4 HEAT AND TEMPERATURE

When someone has fever, the body feels hot. If it gets too hot you worry if the fever has gone too high. By feeling with our hands we can guess whether the fever is low or high. Also by feeling with our hands we can guess whether a cup of tea is still worth sipping or has become too cold; or if the milk is hot enough for making curd. But estimating temperature with our hands can at times mislead us, as can be seen in the following experiment.

Experiment 1

Touch may confuse

Take 3 beakers or glasses. Fill one with hot water, one with tepid water and one with cold water. Put one finger of one hand in hot water, and one finger of the other hand in cold water (Figure 1a). After about half a minute put both the fingers into tepid water (Figure 1b).

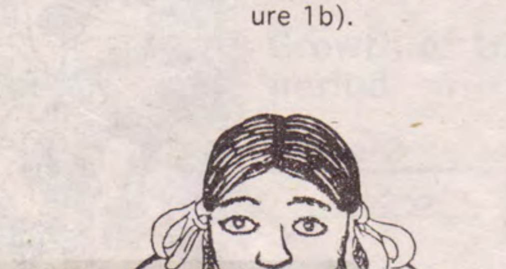


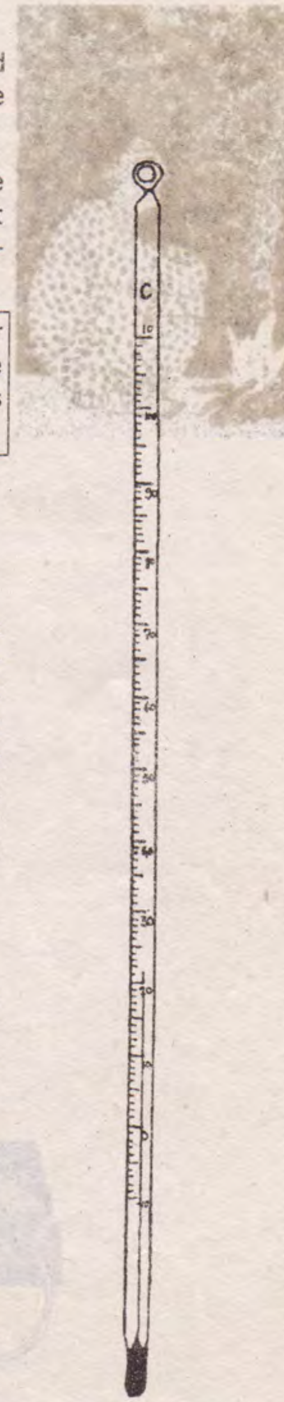
Figure-1a

Figure-1b

Do both fingers feel equally warm? (1)

They are both in the same glass of water, but one finger feels cold and the other feels hot! In estimating heat just by touching it we can sometimes be misled. Look how our hands were confused.

How hot is our body? To find that out we would have to measure the temperature. For this we need to use a **thermometer**. In the next few experiments we shall use a thermometer which is a little different from the ones which are used to measure body temperature.



Our kit does not have many thermometers. So the class teacher should make such arrangements that every student gets a chance to practise using a thermometer. One way would be to make as many groups as there are thermometers, for experiments 2 and 4.

Experiment 2

Measure the temperature with a Thermometer

Look at the thermometer given in the kit. At one end you will see the shiny mercury. There is a thin tube with thick glass walls extending up from this end. When the mercury gets warm it expands and goes up inside this tube. Turn the thermometer from side to side and learn to identify the thin tube. On the outside of the tube there are markings for degree Celsius. Degree Celsius is one unit used to measure temperature. The temperature at which water freezes is zero degree Celsius, or 0^0C. Now look at the markings on your thermometer.

What is the least count of your thermometer? (2)

To find out the temperature of an object, place the shiny end of the thermometer in contact with the object and watch the shiny line of mercury in the tube. The highest mark which this line reaches shows the temperature of the object.

Grip with your hand the mercury end of the thermometer. Watch the mercury going up the tube.

What is the temperature of your hand? (3)

Put the thermometer in water and find out its temperature. (4)

What would be the temperature of air outside? First write down your estimate. (5)

Now measure the temperature of the air in the shade as well as in the sun. (6)

In Libya, an African country, it got so hot one day in 1922 that the air temperature even in the shade was 58^0C. At some places in India the air temperature does rise to a maximum of about 48^0C. The lowest temperature in the world has been measured in Antarctica,

where it once went down to about -89°C. The minus sign is used for temperatures which are less than 0°C. Since water feezees at 0°C, just think how cold -89°C must be! When the air temperature goes down below to about 15-20°C our bodies begin to feel cold.

Now guess what would be the temperature on a winter night in your village or town. (7)

Experiment 3

The temperature of boiling water

Your teacher shall keep some water on a stove for boiling and hang a thermometer into it.

> **For teachers**
>
> For this experiment you may keep some water boiling at one place with a thermometer in it. The thermometer should not touch the vessel. Now call students one by one and ask them to read the thermometer. We will use this hot water in the next experiment so do not throw it away.

Read the temperature of the boiling water and write it on the blackboard. (8)

After all the students have written down the temperature look at the data and say whether the temperature of the water increased even after it had been boiling for sometime. (9)

What is the temperature of the boiling water? (10)

All this time the water is getting heat, but its temperature is not increasing. Because of the heat the water receives, it is converted into steam continuously. At the point when even upon heating, the temperature does not rise and the water keeps vaporising, the temperature is called the boiling point of water. The boiling point of edible oil is about 250°C. Therefore when oil is heated up its temperature continues to rise till about 250°C. If it continues to be heated further, the oil will also boil away.

Experiment 4

What happens when you mix together water kept at different temperatures?

If you take some water at 20°C and mix it with water which is at 60°C, will the temperature of the mixture add up to 80°C? Come on, let us do an experiment to find out.

Take some water at room temperature in a container. What is the temperature of this water? (11)

Fill a beaker one third full with warm water. Note its

temperature. (12)

Now fill this beaker completely by adding the water at room temperature. Stir and immediately measure its temperature. (13)

Suppose we had taken half a beaker of warm water instead of just one-third. Now if we fill the beaker with water at room temperature, will the mixture be warmer or cooler than the earlier? (14)

Experiment 5

Effect of heat on metal

Why does the metal rim have to be heated up before fixing it on the wheel of a bullock cart? Why is there sometimes a little gap left between two pieces of a rail track? In order to answer such questions we will do an experiment with a cycle spoke.

Get a torch bulb, a cell, a candle, a cycle spoke, a 25 or 50 paise coin, and two wooden blocks. Tightly wrap an electric wire around one end of the cycle spoke. Place this end of the spoke on a block of wood and secure it in place by putting a stone or a brick on top of it. The spoke should remain perfectly horizontal, as shown in figure 2. Rest the other end of the spoke on another block of wood. Wrap another electric wire tightly around the 50 paise coin and keep it in place on this wooden block with another stone. Attach a torch bulb and a cell to the electric wires as shown in figure 2. When the end of the spoke is made to touch the 50 paise coin, the circuit should be completed and the bulb light up. If it does not light up, fix the circuit so that it works properly.

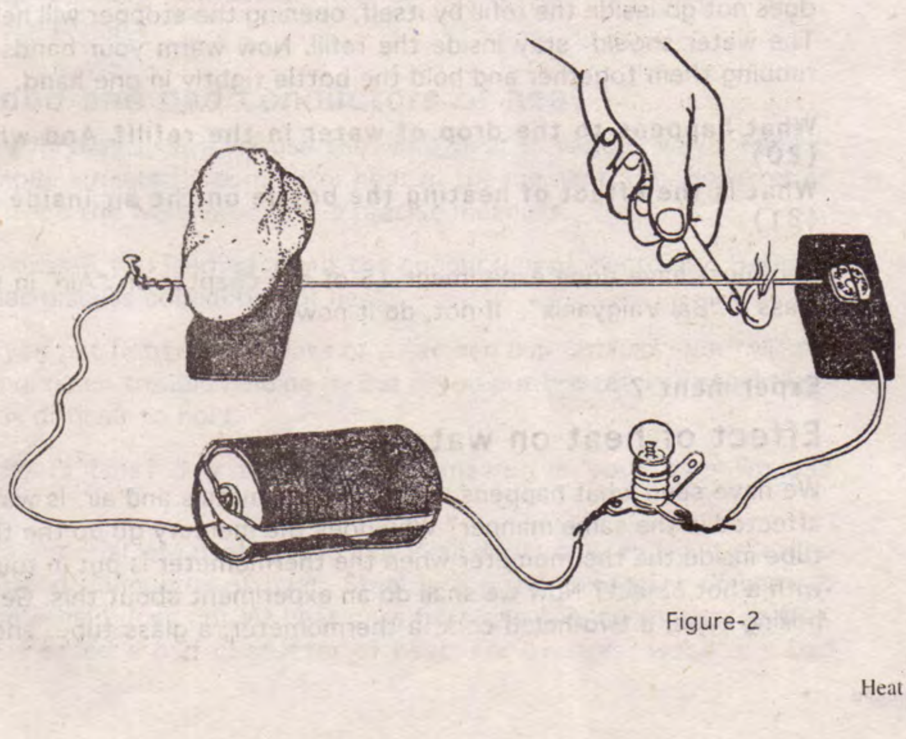


Figure-2

Now place a piece of paper between the end of the spoke and the 5 paise coin. Take the paper away, leaving a gap which is just the width of the piece of paper.

Does the bulb still light up? If not, why not? (14)

You saw that when the spoke and the coin do not touch each other, the bulb does not light up. Now heat the spoke with a candle.

After heating the spoke for some time does the bulb light up? (15).

If so, how did the spoke touch the coin when it was heated? (16)

After removing the candle does the bulb go off? (17)

How does the length of the spoke change when it is heated or cooled? (18)

Can you now tell why a metal rim is heated up before it is to be fixed on to a bullock cart wheel? (19)

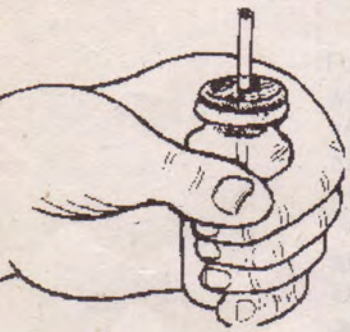


Figure-3

Experiment 6

Effect of heat on air

Do you think that heating will affect air the same way as it does metals? This is what we shall find out in the next experiment.

Get an injection bottle with its stopper, and a piece of an empty ballpen refill about 5 cm long. Make a hole in the stopper with a needle or a nail. Be careful not to make the hole larger than the thickness of the refill. Push the refill a little into the bottle (Figure 3). Put 1 or 2 drops of water into the top of the refill (if the water does not go inside the refill by itself, opening the stopper will help). The water should stay inside the refill. Now warm your hands by rubbing them together and hold the bottle tightly in one hand.

What happens to the drop of water in the refill? And why? (20)

What is the effect of heating the bottle on the air inside it? (21)

You must have done experiment 15 of the chapter on "Air" in the class 7 "Bal Vaigyanik". If not, do it now.

Experiment 7

Effect of heat on water

We have seen what happens when we heat metals and air. Is water affected in the same manner? Why does the mercury go up the thin tube inside the thermometer when the thermometer is put in touch with a hot object? Now we shall do an experiment about this. Get a boiling tube, a two-holed cork, a thermometer, a glass tube, and a candle. Fill the boiling tube to the brim with water. Put one or two drops of ink in the water so that you can easily see the water level in the glass tube. Put the thermometer in one hole of the two-holed cork, and put the glass tube in the other hole. Fit the cork tightly in the boiling tube filled with water. A little water will go up the glass tube. Seal the cork well with wax so that water does not leak out. Make a mark on the glass tube showing the water level. Note the temperature of the water.

Now hold the boiling tube straight and continuously heat it on a candle or kerosene lamp. For every 10°C rise in the temperature, make a mark on the glass tube where the water level is. Blow out the candle after you have made 4 or 5 marks.

Does the water level in the glass tube rise continuously as the temperature increases? Why does this happen? (22)

What do you think happens to the volume of water as it is heated up? (23)

Watch the level of water as it cools down.

What do you think happens to the volume of water as it cools down? (24)

Look at the marks on the glass tube.

For every 10°C increase in temperature, did the water level change by about the same amount? (25)

In fact, mercury expands when it is heated in the same way that water does. A thermometer is based on the property that for every degree rise in temperature the volume of mercury increases by an equal amount.

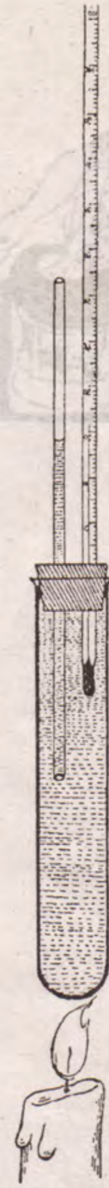


Figure-4

Good and bad conductors of heat

In everyday usage we use the word heat in various ways. For example, a heated argument or heat of the moment, etc. However, in science the word *heat* has a precise meaning.

In class-6 you learned about the conduction of electricity. Here we shall discuss conduction of heat.

If you put hot tea in a glass or a earthen cup (*kulhad*) you will not have much trouble holding it. But if you put hot tea in a steel glass it is difficult to hold.

Why is this? Try to write the answer in your own words? (26)

If a material lets heat spread in it in all directions readily, it is called a good conductor of heat. Steel is a good conductor of heat. If something does not let heat pass from one part to another readily, it is called a bad conductor of heat. For example, wood is a bad

conductor. However hot a hot plate (*tawa*) may be, its wooden handle does not let the heat pass through to our hand.

Often good and bad conductors confuse us. The temperature of all things kept outside all night in winter will be about the same as the air temperature. But an iron rod will feel much colder than a wooden one. We feel this difference because iron allows heat to flow away from our hand quickly and this makes our hand feel cold. But wood does not allow heat to flow away from our hands that quickly, so our hands do not feel that cold when they touch the cold wood.

Think and write down some examples like this from everyday life in which we make use of good and bad conductors of heat. (27)

We use sweaters, coats, quilts, shawls, blankets, etc. to keep ourselves from getting cold. We call them warm clothes. Are they really warm? They do not feel warm to the touch.

What is the source of the warmth which we feel when we wear these clothes? (28)

How do warm clothes protect us from cold? (29)

On hot days, before going out in the sun, people often cover their heads with a piece of cloth (towel or *gamchha*).

This cloth serves as a poor conductor of heat. How does that help? (30)

In some parts of the desert, when the air temperature goes above 50°C people start wearing woollen clothes in the sun.

Discuss and write down what would be the benefit of wearing woollen clothes in such scorching heat. (31)

Mat cloth or sawdust is used to keep ice from melting.

Mat cloth or sawdust prevents heat transfer from which object to which object and how? Think about it and write your answer. (32)

Experiment-8

Transfer of heat in metals

We shall do an experiment with pins stuck with wax on an iron strip in order to see how fast heat spreads in it.

Take a strip of iron about 15 cm long. An old hacksaw blade will do. At a distance of about 3 cm from one end, put a drop of wax and stick the head of a pin in it (figure 5a). When the wax hardens the pin should stand straight. Carefully stick 5 pins like this, one cm apart.

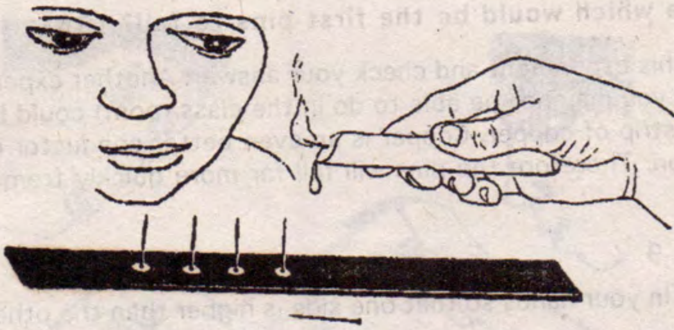


Figure-5a

Hold the iron strip with the pins hanging down. Put a candle flame under the end from where you started sticking the pins (figure 5b).

Figure-5b

Which was the first pin to fall? (33)
Why did all the pins not fall at the same time? (34)
Was there a particular order in which the pins fell? (35)

Suppose we had kept the candle flame in the middle and the pins were stuck on both ends of the strip, as shown in figure 6.

Figure-6

In this case which would be the first pins to fall? (36)

You can do this experiment and check your answer. Another experiment (which you may not be able to do in the class room) could be done with a strip of copper. Copper is an even better conductor of heat than iron. Therefore the pins will fall far more quickly from a copper strip.

Experiment 9

Hold a spoke in your hands so that one side is higher than the other (figure 7).

Figure-7

Now heat the spoke with a candle exactly in the middle.

After a little while, do both the ends feel hot? (37)

In metals does heat travel in the downward direction as well? (38)

Experiment 10

A different kind of heat flow in liquids

Fill two-thirds of a boiling tube with water. Hold it at a slant and heat the part near the surface of the water (figure 8). After a while water will start boiling.

Touch the bottom of the tube to find out if the temperature there has increased as well. Has it? (39)

Why is this? (40)

If you want to heat all of the water, where should you put the flame? (41)

When you heat a metal object in the middle, heat spreads in all directions. In which direction does heat flow in water? (42)

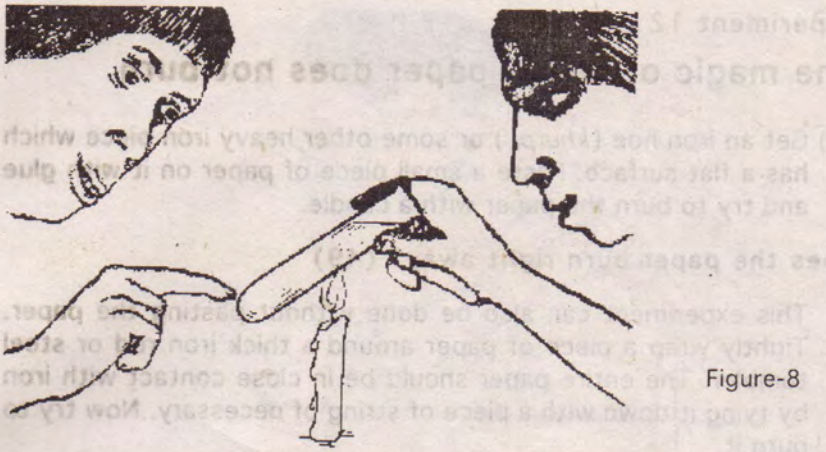


Figure-8

Experiment 11

Heat causes currents in water

From wherever you heat solid things, the heat spreads in all directions. But in liquids why does most of the heat flow upwards? Let us do an experiment to explore this.

(a) Half fill a boiling tube with water. Once the water is still, drop a small crystal of potassium permanganate in it. Watch the colour spread in the water for some time.

In which direction is the colour spreading? (43)

(b) Throw this water out and again fill the boiling tube half way. Put another potassium permanganate crystal in the water. This time, heat the tube from below with a candle (Figure 9).

In which direction does the colour spread now? (44)
What difference do you see in the way the colour spreads in experiments (a) and (b)? (45)

Try to see the upward and downward currents in the water.

Make a picture of these currents. (46)
Is the water that moves upwards cold or hot? (47)
Is the water that moves downwards cold or hot? (48)

In this experiment potassium permanganate was used just to make the water currents visible. Water that is being heated must have many such currents that we cannot see. This process takes place whenever a liquid is heated. It is called **convection**.

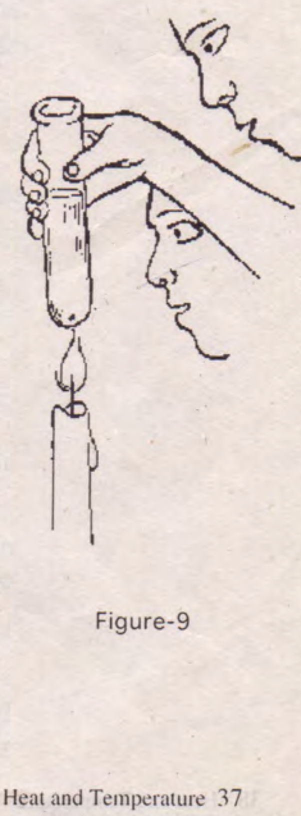


Figure-9

Experiment 12

The magic of heat - paper does not burn

(1) Get an iron hoe (*khurpi*) or some other heavy iron piece which has a flat surface. Paste a small piece of paper on it with glue and try to burn the paper with a candle.

Does the paper burn right away? (49)

This experiment can also be done without pasting the paper. Tightly wrap a piece of paper around a thick iron rod or steel tumbler. The entire paper should be in close contact with iron by tying it down with a piece of string of necessary. Now try to burn it.

(2) Take half a sheet of paper from your note book. Hold it from both ends in the form of a boat so that it can be filled to the top with water, as shown in figure 10. Heat it over a candle for a while. The water will get very hot but the paper would not burn.

Figure-10

In both these experiments the heat of the flame cannot heat the paper enough to set it on fire because most of the heat keeps getting absorbed by the iron or water.

Experiment 13

In which direction does heat flow in air?

Take a test tube or a boiling tube whose bottom is broken. Hold the tube at an angle and heat it in the middle (Figure 11). After a little while put your finger inside the top end.

Is the air at the top hot? (50)

Put your finger inside the bottom end to feel the heat of the air there.

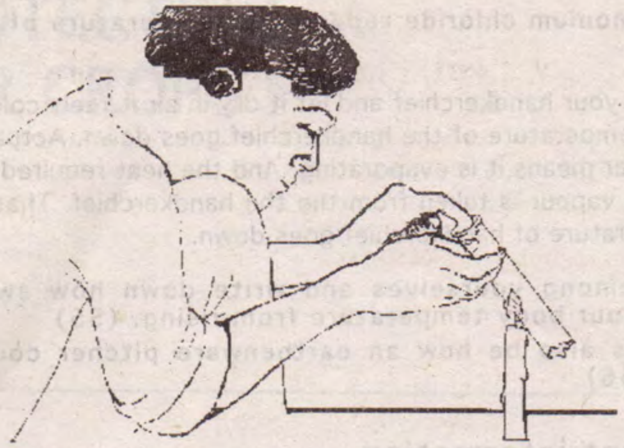


Figure-11

What difference do you feel in the temperatures at the top and bottom? (51)

Compare this with experiment 10 and tell in what way is heat flow through air and water similar. (52)

How does heat reach where there is no air?

In the last experiment you saw that when air is heated it takes the heat upwards. But far out in space there is no air, so how does heat from the sun reach us? In the chapter on 'light' you saw how a black paper can be burned by focussing the sun's rays on it with a lens. Repeat this experiment if you like. This heat comes to us only through the rays of the sun.

Ways to increase or decrease temperature

You must have experienced many ways of raising the temperature of an object.

For example -

(1) Rubbing your hands or rubbing two stones together

(2) Switching on a lamp

(3) Mixing lime with water

Write down other ways of increasing temperature which you can think of. (53)

In order to reduce the temperature of water you can keep it in an earthen pitcher or use ice. Now we shall see a chemical method to reduce the temperature.

Experiment 14

Fill a test-tube one-quarter with water and feel its temperature. Add a pinch of ammonium chloride (*nausadar*) to the water and feel the bottom of the test tube.

Does ammonium chloride reduce the temperature of water? (54)

If you wet your handkerchief and let it dry in air it feels cold. Think how the temperature of the handkerchief goes down. Actually drying of water means it is evaporating. And the heat required to turn water into vapour is taken from the the handkerchief. That is why the temperature of handkerchief goes down.

Discuss among yourselves and write down how sweating prevents our body temperature from rising. (55)

Could this also be how an earthenware pitcher cools the water? (56)

Important information

In this chapter we have measured temperature using only the Celsius scale. Temperatures can also be measured in the Fahrenheit scale. Zero degree on the Celsius scale is equal to 32^0 on the Fahrenheit scale and 100^0C is equal to 212^0F. In case you are using a thermometer with a Fahrenheit scale, water will freeze at 32^0F and boil at 212^0F.

If someone says she has a fever of 102^0, then is her body temperature being measured in the Celsius scale or in the Fahrenheit scale? (57)

Our normal body temperature is about 37^0 Celsius or 98.6^0 Fahrenheit.

NEW WORDS:

Thermometer	heat
degree Fahrenheit	degree Celsius
convection	boiling point