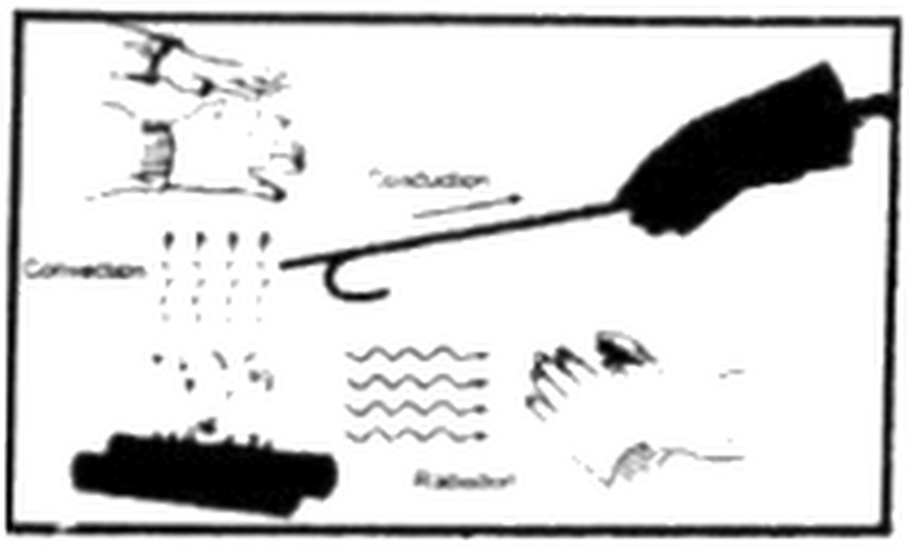
Unit 9

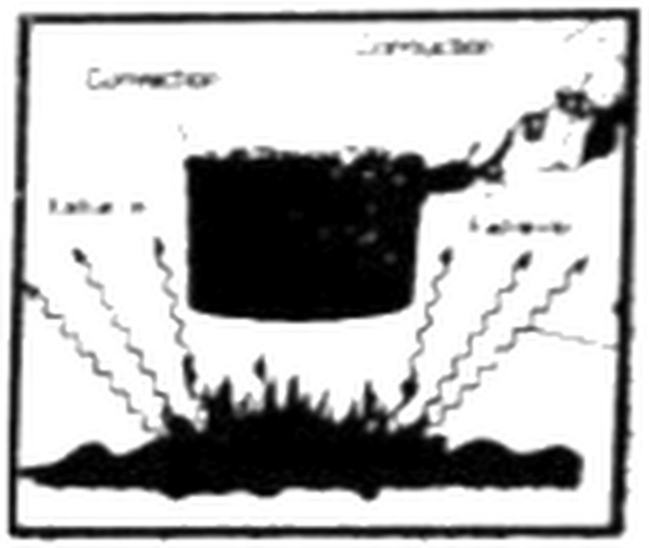
Transfer of Heat

Q1. List three names by which heat can be transfer from one to place to another place?

Ans: Thermal energy from a hot body flows to a cold body in the form of heat. This is called as transfer of heat. There are three ways by which transfer of heat takes place. These are:

- conduction
- convection
- radiation





QUICK QUIZ

Think of objects around us getting heat or giving out heat.

Ans: **(i)** Melting of ice cubes. Ice cube gets heat from the surroundings.

(ii) A hot piece of iron radiate heat.

(iii) A black surface absorbs heat.

(iv) The glass of greenhouse get heat from sun.

Q2. What is meant by conduction?

OR

Describe in terms of molecules and electrons how heat transfer occurs in solids.

Ans: Conduction:

The mode of transfer of heat by vibrating atoms and free electrons in solids from hot to cold parts of a body is called conduction of heat.

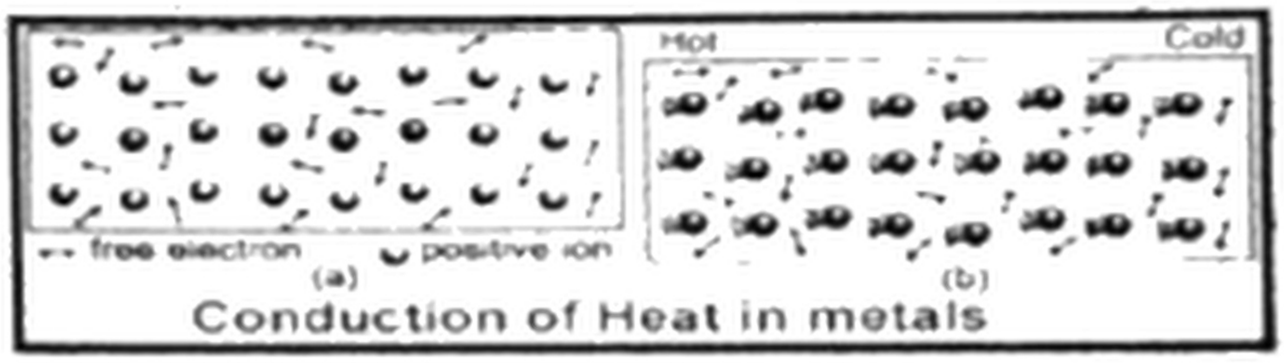
Explanation:

The handle of metal spoon held in hot water soon gets warm. But in case of a wooden spoon, the handle does not get warm. Both the materials behave differently regarding the transfer of heat. Both metals and non-metals conduct heat. Metal are generally better conductors than non-metals.

Conduction in solids:

Transfer of heat takes place from hot to cold parts in solids:

In solids, atoms and molecules are packed close together. They continue to vibrate about their mean position. When one of its ends is heated then the atoms or molecules present at that end begin to vibrate more rapidly. They also collide with their neighboring atoms or molecules. In doing so, they pass some of their energy to neighboring atoms or molecules during collisions with them with the increase in their vibrations. These atoms or molecules in turn pass on a part of the energy to their neighboring particles. In this way some heat reaches the other parts of the solids. This is a slow process and very small transfer of heat takes place from hot to cold parts in solids.



Conduction of Heat in metals

Q3. How does then flow from hot to cold parts in metals so rapidly than non-metals?

Ans: Metals have free electrons. These free electrons move with very high velocities within the metal objects. They carry energy at a very fast rate from hot to cold parts of the object as they move. Thus, heat reaches the cold parts of the metal objects from its hot part much more quickly than non-metals.

All metals are good conductors of heat.

Bad conductors or insulators:

The substances through which heat does not conduct easily are called bad conductors or insulators. Wood, cork, cotton, wool, glass, rubber, etc. are bad conductors or insulators

DO YOU KNOW?

Why Styrofoam boxes are used to keep food hot or ice cream cold for a long time? Styrofoam is a bad conductor of heat. It does not allow heat to leave or enter the box easily.

Q4. Derive relation for thermal conductivity of a substance?

Ans: Thermal conductivity:

Let two opposite faces each of cross-sectional area A is heated to a temperature T_1. Heat Q flows along its length L to opposite face at temperature T_2 in t seconds.

The amount of heat that flows in unit time is called the rate of flow of heat.

Thus Rate of flow of heat = $\frac{Q}{t}$ (i)

It is observed that the rate at which heat flows through a solid object depends upon various factors.

CROSS-SECTIONAL AREA OF THE SOLID:

Larger cross-sectional area A of a solid contains larger number of molecules and free electrons on each layer parallel to its cross-sectional area and hence greater will be the rate of flow of heat through the solid.

Thus Rate of flow of heat $\frac{Q}{t} \propto A$ (ii)

LENGTH OF THE SOLID:

Larger is the length between the hot and cold ends of the solid, more time it will take to conduct heat to the colder end and smaller will be the rate of flow of heat.

Thus Rate of flow of heat $\frac{Q}{t} \propto \frac{1}{L}$ (iii)

Figure Rate at which heat conducts through different solids depends upon various factors.

TEMPERATURE DIFFERENCE BETWEEN ENDS:

Greater is the temperature difference $T_1 - T_2$ between hot and cold faces of the solid, greater will be the rate of flow of heat.

Thus Rate of flow of heat $\frac{Q}{t} \propto (T_1 - T_2)$ (iv)

Combining the above factors i, ii, iii, iv, we get

$$\frac{Q}{t} \propto \frac{A(T_1 \quad T_2)}{L}$$

Rate of flow of heat $$\frac{Q}{t} = \frac{kA(T_1 \quad T_2)}{L}$$

Here k is the proportionality constant called thermal conductivity of the solid.

$$k = \frac{Q}{t} \times \frac{L}{A(T_1 \quad T_2)}$$

Coefficient of thermal conductivity:

Thus, thermal conductivity of a substance can be defined as:

The rate of flow of heat across the opposite faces of a metre cube of a substance maintained at a temperature difference of one kelvin is called the thermal conductivity of that substance.

Unit of thermal conductivity:

$W m^{1} K^{1}$ Or $J m^{1} K^{1} s^{1}$

Q5. Describe the users of conductors and non-conductors with examples?

Ans: Use of conductors and non-conductors:

In houses, good thermal insulation means lower consumption of fuel. For this, following measures may be taken to save energy.

- Hot water tanks are insulated by plastic or foam lagging.
- Wall cavities are filled with plastic foam or wool.
- Ceiling of rooms is covered by insulating materials (false ceiling).

- Double glazed window panes are used. These window panes have air between glass sheets that provides good insulation.

Uses of good conductor:

Good conductors are used when quick transfer of heat is required through a body. Thus cookers, cooking plate, boiler, radiators and condensers of refrigerators, etc. are made of metals such as aluminum or copper. Similarly, metal boxes are used for making ice, ice cream, etc.

Uses of Insulators or bad conductor:

Insulators or bad conductors are used in home utensils such as handles of sauce-pans, hot plates, spoons, etc. They are made up of wood or plastic. Air is one of the bad conductors or best insulators. That is why cavity walls i.e. two walls separated by an air space and double-glazed windows keep the houses warm in winter and cool in summer. Materials which trap air i.e. wool, felt, fur, feathers, polystyrenes, fiber glass are also bad conductors. Some of these materials are used for laggings to insulate water pipes, hot water cylinders, ovens, refrigerators, walls and roofs of houses. Woolen cloth is used to make warm winter clothes.

Soft insulation boards are used between external brick wall of a house.

Q6. List the thermal conductivities of some substances?

Ans: Thermal conductivities of some substances are given the table.

Thermal conductivities of some common substances	
Substance	**$Wm^{-1}K^{-1}$**
Air (dry)	0.026

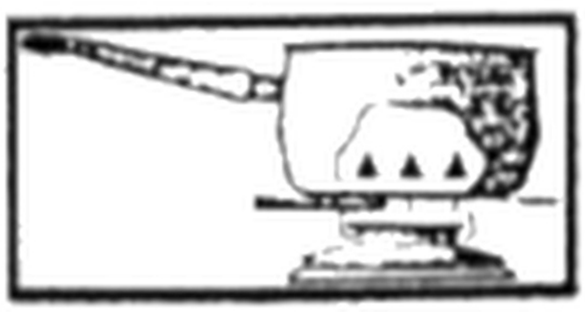
Aluminum	245
Brass	105
Brick	0.6
Copper	400
Glass	0.8
Ice	1.7
Iron	85
Lead	35
Plastic foam	0.03
Rubber	0.2
Silver	430
Water	0.59
Wood	0.08

FOR YOUR INFORMATION

Water is a poor conductor. Water at the top in the test tube starts boiling after getting heat from the burner without melting ice.

DO YOU KNOW

Sauce-pans are made of metal for quick heat transfer.



DO YOU KNOW

Feathers give good thermal insulation especially when fluffed up.

Q7. What is meant by convection current?

OR

Explain convection in sweater to support marine life.

OR

Describe convection in water heating by putting a few pinky crystals in round bottom flask.

Ans: Convection:

Transfer of heat by actual movement of molecules from hot place to a cold place is known as convection.

Liquids and gases are poor conductors of heat. However, heat is transferred through fluids (liquids or gases) easily by another method called convection.

Experiment:

Take a beaker and fill two-third of it with water. Heat the beaker by keeping a burner below it. Drop two or three crystals of potassium permanganate in the water. It will be seen that colored streaks of water formed by the crystals move upwards above the flame and then move downwards from sideways. These colored streaks show the path of currents in liquid. When the water at the bottom of the beaker gets hot, it expands, becomes lighter and rises up. While the cold but denser water moves downward to take its place.

Convection currents in air:

Gases also expand on heating; thus, convection currents are easily set up due to differences in the densities of air at various parts in the atmosphere.

Use of convection currents:

Convection currents set up by electric gas or coal heaters help to warm our homes and offices. Central heating system in buildings work on same principle by convection. Convection currents occur on a large scale in nature. The day-to-day temperature changes in the atmosphere result from circulation of warm or cold air that travels across the region. Land and sea breezes are also the examples of convection currents.

Q8. Why a balloon inflated with hot air rises up?

Ans: A liquid or a gas becomes lighter (less dense) as it expands on heating. Hot liquid or gas rises up above the heated area. The cooler liquid or gas from the surroundings fills the place which in turns is heated up. In this way, all fluid is heated up. Therefore, transfer of heat through the fluids takes place by the actual movement of heated molecules from hot to cold parts of the fluid.

Q9. Why does sea breeze blow during the day? Why does land breeze blow in the night?

Ans: Land and sea breezes:

Land and sea breezes are the result of convection. On hot day, the temperature of the land increases more quickly than the sea. It is because the specific heat of the land increases more quickly than the sea. It is because the specific heat of land is much smaller as compared to water. The air above land gets hot and rises up. Cold air from the sea begins to move towards the land it is called sea breeze.

At night, the land cools faster than the sea. Therefore, air above the sea is warmer, rises up and the cold air from the land begins to move towards the sea it is called land breeze.

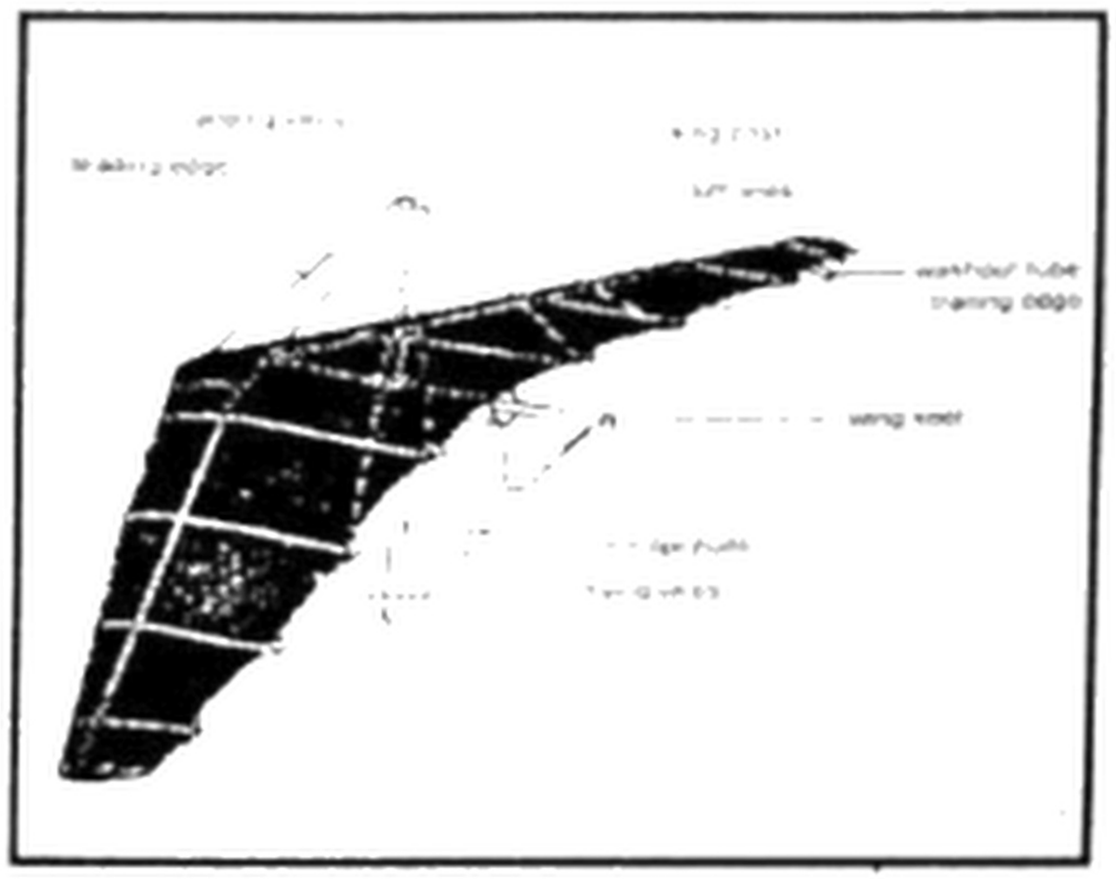
Q10. What causes a glider to remain in the air?

OR

Explain how the birds are able to fly for hours without flapping their wings and glider is able to rise by riding on thermal currents which are streams of hot air rising in the sky.

Ans: A glider looks like a small aero plane without engine. Glider pilots use upward movement of hot air currents due to convection of heat. These rising

currents of hot air are called thermals. Gliders ride over these thermals. The upward movement of air currents in thermals help them to stay in air for a long period.



Q12. How do thermals help birds to fly for hours without flapping their wings?

Ans: The birds stretch out their wings and circle in these thermals. The upward movement of air helps birds to climb up with it. Eagles, hawks and vultures are expert thermal climbers. After getting a free lift, birds are able to fly for hours without flapping their wings. They glide from one thermal to another and thus travel through large distances and hardly need to flap their wings.

Q13. How does heat reach us from the Sun?

OR

Explain the process of radiation?

OR

Explain the energy transfer of a body by radiation does not require a material medium and rate of transfer is affected by:

1. **Colour and texture of the surface**
2. **Surface temperature**
3. **Surface area**

Ans: Radiations:

Radiation is the mode of transfer of heat from one place to another in the form of waves called electromagnetic waves.

Transfer of heat energy from sun to earth:

Our Sun is the major source of heat energy. Sunlight reaches us neither by conduction nor by convection, because the space between the Sun and the Earth's atmosphere is empty. There is a third mode called radiation by which heat travels from one place to another. It is through radiation that heat reaches us from the Sun.

Q14. Why does a cup of hot tea become cold after sometimes?

Ans: When temperature of an object (cup of hot tea) is higher than its surroundings then it is radiating more heat than it is absorbing. As a result, its temperature goes on decreasing till it becomes less than surroundings.

Therefore, a cup of hot tea becomes cold after sometime.

Q15. Why does a glass of chilled (frozen) water become hot after sometimes?

Ans: When temperature of an object (chilled water) is lower than its surroundings, then it is radiating less heat than it is absorbing. As a result, its temperature goes on increasing till it becomes equal to its surroundings. That is why a glass of chilled (frozen) water become hot after sometimes.

Q16. How various surfaces can be compared by a Leslie cube?

OR

Investigate the absorption of radiation by a black surface and silvery surface using Leslie cube. Also investigate the emission of radiation by a black surface and silvery surfaces using Leslie cube.

OR

Explain how rate of energy transfer is affected by:

1. Colour and texture of the surface
2. Surface temperature
3. Surface area

Ans: See Q # 9.10 from exercise

Q17. How does heat reach us directly from a fireplace?

Ans: Heat does not reach us by conduction through air from a fireplace because air is a poor conductor of heat. Heat does not reach us by convection because the air getting heat from the fireplace does not move in all directions. Hot air moves upward from the fireplace. Heat from the fireplace reaches us directly by a different process in the form of waves called radiation. A sheet of paper or cardboard kept in the path of radiations stop these waves to reach us.

Q18. What is greenhouse effect?

OR

Explain the consequences of heat radiation in greenhouse effect and its effect in global warming.

OR

How does the temperature in a greenhouse can be maintained?

Ans: See Q # 9.11 from exercise.

Q19. Explain the impact of greenhouse effect in global warming.

Ans: See Q # 9.12 from exercise.

Q20. Explain application and consequences of radiation?

Ans: Application and consequences of radiation:

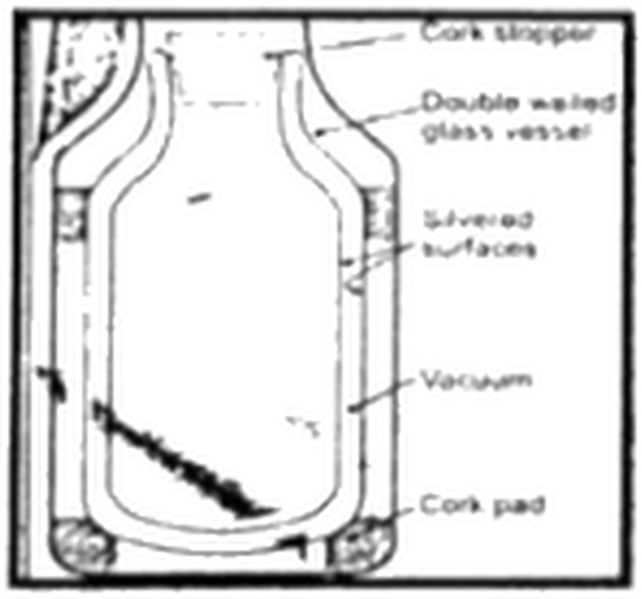
A black and rough surface absorbs more heat than a white or polished surface. Since good absorbers are also good radiators of heat. Thus, a black colored body gets hot quickly absorbing heat reaching it during a sunny day and also cools down quickly by giving out its heat to its surroundings.

The bottoms of cooking pots are made black to increase the absorption of heat from fire. White surfaces reflect more than colored or black surfaces. Similarly, polished surfaces are good reflectors than rough surfaces and reflection of heat radiations is greater from polished surfaces. Hence, we wear white or light-colored clothes in summer which reflect most of the heat radiation reaching us during the hot day.

We polish the interior of the cooking and hot pots for reflecting back most of the heat radiation within them.

FOR YOUR INFORMATION

In a thermos flask, most of the heat is prevented to enter or leave the flask. This is done by suitable measures to reduce the transfer of heat due to conduction, convection and radiation. Thus, anything kept in it, maintains its temperature for a long time.



SUMMARY

1. Heat flows from a body at higher temperature to a body at lower temperature.
2. There are three ways of heat transfer. These are conduction, convection and radiation.
3. **Conduction of heat:** The mode of transfer of heat by vibrating atoms and free electrons in solids from hotter to colder part of a body is called conduction of heat.
4. **Rate of flow of heat:** The amount of heat that flows in unit time is called the rate of flow of heat.
5. The rate at which heat flows through solids depends on the cross-sectional area of the solid, length between hot and cold ends, temperature difference between hot and cold ends and nature of the material.
6. **Thermal conductivity:** The rate of flow of heat across the opposite faces of a metre cube maintained at a difference of 1 K is called the thermal conductivity of the material of the cube.
7. Good conductors are used for quick transfer of heat. Thus cookers, cooking plate, boiler, radiators and condensers of refrigerators etc. are made of metals.
8. Water is a poor conductor of heat.
9. Materials which trap air are also bad conductors such as wool, felt, fur, feathers, polystyrenes and fiber glass.

10. **Convection:** Transfer of heat by actual movement of molecules from hot place to a cold place is known as convection.
11. Land and sea breezes are also the examples of convection.
12. Gliders use upward movement of hot air currents due to convection of heat. Air currents help them to stay in air for a long period.
13. Birds are able to fly for hours without flapping their wings due to the upward movement of air currents.
14. The term radiation means the continual emission of energy from the surface of a body in the form of electromagnetic waves.
15. Radiations are emitted by all bodies. The rate at which radiations are emitted depends on various factors such as colour and texture of the surface, temperature and surface area.
16. A dull black surface is a good absorber of heat as its temperature rises rapidly.
17. A polished surface is poor absorber of heat as its temperature rises very slowly.
18. **Green House**: Radiations from the Sun pass easily through glass/polythene and warms up the materials inside a greenhouse. The radiations given out by them are of much longer wavelengths. Glass/polythene does not allow them to escape out and thus maintains the inside temperature of the greenhouse.
19. Earth's atmosphere contains carbon dioxide and water vapors. It causes greenhouse effect and thus retains the temperature of the Earth.
20. The bottoms of cooking pots are made black to increase the absorption of heat from fire.
21. White surfaces reflect more heat than colored or black surfaces. Similarly, polished surfaces are good reflectors than rough surfaces and reflection of heat radiations is greater from polished surfaces. Therefore, we wear white or light-colored clothes in summer.
22. We polish the interior of the cooking pots for reflecting back most of the heat radiation inside the hot pots.

23. **Thermos flask**: A thermos flask consists of a double-walled glass vessel. It reduces the transfer of heat by conduction, convection and radiation.