14 Heat and Temperature

14.1 Measuring temperature

Environment becomes warm during the day time due to the solar heat and gets cool in the night. Warmness and coldness are two sensations that we feel.

Let us do Activity 14.1 to find out more about warmness and coldness.

Activity 14.1

You will need :- Luke warm water and cold water, two equal size beakers

Method :-

- Get equal amounts of luke warm water and cold water into two beakers of same size (Get the help of your teacher when handling warm water).
- Dip your fingers into the water of the beakers.
- Record what you feel.

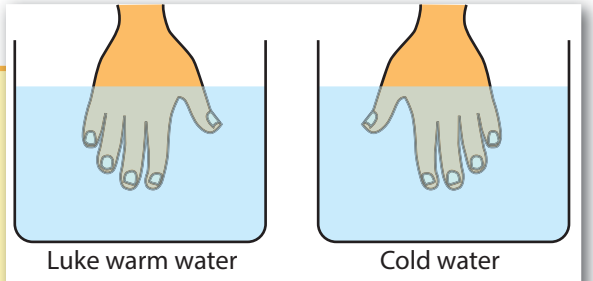


Figure 14.1

You may feel that there is a difference of warmth of the water in the two beakers. What is the difference between cold water and luke warm water? Water was heated on a hearth or on a burner. Then, water was warmed by receiving thermal/heat energy.

The measurement of warmness or coldness of a substance is known as its **temperature.**

Temperature of a substance decreases (cools) because of losing heat from that substance.

For extra knowledge

We feel warm when a heated object is being touched, because heat transfers from that object to our hand. Coldness is felt when a piece of ice is touched, because heat transfers from our hand to the piece of ice.

Measuring temperature by touching is not correct. Let us do Activity 14.2 to find out how to measure temperature correctly.

Activity 14.2

You will need :- Two small glass bottles with rubber stoppers, two empty tubes of ball point pens, two beakers, water, red ink

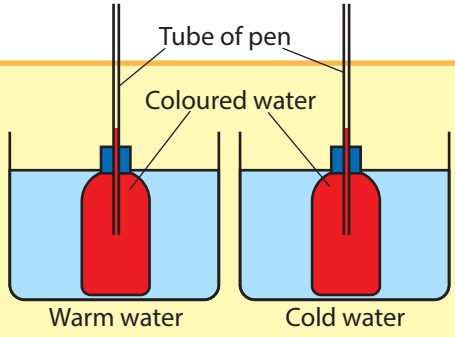


Figure 14.2

Method :-

- Fill the small glass bottles with coloured water and fix the empty tubes of ball point pens.
- Keep one of those bottles in a beaker filled with warm water and the other in a beaker filled with cold water.
- Observe what happens (Take care when using hot water).

Thermometers are used to measure temperature accurately and quantitatively.

It can be observed that;

The liquid column in the tube of the bottle, kept in warm water rises up.

The liquid column in the tube of the bottle, kept in cold water falls down.

Accordingly, heat transfers from warm water in the beaker to the water in the bottle. Then, the volume of water in the bottle increases to rise up along the tube.

Water in the bottle kept in the beaker of cold water, cools to decrease the volume (Contracts). Then the liquid column in the tube of that bottle falls down.

Increase of the volume of a liquid, by gaining heat is called the **expansion of the liquid**.

It is the property of expansion of a liquid, that is used in making thermometers.

14.2 Thermometers

A simple thermometer can be made and calibrated as indicated in the Figure 14.3 below.

A small glass bottle is filled with coloured water and the empty tube of a ball point pen is fixed into it. A paper strip on which a scale is marked, is glued to the tube.

The bottle, thus made is dipped in a beaker of water and the beaker is heated slowly.

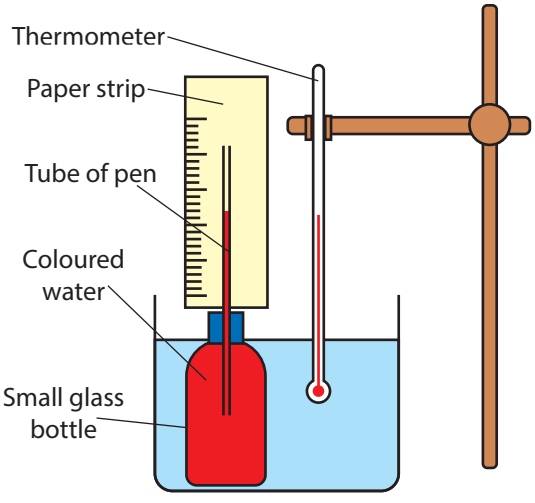


Figure 14.3

A mercury thermometer is dipped in the beaker of water. When the water is being heated, the temperature rises and the coloured water column in the pen tube goes up.

The position of upper end of the coloured water column is marked on the paper strip, for some temperature readings indicated by the thermometer. The relevant temperature also should be indicated at the mark. After marking several temperatures on the paper strip, a simple scale can be made. The water-bottle-thermometer thus made can be used to measure unknown temperatures in a short range. Here you can get an approximate value.

Assignment 14.1

- Mention the short comings of a thermometer as mentioned above. Give suggestions to overcome those shortcomings.

Mercury is used as the liquid of most thermometers used today. In addition alcohol is a liquid used in thermometers. Alcohol used in thermometers is coloured, for clear observation of the thin alcohol column.

Scales of thermometers

There are several scales used in present thermometers. Those are;

- Celsius scale
- Farenheit scale
- Kelvin scale

Units of measuring temperature in each scale is given in Table 14.1.

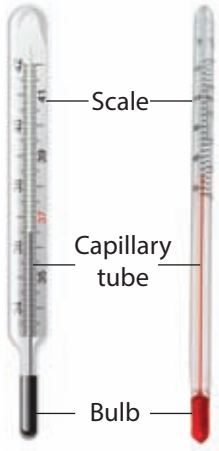


Figure 14.4 ▲ A mercury thermometer and an alcohol thermometer

Table 14.1 ▼

Temperature scale	Unit
Celsius	^{o}C
Farenheit	^{o}F
Kelvin	K

The international standard unit of temperature is Kelvin (K).

The equivalence between principal temperature scales are given in Table 14.2 for some temperatures.

Table 14.2 ▼

Temperature	Celsius scale (^{o}C)	Farenheit scale (^{o}F)	Kelvin scale (K)
Boiling point of water	100	212	373
Freezing point of water	0	32	273
Mean temperature of human body	36.9	98.4	309.9

Melting point and boiling point

There is a constant temperature, at which a soild substance changes to its liquid state .

Let us do Activity 14.3 to find out the constant temperature at which ice changes to water.

Activity 14.3

You will need :- A few pieces of ice cubes, a mercury thermometer, a glass funnel, a beaker

Method :-

- Put some piece of ice into the glass funnel and place the bulb of the thermometer in ice.
- Keep the funnel on the beaker and find the temperature of melting ice.

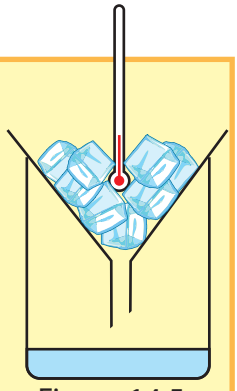


Figure 14.5

Here, it can be observed that the temperature at which ice is melting is 0 °C. Therefore, the constant temperature at which ice melts is called the melting point of ice.

Ice (solid) —(Absorbing heat)→ Water (liquid)

Melting point

The constant temperature at which a solid substance changes to its liquid state is known as the melting point of that substance.

When water is cooled, ice (solid) forms. The temperature at which water solidifies is also 0 °C and is known as the freezing point of water.

Melting points of some substances are given in Table 14.3.

Table 14.3

Substance	Melting point (°C) at 1 atm
Ice	0
Paraffin wax	60
Lead	317
Iron	1539

Boiling point

The boiling point can be simply explained as the constant temperture at which a liquid substance changes to its gaseous state.

Let us do Activity 14.4 to find out the boiling point of water.

Activity 14.4

You will need :- A boiling tube, a thermometer, some water, a burner, a laboratory stand

Method :-

- Take some water into a boiling tube, and prepare the set-up as shown in Figure 14.6.
- Heat the water for few minutes till it boils.
- Record the reading of the thermometer.

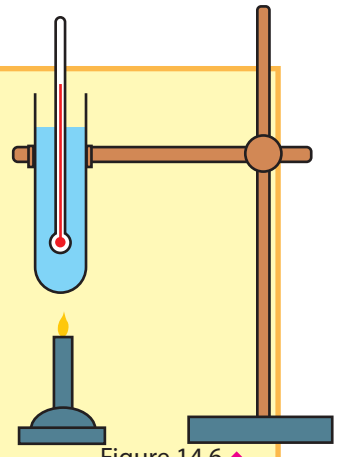


Figure 14.6

It can be observed that the temperature at which water boils (with bubbles evolving steam) is 100 °C. It can be concluded that there is an exact temperature of boiling water.

The constant temperature at which a liquid substance changes to it's gaseous state is known as the boiling point of that substance.

Table 14.4 Boiling point of some substances

Substance	Boiling point (°C) at 1 atm
Alcohol	77
Paraffin wax	370
Water	100
Lead	1744
Iron	2900

For extra knowledge

Celsius scale

This scale is prepared by dividing the range between the melting point of ice (0 °C) and the boiling point of water (100 °C) into 100 equal parts.

Farenheit scale

This scale is prepared by dividing the range between upper fixed point (212 °F) and lower fixed point (32 °F) into 180 equal parts.

The values of melting point and boiling point vary according to the atmospheric pressure. The values given in table 14.3 and 14.4 are measured at 1 atm of atmospheric pressure.

Using thermometer correctly

1. Thermometer should be held vertically. So, that the bulb of the thermometer is well in contact with the substance / liquid of which the temperature should be measured.
2. When taking the readings the thermometer should be adjusted to the eye level.
3. Eye should be kept correctly in line with the mercury column as shown in Figure 14.7.
   (Observe below or above is incorrect.)

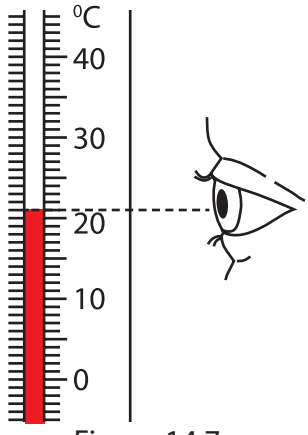


Figure 14.7

Assignment 14.2

Find out the factors, that should be considered when using a thermometer and make a report.

For extra knowledge

For the protection of the thermometer, it should be selected in such a way that the measuring temperature should be within the temperature range of that thermometer.

Engage in Activity 14.5 and Activity 14.6 to take the reading correctly.

Activity 14.5

You will need :- A beaker, water, a thermometer, a laboratory stand

Method :-

- Place the bulb of the thermometer at the middle of water and clamp it vertically.
- Observe the level of the mercury column and take the reading accurately as shown in Figure 14.8.

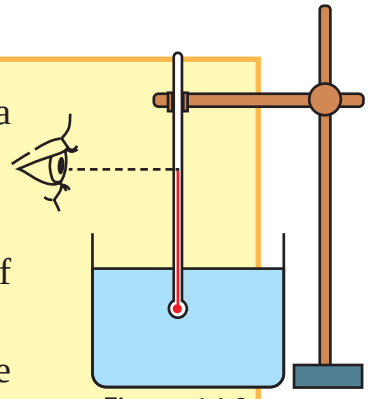


Figure 14.8

Activity 14.6

You will need :- A thermometer

Method :-

- Hold the thermometer vertically.
- Observe the mercury column accurately and take the reading.

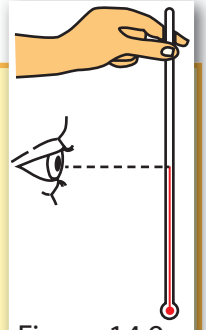


Figure 14.9

Assignment 14.3

Measure the temperature of air in some places like under a large tree, open air with lot of sunlight, near a water body.

Tabulate your readings

Activity 14.7

You will need :- A thermometer, a beaker full of soil

Method :-

- Fill the beaker with soil and dip the bulb of the thermometer well into the soil.
- After some time take the reading of the thermometer.

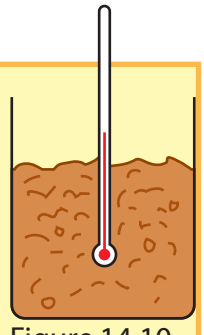


Figure 14.10

Soil temperature can be measured by the soil thermometer, in the natural environment as shown in Figure 14.11.

Figure 14.11 Measuring soil temperature

Assignment 14.4

Measure the soil temperature in the following places and tabulate the readings

- Under a large tree
- In a dry place
- In a place with sandy soil
- In a place with high moisture content

Clinical thermometer

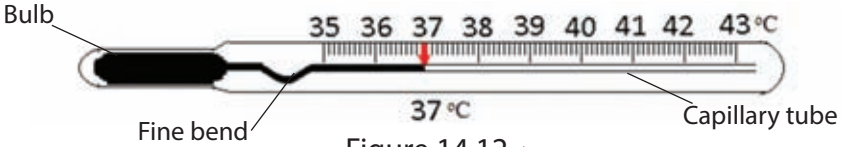


Figure 14.12

Special features of a clinical thermometer;

- There is a fine bend in the capillary tube containing mercury.
- The temperature range is short (35 °C - 43 °C)

Clinical thermometer is used to measure the body temperature.

Measuring body temperature, by using clinical thermometer;

- First wash the bulb of the thermometer with an antiseptic solution.
- Keep the bulb of the thermometer under the tongue of the patient for about two minutes as shown in Figure 14.13.
- Remove the thermometer from the mouth and take the reading accurately while holding it vertically.

Figure 14.13

(Body temperature of small babies can be measured by keeping the bulb of the thermometer under their arm pits for few minutes.)

Figure 14.14 Bend in the mercury column of clinical thermometer

There is a fine bend in the capillary tube of the clinical thermometer. It prevents the mercury column rising up or falling down before taking the measurements. Therefore, the reading of the temperature can be kept unchanged, even after the thermometer is removed from the mouth of the patient. Thermometer should be shaken well to send the mercury column down the bend before it is used for the next time.

Assignment 14.5

Measure and record the body temperature of your family members and some of your friends.

For extra knowledge

- Body temperature of a healthy person is 36.9 °C or 98.4 °F

- New types of thermometers are invented for measuring body temperature accurately.

Assignment 14.6

Collect and record information about modern equipment used to measure temperature.

14.3 Heat transfer

Heat is a type of energy. The sun is our largest heat source. Though the sun is some millions of kilometres away from the earth, we get solar heat very soon. This indicates that heat has travelled from the sun to the earth very quickly.

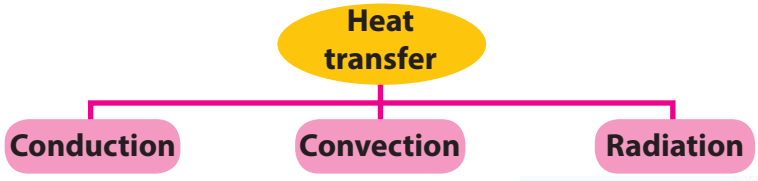
Figure 14.15 ▲ Students near a fire

Figure 14.16 ▲ Touching a hot cup of tea

We feel warm, though we are few metres away from a fire. Hand will be burnt, if a heated object is touched.

In the above instances heat has travelled from one place to another place. Travelling of heat from one place to another place is called **heat transfer.**

There are three methods of heat transfer.



Conduction

A metal spoon in a cup of tea gets heated soon.

The far end of a metal spoon gets heated when it is put into a pan on a cooker.

Figure 14.17 ▲ Heated pan on a cooker

Let us do Activity 14.8 to find out how heat transfers through a solid substance.

Figure 14.18 ▲ A hot cup of tea

Activity 14.8

You will need :- A metal (iron) rod of about 20 cm long, few pins, a candle

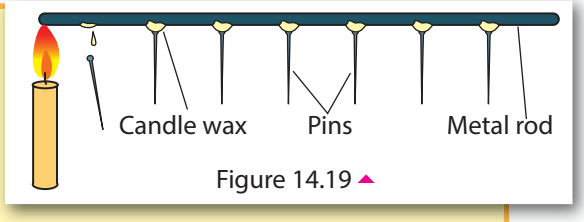


Figure 14.19 ▲

Method :-

- Take the metal rod and fix pins on it, in 2 cm intervals, using candle wax, as shown in Figure 14.19
- Heat one end of the rod using the candle
- Record your observations after sometime.

You can observe that pins are dropping down gradually, starting from the heating end of the rod, because of the melting of wax. Thus, it can be concluded that heat has transferred through particles of the rod, starting from heating end. Here, the heat transfers from one particle to the other.

This method of transferring heat from particle to paricle without the motion of particles through a solid, is known as conduction of heat.

Most of the metals conduct heat well. They are known as heat conductors.

e.g.:- Iron, Copper, Aluminium, Gold, Silver

Assignment 14.7

Make a report on the substances/ metals that conduct heat.

Substances that do not conduct heat well are known as heat insulators.

e.g.:- glass, wood, plastic, cloth, air, water

Heat conductors as well as heat insulators are important in day-to-day activities.

Figure 14.20 ▲ Instances where heat conductors and heat insulators are used

Assignment 14.8

Find out some other instances where heat conductors and heat insulators are used in day-to-day life.

For extra knowledge

People living in cold countries use woolen clothes to maintain their body temperature (in winter). As woolen clothes are good heat insulators, they prevent losing body heat to the environment.

Convection

You may have seen that small twigs of trees above a large fire are waving. What can be the reason for this?

Heated air near the fire rises up and cool air from downwards flow towards the fire. Heated air currents rising up like this is called convectional currents. When these currents strike with the twigs of trees, they start to wave.

Figure 14.21 ▲ A fire under a tree

Figure 14.22 ▲ Convectional currents of air near a fire

Let us do Activity 14.9 to study further about the way that heat travels through air.

Activity 14.9

You will need :- A tall beaker, a piece of cardboard, a candle, some joss sticks

Method :-

- Cut the piece of cardboard to the shape as shown in the figure.
- Place the piece of cardboard, at the middle of the beaker to divide the inside of it into two chambers.
- Then, place the lighted candle in the side B of the beaker as shown in the figure.
- Light some joss sticks and hold them at the mouth of the beaker on the other side (side A) of the piece of cardboard.
- Observe what happens.
- Now blow out the candle and hold the joss sticks in the side A.
- Observe what happens again.

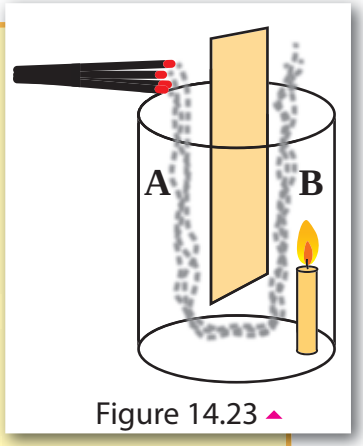


Figure 14.23

It can be observed that the smoke of joss sticks enter into the beaker from side A and comes out from side B.

When heated air rises up from chamber B, where the lighted candle is placed cool air flows down into chamber A. It is clear that the smoke of joss sticks also flow with air currents. Thus, it is clear that heat travels through air as convectional currents.

Let us do Activity 14.10 to find out how heat travels through liquids.

Activity 14.10

You will need :- A few condis crystals, a candle, a burner, a round-bottomed flask, a laboratory stand

Mehtod :-

- Place some condis crystals at the bottom of the flask and cover them with wax.
- Pour water into the flask and heat it.
- Observe what happens.

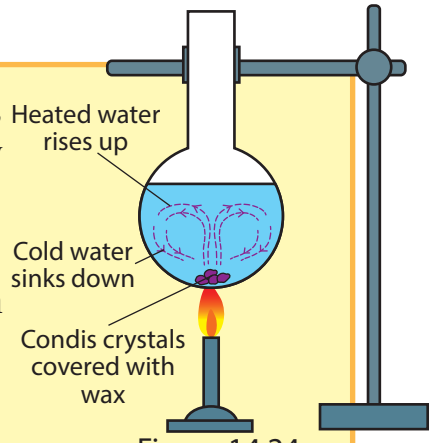


Figure 14.24

It can be observed that purple colour rises up as currents from condis crystals in water, and sinks down near the wall of the flask. Here, water at the bottom of the flask is heated and rises up because of the reduction of its density. Mean while, cold water at the top sinks down because of its higher density.

Rising heated water currents and sinking cold water currents are known as convectional currents. Water in the flask heats because of these convectional currents.

The method of transferring heat through liquids and gases by convectional currents is known as convection.

Assignment 14.9

Make toys operate by convectional currents and display them in classroom.

14.4 Application of convectional currents

Occuring of sea breeze and land breeze

Sea breeze

Wind that blows from the sea towards the land is known as sea breeze. Sea breeze occurs in day time.

During day time land area heats faster than the sea water because of the solar heat. This cause the layer of air contacted with the land to heat and rise up as convectional currents. To fill the low pressure area created on the land, air currents flow from the sea towards the land. This is known as sea breeze.

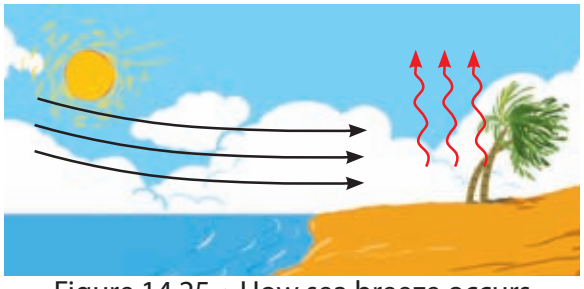


Figure 14.25 ▲ How sea breeze occurs

Land breeze

Wind that blows from land towards the sea is known as land breeze. Land breeze occurs at night.

During night time the temperature of land area decreases faster than the sea water. Therefore, land area cools faster. Because of the high temperature of sea water, the layers of air contacted with sea water get heated and rise up as convectional currents. To fill the low pressure area created on the sea, air currents flow from the land towards the sea. This is known as land breeze.

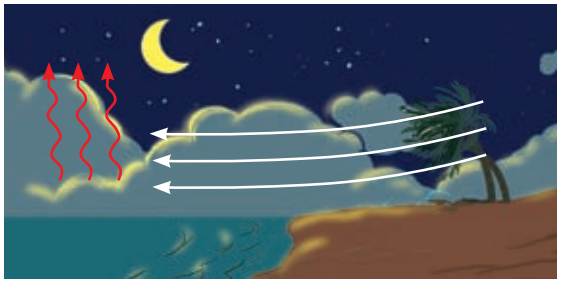


Figure 14.26 ▲ How land breeze occurs

For extra knowledge

It is with the support of the land breeze that fishermen launch their sail boats to the sea in the night time. They return back to the shore in day time with the support of sea breeze.

Assignment 14.10

Prepare a list of other applications/ important occasions associated with convectional currents.

Radiation

The method of heat transfer, without participation of the particles of a medium is known as radiation. Heat travels from the sun to the earth by radiation.

We feel warm when we are near a fire or a heated object, because heat travels towards our body by radiation.

Any heated object radiates heat.

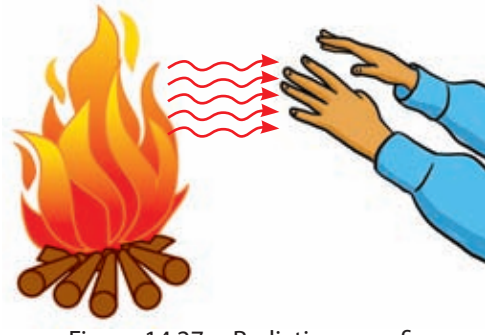


Figure 14.27 ▲ Radiation near fire

Let us do Activity 14.11 to investigate more about radiation.

Activity 14.11

You will need :- Three equal tin cans, three thermometers, cork stoppers, black and white paint, cold water, few pieces of cardboard, stop clock

Figure 14.28 ▲

Method :-

- Keep one tin can as it is, with the shining outer surface. Paint one of the other tin cans with black paint and final one with white paint (See Figure 14.28).

- Add equal volume of cold water into each tin. Fix a thermometer to each tin can as shown in the figure and measure the initial temperature
- Place all the three cans in the same place in the sun. Measure the temperature in every five minutes time and tabulate the readings.

Time (min)	Temperature of water in the cans (^{0}C)		
	Black can	White can	Can with shining surface
0			
5			
10			

After some time, it can be observed that the temperature of water in black can has risen higher than that of both the other cans. Also it can further be observed that the temperature of water in the can with shining outer surface has risen very less.

Water in the tin cans is heated by the solar radiation. It is clear that black colour absorbs radiated heat very fast and polished shining surfaces do so very slowly. White surfaces also absorb radiated heat less than black surfaces.

Black surfaces lose heat very fast while polished, shining surfaces do so very slowly. Therefore, hot water in containers with polished, shining surfaces can be kept hot for a long time.

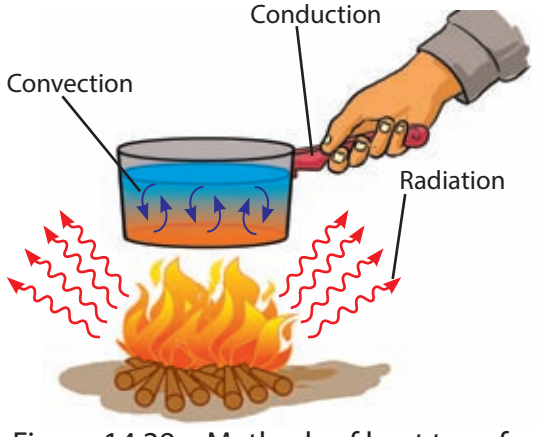


Figure 14.29 ▲ Methods of heat transfer

Countries like Sri Lanka gets more sun light through out the year. Therefore, it is more suitable to use light colours to paint outer walls of the buildings rather than dark colours. It is because light colours absorb radiated heat less, that prevents the interior of the house from heating.

Assignment 14.11

Find and report the outside colour of the vehicle radiators. Discuss the reason for painting radiators in that colour with your teacher.

Summary

- The measurement of coldness or hotness of an object is known as temperature.
- Heat is a type of energy.
- Temperature of an object increases when heat is supplied and it decreases when heat is removed from the object.
- Thermometers are used to measure temperature.
- The property of expansion of a liquid is used in making liquid thermometers.
- Units of measuring temperature are degrees celsius, degrees farenheit and Kelvin.
- Kelvin is the international unit of measuring temperature.
- Clinical thermometer is used to measure body temperature.
- The boiling point (100 ^{o}C) and the freezing point (0 ^{o}C) of water are the fixed points of a liquid thermometer at 1 atm.
- Heat transfers by means of conduction, convection and radiation.

Exercise

1) Select the suitable word to fill the blanks from the words given in the brackets.

i. International unit of measuring temperature is ..... (degrees celsius/Kelvin)
ii. Heat transfers from the sun to the earth by ..... (conduction/radiation)
iii. Aluminium pot on a hearth, heats mainly by getting heat by .... (conduction/convection)

iv. Temperature, at which liquid water converts to ice is called the ... . of water at atmospheric pressure. (boiling point/ freezing point)

v. Sea breeze and land breeze occur because of the phenomenon of ... . in the air. (convection/radiation)

2) Select the correct answer out of those given.

1. The body temperature of a healthy man is;
   1. 0 ^{0}C 2. 37 ^{0}C 3. 98 ^{0}C 4. 100 ^{0}C

2. A substance that conducts heat well is;
   1. Water 2. Air 3. Glass 4. Iron

3. A heat insulating substance is;
   1. Aluminum 2. Copper 3. Paper 4. Lead

4. A liquid that conducts heat well is;
   1. Water 2. Alcohol 3. Mercury 4. Kerosene

5. Warm is felt in a house, where the roof is covered with metal sheets. What is the method of heat transfer into this house?
   1. Expansion 2. Conduction 3. Convection 4. Radiation

Technical Terms

Temperature	-	උෂ්ණත්වය	-	வெப்பநிலை
Heat	-	තාපය	-	வெப்பம்
Freezing point	-	හිමාංකය	-	உறைநிலை
Melting point	-	ද්‍රවාංකය	-	உருகுநிலை
Boiling point	-	තාපාංකය	-	கொதிநிலை
Thermometer	-	උෂ්ණත්වමානය	-	வெப்பமானி
Heat transfer	-	තාප සංක්‍රාමණය	-	வெப்ப இடமாற்றம்
Conduction	-	සන්නයනය	-	கடத்தல்
Convection	-	සංවහනය	-	மேற்காவுகை
Radiation	-	විකිරණය	-	கதிர்ப்பு