, have a low specific heat capacity, making them easy to heat up and cool down.

*Substances that do not conduct heat are called **insulators**.* For example, wood, clay, rubber, etc. These substances have high specific heat capacity. The higher the specific heat capacity of a substance, the less heat it conducts.

THINK QUEST



Given equal masses of aluminium and copper, which would require more heat if both are heated to a same temperature (*Hint: think of the specific heat capacities of copper and aluminium.*)

Principle of calorimetry

Measurement of specific heat capacities of substances is based on a very simple principle called the *principle of calorimetry.*

*The **principle of calorimetry** states that when two bodies, at different temperatures, are in contact, the heat lost by the hot body is equal to the heat gained by the cold body.*

To make accurate measurements of heat lost and heat gained, a specially designed device called the *calorimeter* is used (Figure 3.2).

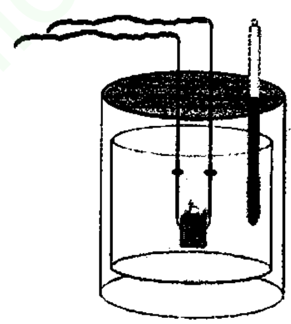


Fig. 3.2 *A calorimeter*

HEAT CAPACITY

We have just studied that the specific heat capacity is the heat required for 1 g or 1 kg of a substance to raise its temperature by 1°C. When we talk of the heat required to raise the temperature of

THINK QUEST

Which has more heat capacity: a bucket full of water or a mug full of water?
Do you know that the base of cooking vessels and electric iron is made thicker to increase its heat capacity so that it can impart heat at a low temperature or remain hot for a long time.

the whole substance by 1 °C and not just 1 g or 1 kg of it, we simply call it the *heat capacity* of the substance.

Thus, ***heat capacity is defined as the heat required to raise the temperature of the whole substance by 1 °C***. The unit of heat capacity is J/°C.

The heat capacity of a substance depends on two factors:

1. mass of the substance; and
2. nature or specific heat capacity of the substance.

Keeping these two together, we say that heat capacity = mass × specific heat capacity or

$$\text{Heat capacity} = m \times C$$

Some solved examples based on this formula are as follows.

SOLVED EXAMPLES

1. If an iron ball has a mass of 2 kg and specific heat capacity 480 J/kg °C, what is the heat capacity of the ball?

Mass of the iron ball (m) = 2 kg

Specific heat capacity of the ball

(C) = 480 J/kg °C

Heat capacity = $m \times C$

= 2 × 480

= 960 J/°C.

2. If the heat capacity of a vessel is 5,000 J/°C and its mass is 20 kg, find its specific heat capacity if it is heated through 10 °C.

Heat capacity = 5,000 J/°C

Mass of the vessel = 20 kg

We know that, heat capacity = $m \times C$

Thus, C (specific heat capacity) = $\dfrac{\text{heat capacity}}{\text{mass } (m)}$

C = 5,000/20 = 250 J/kg °C.

Table 3.2 *Melting and boiling points of some substances*

Substance	*MP**	*BP**
Oxygen	–218	–183
Alcohol	–114	78
Mercury	–39	357
Water	0	100
Lead	327	1,750
Silver	961	2,212
Copper	1,083	1,187

* MP – Melting point in °C;
BP – Boiling point in °C

CHANGE OF STATE

We have studied earlier that gain or loss of heat can cause a change in the state of a substance. Any of the three physical states in which matter exists (i.e., solid, liquid, or gas) is called a *state of matter*. Figure 3.3 shows the three states of matter. We have just discussed how heating a body can change its temperature. Let us now discuss how gain or loss of heat changes the state of a body.

Let us familiarize with some of the terms regarding the change of state of matter.

Melting or fusion: the process by which a solid changes into a liquid state at a particular temperature by gaining heat is called *melting* or *fusion*. This particular temperature is called the *melting point*. E.g., the melting point of ice is 0 °C.

Boiling or vaporization: the process by which a liquid rapidly changes into a gaseous state at a particular temperature by gaining heat is called *boiling*. This particular temperature is called the *boiling point*. E.g., the boiling point of water is 100 °C.

Condensation or liquefaction: the process by which a gas changes to a liquid state, at a particular temperature called the *liquefaction point*, due to the liberation (loss) of heat is called *liquefaction*. E.g., the liquefaction point of water is 100 °C.

Freezing or solidification: the process by which a liquid changes into a solid state at a particular temperature by the liberation (loss) of heat is called *freezing*. This particular temperature is called the *freezing point*. E.g., the freezing point of water is 0 °C.

We must note that for a given substance, the *liquefaction* and the *boiling points* are the same, and the *melting* and the *freezing points* are the same (at the same pressure).

In all the processes above, you will find that a change in state occurs when heat is gained or lost by a body, but at a particular temperature.

So far, we have studied that when heat is gained or lost by a body, its temperature rises or falls. Since all the above processes occur at a particular temperature, where does the heat gained or lost go? This heat is used to overcome the forces of attraction between the molecules of a substance (Internal potential energy) and to change its state. Since, the heat involved does not result in any change in temperature, it is known as *latent heat*.

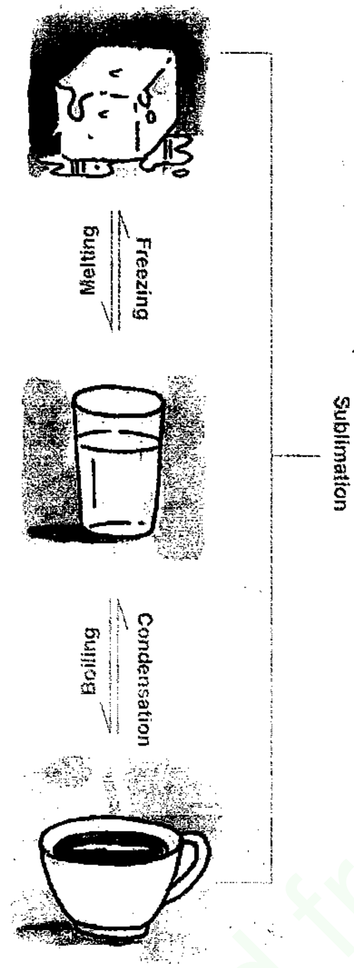


Fig. 3.3 *Change of state of matter*

LATENT HEAT

During a change of state, the substance uses up the heat gained or lost to overcome the forces of attraction between the molecules, keeping the temperature constant.

The quantity of heat absorbed or released when a substance changes its state of matter at a constant temperature is called ***latent heat***. If it is for unit mass, we call it *specific latent heat*. The SI unit of specific latent heat is J/kg.

The heat that a body absorbs in melting, evaporating, or subliming and gives out in freezing or condensation is called latent heat because it does not produce a change in temperature of the body.

THINK QUEST

Do you know that some substances change directly from solid to gas, without changing into the liquid state? Can you name some of them?

....

....

....

....

ACTIVITY

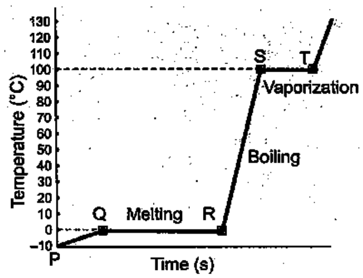
Aim: To observe that the temperature remains constant during a change of state.

Materials required: A pan, ice cubes, and a thermometer.

Procedure: 1. Take the ice cubes in a pan and fix a thermometer into it.

2. Watch the reading of the thermometer carefully. What do you notice?

3. You will notice that the reading of the thermometer remains constant but the ice starts melting and changes to water.



Temperature vs. time graph

Let us now understand latent heat with a graph.

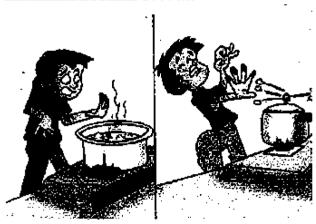
The graph alongside shows the changes of state that occur in ice when it is heated. Point ***P*** shows ice, which is at −10 °C. When ice is heated at −10 °C, its temperature starts increasing and it reaches 0 °C (point ***Q***). ***Q*** is the *melting point* of ice (0 °C). After reaching point ***Q***, the heat energy gained by ice is used to break the forces of attraction between the molecules and water at 0 °C is formed at ***R***. Since no rise in temperature is experienced, the graph from ***Q*** to ***R*** is a straight line. This amount of heat energy from ***Q*** to ***R*** is called the *latent heat of fusion*.

*The **latent heat of fusion** is the quantity of heat required to change a substance from solid to liquid or from liquid to solid without any change in temperature*. E.g., the specific latent heat of fusion of ice is 336×10^3 J/kg.

When all the ice changes to water at 0 °C, further heating this water raises its temperature and the temperature reaches 100 °C, and the water starts boiling at ***S***. This is the *boiling point* of water (100 °C). The graph from ***R*** to ***S*** is seen rising because of the rise in temperature. When water reaches 100 °C at ***S***, it changes to steam at 100 °C after gaining more heat. This heat gained is again used to break the forces between the molecules of water to form steam and so the graph from ***S*** to ***T*** again remains straight. This amount of heat is called the *latent heat of vaporization*.

*The **latent heat of vaporization** is the quantity of heat required to change a substance from liquid to vapour state or from vapour to liquid state without any change in temperature*. E.g., the specific latent heat of vaporization of steam is $2,260 \times 10^3$ J/kg. The high latent heat of fusion of ice and the high latent heat of vaporization of steam have some everyday effects, which are summarized below.

THINK QUEST



Explain why a burn caused by steam at 100°C is more serious than a burn caused by boiling water at 100°C. (*Hint: compare heat energy given out by steam with that by water, both at 100°C.)*

Effects of high latent heat of vaporization of steam

- Steam pipes are used in cold countries for heating

Effects of high latent heat of fusion of ice

- Soft drinks are cooled by placing them in ice rather than water at 0 °C because when 1 g of ice melts, it the buildings faster than hot water pipes as 1g of steam at 100 °C can give out 2,260 J of heat energy when it condenses, whereas 1 g of hot water at 100 °C can give out only 4.2 J of heat energy, while cooling by 1 °C.

- Since latent heat of vaporization of steam is very high, enormous amount of heat is required to vaporize water. Thus water from lakes, rivers, and seas and also from the soil does not vaporize rapidly.
- Steam is used in thermal stations to convert heat energy of coal to electrical energy as 1 g of steam contains 2,260 J of heat energy as compared to any other gas at low temperature.

takes in 336 J of heat from the soft drink and makes the drink cooler.

- Water bodies like rivers and lakes do not freeze quickly in winter as every gram of water has to give out 336 J of heat energy. They freeze slowly and thus keep the surroundings at a moderate temperature.
- Ocean currents carry icebergs for a long distance due to the high specific latent heat of fusion of ice.

The amount of heat gained or lost by a substance when its state is changed, without any change in the temperature is given by the expression $H = m \times L$, where H = the amount of heat gained/lost; m = mass of the substance; and L = specific latent heat of fusion/vaporization of the substance. Note that there is no temperature factor in the formula as temperature remains constant during a change of state. You will study about the quantitative applications of this formula in higher classes.

So far, you have studied that a liquid boils and changes into a gaseous state at a particular temperature, called the boiling point of the liquid. But can a liquid change to a gaseous state at temperatures below the boiling point of that liquid? Yes! This happens in evaporation, which you studied in detail in class 7.

*The process by which a liquid changes into a vapour state at a temperature below its boiling point is called **evaporation**.* This takes place from the surface of the liquid. Let us study the cooling effect of evaporation here.

During evaporation, the liquid requires the latent heat of vaporization to change into a gaseous state. This heat is absorbed from the surface of the liquid itself. As a result, the liquid loses heat and gets cooled. This is how cooling is produced from evaporation. Some day-to-day applications of the cooling effect of evaporation are shown alongside.

Water gets cooled in an earthen pot in summer

Sitting under the fan on a hot day makes us feel cool

KEYWORDS

Specific heat capacity Amount of heat required to raise the temperature of a unit mass of a substance by 1 °C

Heat capacity Amount of heat required to raise the temperature of the whole substance by 1 °C

Latent heat Amount of heat gained or lost to change the physical state of a substance at a constant temperature

Evaporation Process by which a liquid changes into vapour state at any temperature below its boiling point

SUMMARY

- Heat is a form of energy that is transferred by a difference in temperature.
- Heat energy flows from a body at a higher temperature to a body at a lower temperature.
- The heat required to increase or decrease the temperature of a body depends on the mass of the body, the rise or fall in temperature of the body, and the nature of the body. $Q = mC\Delta T$
- Conductors have generally low specific heat capacities, and insulators have high specific heat capacities.
- Principle of calorimetry states that heat lost by the hot body = heat gained by the cold body.
- Heat capacity of a body is defined as the heat required to raise the temperature of the whole body through 1 °C. Heat capacity = mass x specific heat capacity of the body.
- The quantity of heat gained or lost when a substance changes its physical state at a constant temperature is called latent heat.
- Ice has the highest latent heat of fusion, and steam has the highest latent heat of vaporization.
- Evaporation is the process by which a liquid slowly changes into vapour state at any temperature below its boiling point.
- The heat gained or lost during a change of state from solid to liquid or from liquid to solid is called the latent heat of fusion.
- The heat gained or lost during a change of state from liquid to gas or gas to liquid is called the latent heat of vaporization.

EXERCISES

I. Review questions

A. Choose the correct answer

1. The SI unit of heat capacity is ....
   (a) J/kg °C (b) J/g °C (c) J/kg (d) J/°C
2. Water from the soil does not evaporate quickly due to its ....
   (a) high specific heat capacity (b) high latent heat of fusion
   (c) high latent heat of vaporization (d) high evaporation constant
3. The specific heat capacity of silver is 230 J/kg °C. What will be the amount of heat required to raise the temperature of 1 kg of silver from 50 °C to 51 °C?
   (a) 115 J (b) 230 cal (c) 230 J (d) 11,500 J
4. Ice does not melt rapidly because of ....
   (a) high specific heat capacity (b) high latent heat of fusion
   (c) high heat capacity (d) high latent heat of vaporization
5. Evaporation takes place at .... temperature/s.
   (a) a fixed (b) boiling (c) all (d) melting

B. Fill in the blanks

1. Heat is a form of .... (liquid/energy), which flows from higher temperature to lower temperature.
2. The SI unit of heat energy is .... (joule/calorie).
3. When mass of a body is less, the heat absorbed to change its temperature will be .... (more/less).
4. The amount of heat required to raise the temperature of 1 kg of a substance by 1 °C is called the .... (latent heat/specific heat capacity) of that substance.
5. Water has the .... (highest/lowest) specific heat capacity.
6. The amount of heat required to raise the temperature of the whole substance through 1 °C is called the .... (heat capacity/specific heat capacity).
7. J/kg °C is the unit of .... (specific heat capacity/heat capacity).
8. Generally, metals have .... (low/high) specific heat capacity.
9. The amount of heat required to vaporize a liquid at its boiling point is called the .... (latent heat of fusion/latent heat of vaporization).
10. If you put a few drops of nail polish remover on your hand, you experience a cooling effect as .... (condensation/evaporation) causes cooling.

C. Match the following

1. Heat	(a) High specific heat capacity
2. Temperature	(b) Low specific heat capacity
3. Steam	(c) Degree of hotness or coldness
4. Wood	(d) High latent heat of vaporization
5. Copper	(e) Form of energy

D. Answer the following questions

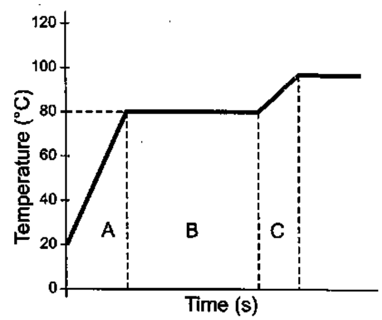
1. What is heat?
2. Define calorie. What is its relation with joule.
3. Define the specific heat capacity of a substance. Write its SI unit.
4. The specific heat capacity of two bodies A and B of same mass are 2,000 J/kg °C and 3,000 J/kg °C. If both are at the same temperature of 80 °C, which one will cool faster and why?
5. Explain why the sand on the beach is hotter than the sea water on the beach on a hot day.
6. Explain the difference between heat capacity and specific heat capacity.
7. Differentiate between the boiling point and liquefaction point.
8. Why is it easy to cool lime juice with ice cubes than by adding water at 0 °C?
9. What is the principle of calorimetry?
10. Give an example to show that evaporation causes cooling.

E. Numerical problems

1. Calculate the amount of heat required to raise the temperature of 200 g of copper from 30 °C to 80 °C, if the specific heat capacity of copper is 390 J/kg °C. **(Ans:** 3,900 J)
2. 48 J of heat energy is supplied to a certain amount of mercury whose specific heat capacity is 0.12 J/g °C. If the temperature rises from 20 °C to 40 °C, what is the mass of mercury? **(Ans:** 20 g)
3. 500 g of oil having specific heat capacity 2,000 J/kg °C is cooled from 400 °C to 35 °C. Calculate the energy given out. **(Ans:** 365,000 J)
4. A block of aluminium of mass 2 kg was supplied with 9,200 J of heat energy. Calculate the rise in temperature if the specific heat capacity of aluminium is 920 J/kg °C. If the initial temperature was 30 °C, find the final temperature. **(Ans:** 5 °C, 35 °C)

II. Skill-based questions

F. The temperature–time graph alongside shows a solid, which undergoes a change of state when heat is given to it. Answer the following questions by studying the graph:



1. In which state of matter is the substance in regions *A* and *C*?
2. What is the melting point of the solid?
3. If the mass of the substance is 2 kg and its specific heat is 2,000 J/kg°C, what would be the amount of heat absorbed in region 'A'?
4. What is the boiling point of the substance?
5. Explain why the graph is straight in the region B?

G. Study the table and answer the questions

Substances	*Specific heat capacity (J/kg °C)*
Glass	670
Vegetable oil	1,670
Silver	230
Copper	385

1. If 400 g of each of the substances is heated from 25 °C to 35 °C, which substance will require the greatest amount of heat and which one the least?
2. If 200 g of each substance is heated for a minute at the same initial temperature, which one will acquire the highest temperature and which one the lowest?

III. Fun time

Following the directions given, cross out words from the given grid. If all the directions are carried out without any mistake, you will be left with a couple of words, unjumbling which you get a statement that you have studied in the chapter. Write the statement in the space given.

A	*B*	*C*	*D*	*E*
Is	Place	Rope	Apple	Idli
Tanned	Might	Green	Energy	Water
Idea	March	Possible	Seed	You
Height	Work	Heat	Plant	Science
Case	Of	Speed	Woman	A
Waste	Right	Holi	Power	Manner
Form	Noise	Little	Class	Light

Directions:

1. Cross out words in which one alphabet is repeating itself and both occur together.
2. Cross out words beginning with W.
3. Cross out words rhyming the word 'Sight'.
4. Cross out words that end in a vowel.
5. Cross out words from columns B and D having just five letters.

Statement: ....

PROJECT IDEAS

- **Aim:** To make your own calorimeter and calculate the heat absorbed/lost.
  Materials required: A polystyrene cup with a lid, 50 g of water, thermometer, and 5 g of ammonium nitrate.
  Procedure: 1. Take a polystyrene cup and fill it with 50 g of water.
  2. Cover the cup with its lid.
  3. Now insert a thermometer inside the cup by making a hole in the lid and make sure that the bulb of the thermometer dips in the water. Note the temperature.
  4. Take 5 g of ammonium nitrate and dissolve it in water. Now note the temperature again. Calculate the fall in temperature.
  Your calorimeter is ready. Now calculate the heat lost by water by using the formula
  Heat gained/lost = mass of water x specific heat capacity of water x rise/fall in temperature.
  This will give you the heat lost by water during the chemical reaction.
- Using internet or books from your library, find out how Count Rumford in the 18th century found out that heat could be produced by mechanical means without fire, light, or chemical reaction.

TEACHER'S NOTES

- The difference between heat capacity and specific heat capacity could be explained clearly using examples.
- The concept of latent heat could be explained clearly by performing an experiment on heating of ice in the laboratory.
- Teachers could discuss the elementary principles behind heat engines to show that heat is a form of energy.

Website references

http://www.ftexploring.com/energy/enrg-types.htm (accessed 30 Apr 07)
http://www.ftexploring.com/energy/heatflow.htm (accessed 30 Apr 07)
http://www.physchem.co.za/Heat/Specific.htm (accessed 30 Apr 07)