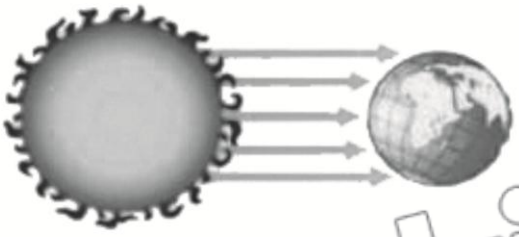


UNIT 9

TRANSFER OF HEAT

9.1 TRANSFER OF HEAT
9.2 CONDUCTION

LONG QUESTIONS

Q.1. What is Conduction? Explain the process and write down it usage in our daily life. ***(K.B+U.B+A.B)***

Ans:

CONDUCTION

Definition:

"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".

Example:

Transfer of heat from one part of a solid rod to its another part is due to conduction. Conduction takes place only on solids because only in this state of matter atoms are very close to each other and can interact each other by their vibrations.

Conduction Process:

In solids, atoms and molecules are packed close together. They continue to vibrate about their mean position. When one end of the solid 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 and 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 solid. This is slow process and very small transfer of heat takes place from hot to cold parts in solid as shown in the figure:

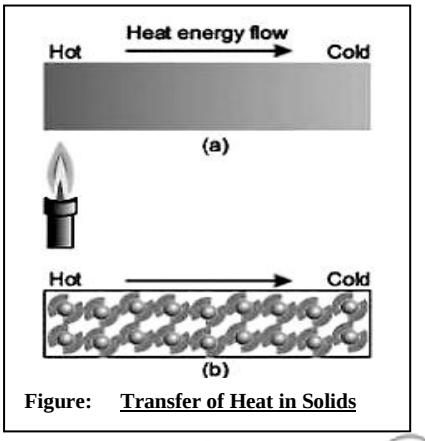


Figure: Transfer of Heat in Solids

Speed of Conduction in Metals and Non – Metals:

Metals have free electrons as shown in figure below:

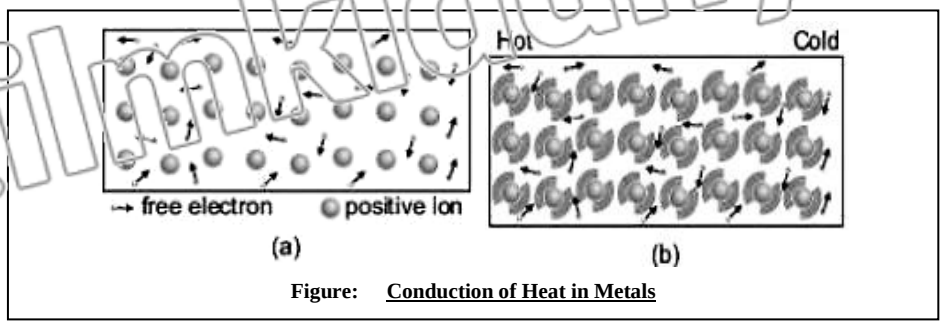


Figure: Conduction of Heat in Metals

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 objects as they move. Thus, heat reaches the cold parts of the metal objects from its hot part much more quickly than non-metals.

Usage in Household Crockery:

The handle of metal spoon held in hot water soon gets warm. But in case of wooden spoon 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.

Bad Conductors:

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

Q.2. Define rate of flow of heat and explain factors affecting it. *(K.B+U.B+A.B)* (GRW 2015)

Ans:

RATE OF FLOW OF HEAT

Definition:

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

Formula:

$$\text{Rate of flow of heat} = \frac{Q}{t}$$

Unit:

The unit of rate of flow of heat is Joule per second (Js^{-1}) that is also called **"Watt"**

Explanation:

Conduction of heat occurs at different rates in different materials. In metals, heat flows rapidly as compared to insulators such as wood or rubber. Consider a solid block as shown in the figure:

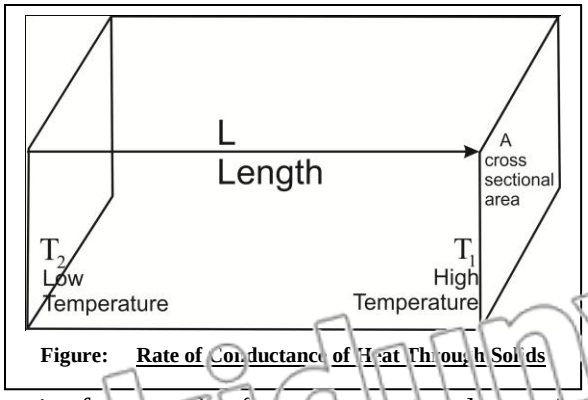


Figure: Rate of Conductance of Heat Through Solids

One of its two opposite faces each of cross – sectional area **A** is heated to a temperature $\mathbf{T_1}$. Heat **Q** flows along its length **L** to opposite face at temperature $\mathbf{T_2}$ in **t** seconds.

Dependence:

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

- Cross sectional area of the solid
- Length of the solid
- Temperature difference between ends

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 $\frac{Q}{t} \propto A$

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 = $\frac{Q}{t} \propto \frac{1}{L}$

Temperature Difference Between Ends:

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

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

Combining above factors, we get

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

Rate of flow of heat $$\frac{Q}{t} = \frac{k\,A(T_1 - T_2)}{L}$$

Thermal Conductivity:

Here k is the proportionality constant called **thermal conductivity of the solid**. Its value depends on the nature of the substance and it is different for different materials. Value of k can be found as:

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

The thermal conductivity of the substance can be defined as:

"The rate of flow of heat across the opposite faces of a meter cube of a substance maintained at a temperature difference of one Kelvin is called the thermal conductivity of that substance**"**

Unit of Thermal Conductivity:

The unit of thermal conductivity is Watt per metre per Kelvin ($Wm^{-1}K^{-1}$).

Examples:

Thermal conductivity of some common substances is as follows:

- Aluminum 245 $Wm^{-1}K^{-1}$
- Copper 400 $Wm^{-1}K^{-1}$
- Water 0.59 $Wm^{-1}K^{-1}$

Q.3. Define and explain thermal conductivity. ***(K.B+U.B+A.B)***

Ans: **THERMAL CONDUCTIVITY**

Definition:

"The rate of flow of heat across the opposite faces of a meter cube of a substance maintained at a temperature difference of one Kelvin is called the thermal conductivity of that substance**"**.

Formula:

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

Unit:

The unit of thermal conductivity is Watt per metre per Kelvin ($Wm^{-1}K^{-1}$).

Explanation:

Conduction of heat occurs at different rates in different materials. In metals, heat flows rapidly as compared to insulators such as wood or rubber. Consider a solid block as shown in the figure:

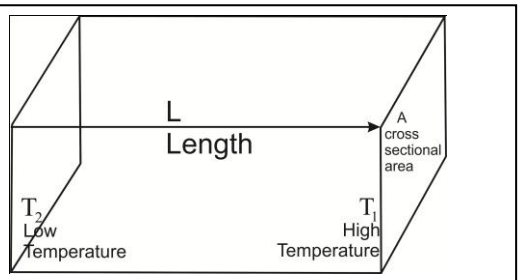


Figure: Rate of Conductance of Heat Through Solids

One of its two opposite faces each of cross – sectional area **A** is heated to a temperature $\mathbf{T_1}$. Heat **Q** flows along its length **L** to opposite face at temperature $\mathbf{T_2}$ in **t** seconds.

We can explain thermal conductivity by explaining rate of flow of heat.

Rate of Flow of Heat:

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

Formula:

$$\text{Rate of flow of heat} = \frac{Q}{t}$$

Unit:

The unit of rate of flow of heat is Joule per second (Js^{-1}) that is also called **"Watt"**

Dependence:

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

- Cross sectional area of the solid
- Length of the solid
- Temperature difference between ends

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 $\text{Rate of flow of heat } \frac{Q}{t} \propto A$

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 = $\frac{Q}{t} \propto \frac{1}{L}$

Temperature Difference Between Ends:

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

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

Combining above factors, we get

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

Rate of flow of heat $$\frac{Q}{t} = \frac{k A(T_1 - T_2)}{L}$$

Thermal Conductivity:

Here k is the proportionality constant called **thermal conductivity of the solid**. Its value depends on the nature of the substance and it is different for different materials. Value of k can be found as:

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

Examples:

Thermal conductivity of some common substances is as follows:

- Aluminum 245 $Wm^{-1}K^{-1}$
- Copper 400 $Wm^{-1}K^{-1}$
- Water 0.59 $Wm^{-1}K^{-1}$

Q.4. Write down the uses of conductors and non – conductors. ***(A.B)*** **(LHR 2015)**

Ans: **USES 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 room 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.
- 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.
- Insulators or bad – conductors are used in utensils such as handles of sauce – pans, hot plates, spoons etc. They are made of wood or plastic. Air is one of the bad conductors or best insulator. 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, polystyrene, and 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.

9.1, 9.2 SHORT QUESTIONS

Q.1 Define transfer of heat write its methods? *(K.B)* **(LHR 2014)**

Ans: **TRANSFER OF HEAT**

Definition:

"Flow of thermal energy from a hot body to a cold body in the form of heat is called transfer of heat**"**.

Transfer of heat is a natural process. It continues all the time as long as the bodies in thermal contact are at different temperature. There are three ways by which transfer of heat takes place.

These are:

- Conduction
- Convection
- Radiation

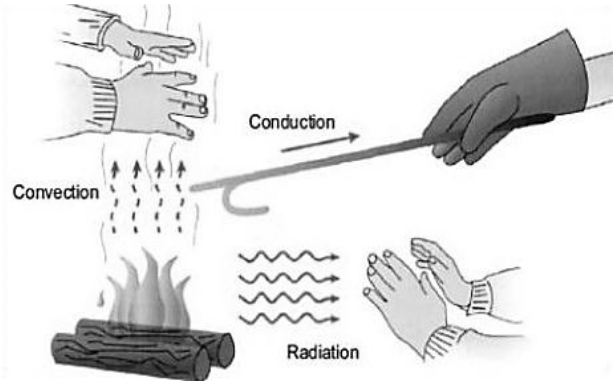


Figure: Three Ways of Heat Transfer

Q.2 Define conduction. *(K.B+U.B+A.B)*

Ans: Given on Page # 332

Q.3 What are Bad conductors or Insulator? Give examples? *(K.B)*

Ans: **INSULATORS**

Definition:

"The substances through which heat does not conduct easily are called bad conductors or insulators**"**.

Examples:

Wood, cork, cotton, wool, glass, rubber etc.

Q.4 What are Conductors? Give examples. *(K.B)*

Ans: **CONDUCTORS**

Definition:

"The substances through which heat can pass easily are called conductors.**"**

All metals are good conductors of heat because of having free electrons.

Examples:

Copper, Iron, Aluminum etc.

Q.5 How does heat flow from hot to cold parts in metals so rapidly than non-metals? *(K.B)*

Ans:

CONDUCTION IN METALS

Metals have free electrons as shown in figure below.

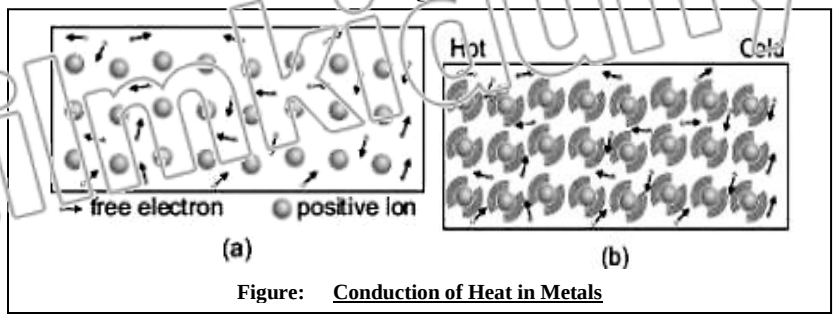


Figure: Conduction of Heat in Metals

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 objects as they move. Thus, heat reaches the cold parts of the metal objects from its hot part much more quickly than non-metals.

Q.6 Why Styrofoam boxes are used to keep food hot or ice cream cold for a long time? *(K.B+A.B)*

Ans:

STYROFOAM

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

Q.7 Define rate of flow of heat write its formula and unit *(K.B+U.B+A.B)*

Ans: Given on Page # 333

Q.8 Define thermal conductivity write its formula and unit. *(K.B+U.B+A.B)*

Ans: Given on Page # 334

Q.9 Draw a chart of thermal conductivities of some substances. *(K.B+U.B+A.B) (Table for MCQS)*

Ans:

VALUES OF THERMAL CONDUTIVITIES

Thermal conductivities of some substances are as follows:

Sr. #	Substance	$Wm^{-1}K^{-1}$	Sr. #	Substance	$Wm^{-1}K^{-1}$
1	Air (dry)	0.026	8	Iron	85
2	Aluminum	245	9	Lead	35
3	Brass	105	10	Plastic foam	0.03
4	Brick	0.6	11	Rubber	0.2
5	Copper	400	12	Silver	430
6	Glass	0.8	13	Water	0.59
7	Ice	1.7	14	Wood	0.08

Q.10 Write down some uses of conductors and non – conductors. ***(A.B)*** **(GRW 2013)**

Ans: Given on Page # 336

EXAMPLE 9.1 *(U.B+A.B)*

The exterior brick wall of a house of thickness 25 cm has an area 20 m^2. The temperature inside the house is 15°C and outside is 35°C. Find the rate at which thermal energy will be conducted through the wall, the value of k for bricks is 0.6 $Wm^{-1} K^{-1}$.

Solution:

Given Data:

Thickness of brick = Length travelled by the heat = L = 25cm = 0.25m

Area of the brick = A = $20m^2$

Inside temperature of the house = $T_1 = 15\ ^oC = 15+273 = 308K$

Outside temperature of the house = $T_2 = 35\ ^oC = 35+273 = 288K$

The value of thermal conductivity for bricks = k =0.6 $Wm^{-1} K^{-1}$

To Find:

Rate of conduction of thermal energy = Q/t = ?

Calculations:

First we find ΔT

We know,

$$\Delta T = T_1 - T_2$$

Putting values,

$$\Delta T = 308 - 288 = 20K$$

We know that,

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

By putting the values, we have

Rate of flow of heat $\frac{Q}{t} = \frac{0.6 \times 20 \times 20}{0.25} = 960$ watts or $960 Js^{-1}$

Result:

Hence, the rate of flow of thermal energy across the wall will be 960 joules per second.

9.1, 9.2 MULTIPLE CHOICE QUESTIONS

1. Water is a: *(K.B)*
(A) Good conductor (B) Insulator
(C) Perfect Conductor (D) Poor conductor

2. Ice is an: *(K.B)*
(A) Good conductor (B) Bad conductor
(C) Perfect Conductor (D) None

3. Methods of transmission of heat are: *(K.B)*
(A) 1 (B) 2
(C) 3 (D) 4

4 Which of the following is best for insulation? *(K.B)*
(A) Glass (B) Air
(C) Brass (D) Fiber glass

5. Transmission of heat from one body to another body by the interaction of atoms and electrons: *(K.B)*
(A) Conduction (B) Convection
(C) Radiation (D) All of above

6. Feathers of the birds are: (K.B)
(A) Conductor (B) Semiconductor
(C) Insulators (D) None of them

7. Which one is (are) the insulator (s)? *(K.B)*
(A) Cork (B) Cotton
(C) Rubber (D) All of them

8. The thermal conductivity of copper is: *(K.B)*
(A) 400 $Wm^{-1}K^{-1}$ (B) 245 $Wm^{-1}K^{-1}$
(C) 0.8 $Wm^{-1}K^{-1}$ (D) 0.6 $Wm^{-1}K^{-1}$

9. The thermal conductivity of Aluminum is: *(K.B)*
(A) 400 $Wm^{-1}K^{-1}$ (B) 245 $Wm^{-1}K^{-1}$
(C) 0.8 $Wm^{-1}K^{-1}$ (D) 0.6 $Wm^{-1}K^{-1}$

10. The thermal conductivity of glass is: *(K.B)*
(A) 400 $Wm^{-1}K^{-1}$ (B) 245 $Wm^{-1}K^{-1}$
(C) 0.8 $Wm^{-1}K^{-1}$ (D) 0.6 $Wm^{-1}K^{-1}$

11. The thermal conductivity of brick is: *(K.B)*
(A) 400 $Wm^{-1}K^{-1}$ (B) 245 $Wm^{-1}K^{-1}$
(C) 0.8 $Wm^{-1}K^{-1}$ (D) 0.6 $Wm^{-1}K^{-1}$

12. Styrofoam is a: *(K.B)*
(A) Conductor (B) Semiconductor
(C) Bad conductor (D) None of them

13. Unit of thermal conductivity is: *(K.B)*
(A) W m^{-1} K^{-1} (B) W m^{-1} K^{-2}
(C) W m^{-2} K^{-1} (D) W m^{2} K^{-1}

9.3 CONVECTION

LONG QUESTIONS

Q.1 What is convection? Explain the process. *(K.B+U.P+A.B)*

Ans:

CONVECTION

Definition:

"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.

Process:

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 the fluid is heated up. Therefore, transfer of heat through fluids takes place by the actual movement of heated molecules from hot to cold parts of the fluid.

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 coloured streaks of water formed by the crystals move upwards above the flame and then move downwards from sideways as shown in the figure:

Figure: Crystals of Potassium Permanganate are Used to Show the Movement of Water on Heating

- These coloured streaks show the path of currents in the 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.

Q.2 What do you know about convection currents in Air? How do land and sea breezes blow?
(LHR 2013, 2014, 2015)

Ans:

CONVECTION CURRENTS IN AIR

Definition:

"Free movement of gaseous molecules from one place to another place due to difference of densities between those places are called convection currents".

Gases also expand on heating, thus convection currents are easily set up due to the differences in the densities of air at various parts in the atmosphere. This can be observed by a simple experimental set up as shown in the figure:

Figure: Smoke Showing the Path of Convection

Explanation:

In above figure air above the candle gets hot, becomes less dense and lighter hence it moves up through chimney **A** leaving vacant space behind it. In order to fill this vacant space cold air enters into the box through chimney **B.** In this way convection currents set up in atmosphere.

Uses of Convection Currents:

Convection currents occur on a large scale in nature. Some uses of convection currents are given below:

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

Land and Sea Breezes:

Land and sea breezes are the result of convection.

Sea Breeze:

On a hot day, the temperature 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 as shown in the figure:

Figure: Sea Breeze Blows From Sea to Land in Daytime

Land 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 as shown in the figure:

Figure: Land Breeze Blows From Land to Sea in During Night

9.3 SHORT QUESTIONS

Q.1 Why a balloon inflated with hot air rises up? ***(K.B)***

Ans: **INFLATED BALOON**

A liquid or a gas becomes lighter (less dense) as it expands on heating that is why a balloon inflated with hot air rises up.

Figure: Balloons Inflated with Hot Air Rise up Air Becomes Lighter on Heating

Q.2 Define convection with examples? ***(K.B)*** **(LHR 2016,17)**

Ans: Given on Page #341

Q.3 What do you know about convection currents in Air? Write down some uses. ***(K.B+A.B)*** **(GRW 2013)**

Ans: Given on Page #341

Q.4 How land and sea breezes are produced? ***(K.B)*** **(LHR 2013, 2014, 2015)**

Ans: Given on Page #342

Q.5 How do land and sea breezes help to keep the temperature moderate in coastal areas? ***(K.B+A.B)***

Ans: **TEMPERATURE IN COASTAL AREAS**

When the land is warmer than the sea in the morning the cooler sea breeze moderates the climate over the land. During night cooler winds over the land move towards the sea thus saving the land from chilly climate in this way land and sea breezes help to keep the temperature moderate in coastal areas.

Q.6 Define thermals and thermal climbers. ***(K.B)***

Ans: **THERMALS**

Definition:

"The rising currents of hot air are called thermals**"**.

Thermal Climbers:

"The birds that use rising currents of hot air for free ride are called thermal climbers.**"**

Examples:

Eagles, hawks and vultures are expert thermal climbers.

Q.7 What is gliding?

OR What causes a glider to remain in air? ***(K.B)***

Ans: **GLIDING**

A glider looks like a small aeroplane without engine. Glider pilots use upward movement of hot air current 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 helps them to stay in air for a long period.

Figure: A Glider

Q.8 What do you know about birds gliding?

OR How do thermals help birds to fly for hours without flapping their wings? ***(K.B)***

Ans: **BIRD GLIDING**

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.

Figure: Bird Fly Taking the Advantage of Thermal Air Currents

Q.9 Explain hot water system? ***(K.B+A.B)***

Ans: Hot water for the taps comes from a large strage tank. The water is heated by a coil of copper pipe, hot water from a boiler flow through this and is recirculated by a pump. In the tank the heated water rises to the top by convection. In this way, a supply to hot water collects from losses by conduction and convection.

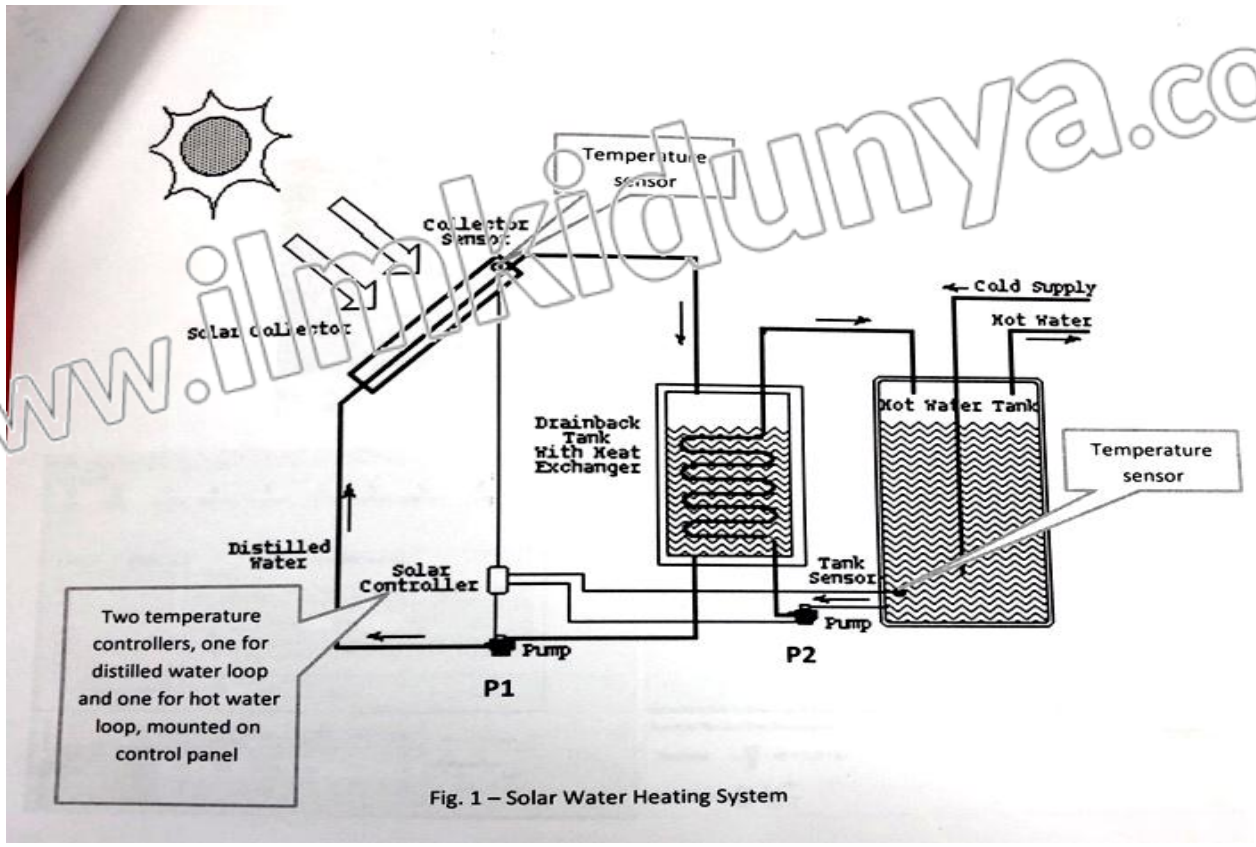


Fig. 1 – Solar Water Heating System

Q.10 Explain the heating of room and cooling in refrigerator with the help of convection? ***(K.B+A.B)***

Ans: The heating of room is possible due to convection. Warm air rises above the convector heater or radiators carries thermal energy all around the room -though unfortunately the coolest air is always around your feet.

In refrigerator cold air sinks below the freezer compartment. This sets up a circulating current of air which cools all the food in the refrigerator.

9.3 MULTIPLE CHOICE QUESTIONS

1. Transfer of heat by the actual movement of molecules: ***(K.B)***

(A) Conduction (B) Convection
(C) Radiation (D) All of above

2. Geysers work on the principle of: ***(K.B)***

(A) Conduction (B) Convection
(C) Radiation (D) All of above

3. Ventilation in our houses is only possible due to: ***(K.B)***

(A) Conduction (B) Convection
(C) Radiation (D) All of above

4. Land and sea breezes are due to: ***(K.B)***

(A) Conduction (B) Convection
(C) Radiation (D) All of them

9.4 RADIATION

9.5 APPLICATIONS AND CONSEQUENCES OF RADIATION

LONG QUESTIONS

Q.1 Define Radiation. How does heat reach us from the sun? Explain Radiation. *(K.B)*

Ans:

RADIATION

Definition:

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

Energy From the Sun:

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

Example (Heat From Fireplace):

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 stop these waves to reach us.

Figure: Heat from Fire Place Reaches us by Radiation

Dependence of Rate of Radiation:

Radiations are emitted by all bodies. The rate at which radiations are emitted depends upon various factors such as:

- Colour and texture of the surface
- Surface temperature
- Surface area

Heat Absorbing and Radiating.

All the objects lying inside a room including the walls, roof and floor of the room are radiating heat. However, they are also absorbing heat at the same time.

Radiation of Heat:

When temperature of an object is higher than its surroundings then it radiating more heat than it is absorbing. As a result, its temperature goes on decreasing till it becomes equal to its surroundings. At this stage, the body is giving out the amount of heat equal to the

amount of heat it is absorbing.

Absorption of Heat:

When temperature of an object 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. The rate at which various surfaces emit heat depends upon the nature of the surface.

Q.2 What is Leslie cube? How various surfaces can be compared by Leslie's cube? *(K.B+A.2)*

(GRW 2014)

Ans:

LESLIE's CUBE

Introduction:

A Leslie's cube is a metal having faces of different nature. It is used to find rate of radiation from different surfaces. A Leslie's cube is shown in figure below:

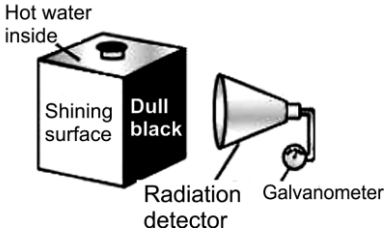


Figure: Radiations From Leslie's Cube

Faces of Leslie's Cube:

The four faces of Leslie's cube may be as follows:

- A shining silvered surface
- A dull black surface
- A white surface
- A coloured surface

Hot water is filled in the Leslie's cube and is placed with one of its face towards a radiation detector. It is found that black dull surface is good emitter of heat. The rate at which various surfaces absorb heat also depends upon the nature of those surfaces.

Example:

Take two surfaces, one is dull black and the other is silver polished surface with a candle at the middle of the surface as shown in the figure:

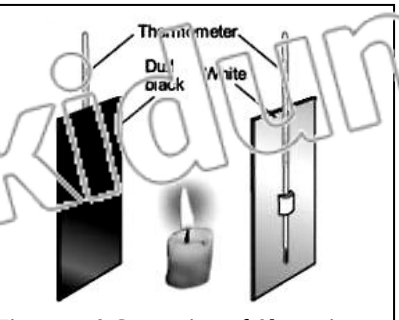


Figure: A Comparison of Absorption of Radiation

It is found that:

- A dull black surface is a good absorber of heat and its temperature rises rapidly.

- A polished surface is poor absorber of heat as temperature rises very slowly. It is also found that the transfer of heat by radiation is also affected by the surface area of the body emitting or absorbing heat.
- Larger is the area, greater will be the transfer of heat. It is due to this reason that large numbers of slots are made in radiators to increase their surface area.

Summary of Observations:

The summary of the observations made from the set up as shown in above figure shown in the table below: (Table for MCQS)

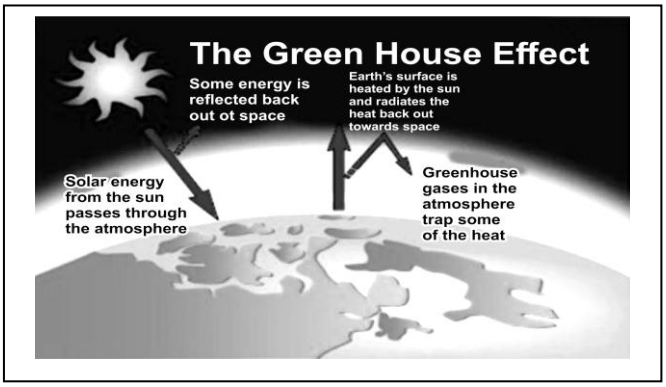
Surfaces	Emitter	Absorber	Reflector
Dull black surface	Best	Best	Worst
Coloured surface	Good	Good	Bad
White surface	Bad	Bad	Good
Shining silvered surface	Worst	Worst	Best

Q.3 How does the temperature in a greenhouse can be maintained?
OR What is greenhouse effect? Explain greenhouse effect in air and its impact in global warming. ***(K.B)*** **(LHR 2013, GRW 2013)**

Ans:

GREEN HOUSE EFFECT

Light from the Sun contains thermal radiations (infrared) of long wavelengths as well as light and ultraviolet radiations of short wavelengths. Glass and transparent polythene sheets allow radiations of short wavelength to pass through easily but not long wavelengths of thermal radiations. Thus, a greenhouse becomes a heat trap. Radiations from the Sun pass easily through glass and warms up the objects in a greenhouse. These objects and plants such as shown in figure below give out radiations of much longer wavelengths.



Glass and transparent polythene sheets do not allow them to escape out easily and are reflected back in the greenhouse. This maintains the inside temperature of the greenhouse. Greenhouse effect promises better growth of some plants.

Greenhouse Effect in Nature:

Carbon dioxide and water also behave in a similar way to radiations as glass or polythene. Earth's atmosphere contains carbon dioxide and water vapours. It causes greenhouse effect on the Earth.

Global Warming:

During the recent years, the percentage of carbon dioxide has been increased considerably. This has caused an increase in the average temperature of the Earth by trapping more heat due to greenhouse effect. This phenomenon is known as **global warming**. This has serious implications for global climate.

Q.4 Explain the application and consequences of Radiations. ***(A.B)***

Ans:

APPLICATIONS AND CONSEQUESCES OF RADIATION

Different objects absorb different amounts of heat radiations falling upon them reflecting the remaining part. The amount of heat absorbed by a body depends upon the colour and nature of its surface.

Black Surface:

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 coloured body quickly absorbing heat reaching it during a sunny day and 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 and Polished Surface:

Like light rays, heat radiators also obey laws of reflection. The amount of heat reflected from an object depends upon its colour and nature of the surface. White surfaces reflect more than coloured 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 coloured 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 within them.

9.4, 9.5 SHORT QUESTIONS

Q.1 Define Radiation. ***(K.B)*** **(GRW 2017)**

Ans: Given on Page #246

Q.2 Why tea in a cup becomes cold earlier as compared to a teapot? ***(K.B)*** **(GRW 2016)**

Ans:

CUP OF TEA

In a teapot there is a large amount of tea and also the mouth of the teapot is narrow, so loss of heat is minimum. On the other hand in a tea cup, there is little amount of tea and the mouth of cup is also large as compared to teapot. Since, larger the surface area, greater will be the heat loss by convection. That is why tea in a cup becomes cold earlier as compare to teapot.

Q.3 On which factors rate of radiation depends? ***(K.B)***

Ans: Given on Page # 246

Q.4 Define Greenhouse Effect. ***(K.B)*** **(LHR 2017)**

Ans: Given on Page # 248

Q.5 What is Global warming?

Ans: Given on Page # 248

Q.6 We wear white and light coloured cloth in summer. Why? ***(K.B)*** **(LHR 2017)**

Ans:

WHITE CLOTHES IN SUMMER

Different objects absorb different amounts of heat radiations falling upon them reflecting the remaining part. The amount of heat absorbed by a body depends upon the colour and nature of its surface.

White and light colours are a good reflector of heat so we wear white and light coloured clothes in summer to avoid heat.

Q.7 We wear black and dark coloured cloth in winter. Why? *(K.B)*

Ans: **BLACK CLOTHES IN WINTER**

Different objects absorb different amounts of heat radiations falling upon them reflecting the remaining part. The amount of heat absorbed by a body depends upon the colour and nature of its surface.

Black and dark colours are a good absorber of heat so we wear black and dark coloured clothes in winter to keep ourselves warm.

Q.8 Draw structure of thermos flask. Why transfer of heat does not take place through it?

Ans: **THERMOS FLASK**

The structure of thermos flak is given below:

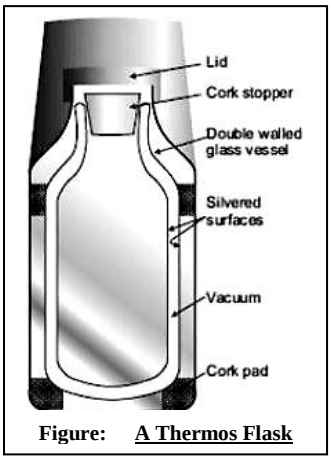


Figure: A Thermos Flask

The thermos flask or vacuum flask can keep drink hot (or cold) for hours. It has these features for reducing the rate at which thermal energy flows out (or in):

1. An insulated stopper to reduce conduction and convection.
2. A double-walked container with a gap between the walls. Air has been removed from the gap to reduce conduction and convection.
3. Walls with silvery surfaces to reduce thermal radiation.

Q.9 Why planet Venus is hottest planet as compared to other one specially mercury?

Ans: Venus is the hottest planet of our solar system but mercury is nearest planet from sun because mercury does not have atmosphere and due to that it does not contain CO_2 and H_2O in its atmosphere. That is why global warming does not happen on mercury but Venus has atmosphere and due to global warming it is the hottest planet in this universe.

9.4 , 9.5 MULTIPLE CHOICE QUESTIONS

1. Transmission of heat by waves without affecting medium on its way: *(K.B)*

(A) Conduction (B) Convection
(C) Radiation (D) All of above

2 Heat from sun reaches us by: *(K.B)*

(A) Conduction (B) Convection
(C) Radiation (D) All of above

3. Global warming in the world is due to: ***(K.B)***

(A) Greenhouse effect (B) Land and sea breezes
(C) Radiation (D) None of them

4. Black surfaces are: ***(K.B)***

(A) Best emitter (B) Good emitter
(C) Worst emitter (D) Poor emitter

5. Shinning silvered surfaces are: ***(K.B)***

(A) Best reflector (B) Good reflector
(C) Worst reflector (D) Poor reflector

6. Coloured surfaces are: ***(K.B)***

(A) Best absorber (B) Good absorber
(C) Worst absorber (D) Poor absorber

7. The gases in the Earth's atmosphere, which causes the greenhouse effect: ***(K.B)***

(A) Carbon dioxide (B) Water vapors
(C) Both A & B (D) None of them

MCQ'S ANSWER KEY (TOPIC WISE)

9.1 TRANSFER OF HEAT

9.2 CONDUCTION

1	2	3	4	5	6	7	8	9	10	11	12
D	B	C	B	A	C	D	A	B	C	D	C

13
A

9.3 CONVECTION

1	2	3	4
B	B	B	B

9.4 RADIATION

9.5 APPLICATIONS AND CONSEQUENCES OF RADIATION

1	2	3	4	5	6	7
C	C	C	A	A	B	C

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

9.1 Encircle the correct answer from the given choices. (*K.B*)

i. In solids, heat is transferred by: **(LHR 2015, GRW 2017)**
(a) Radiation (b) Conduction
(c) Convection (d) Absorption

ii. What happens to the thermal conductivity of a wall if its thickness is doubled? ***(U.B)*** **(GRW 2015)**
(a) Becomes double (b) Remains the same
(c) Becomes half (d) Becomes one forth

iii. Metals are good conductor of heat due to the: ***(K.B)***
(a) Free electrons (b) Big size of their molecules
(c) Small size of their molecules (d) Rapid vibration of their atoms

iv. In gases, heat is mainly transferred by: ***(K.B)*** **(LHR 2015, GRW 2017)**
(a) Molecular collision (b) Conduction
(c) Convection (d) Radiation

v. Convection of heat is the process of heat transfer due to the: ***(K.B)***
(a) Random motion of molecules (b) Downward movement of molecules
(c) Upward movement of molecules (d) Free movement of molecules

vi. False ceiling is done to: ***(K.B)*** **(LHR 2016 , GRW 2017)**
(a) Lower the height of ceiling (b) Keep the roof clean
(c) Cool the room (d) Insulate the ceiling

vii. Rooms are heated using gas heaters by: ***(K.B)*** **(GRW 2016, LHR 2017)**
(a) Conduction only (b) Convection and radiation
(c) Radiation only (d) Convection only

viii. Land breeze blows from: ***(K.B)*** **(LHR 2016)**
(a) See to land during night (b) Sea to land during the day
(c) Land to sea during night (d) Land to sea during the day

ix. Which of the following is a good radiator of heat? ***(K.B)***
(a) A shining silvered surface (b) A dull black surface
(c) A white surface (d) A green colored surface

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
B	B	A	C	C	D	B	C	B

9.2 Why metals are good conductors of electricity? ***(K.B)*** **(GRW2013, 2014, 2016)**

Ans: **METALS ARE GOOD CONDUCTORS**

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 objects as they move, that is why metal are good conductors of heat.

9.3 Explain why?

(a) A metal feels colder to touch than wood kept in a cold place? ***(K.B)***

Ans: **METAL FEELS COLDER**

Conductors have good conduction property. So by touching cold conductors, there is a rapid transfer of heat from our hand to cold conductor and it feels colder. As wood is a bad conductor, so transfer of heat from our hand to wood is very low. Due to this reason, we feel less cold.

(b) Land breeze blows from land towards sea?

Ans: **LAND 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.

(c) Double walled glass vessel is used in thermos flask?

Ans: **DOUBLE WALLED VESSEL**

A double walled glass is used to prevent the flow of heat due to conduction and convetion through the vacuum between double walls of vessel.

(d) Deserts soon get hot during the day and soon get cold after sunset.

Ans: **DESERT SOON GET HOT**

As the specific heat of sand is low, so it absorbs the heat more quickly and gets hot in day. In night, it releases heat more quickly and become cold quickly after sunset.

9.4 Why conduction of heat does not take place in gases? ***(K.B)*** **(GRW 2015)**

Ans: **NO CONDUCTION IN GASES**

Gases are poor conductor of heat because gases do not have fee electrons. Furture more for conduction molecules should be close while in gases molecules have vast spaces. That why gases do not undergo conduction.

9.5 What measures do you suggest to conserve energy in house? ***(K.B)*** **(LHR 2016)**

Ans: **CONSERVATION OF ENERGY**

To conserve energy in our house, following measure may be taken:

- Hot water tanks are insulated by plastic or foam lagging
- Wall cavities are filled with plastic foam or wool
- Ceiling of room is covered by insulating materials (false ceiling)
- Double glazed window panes are used, these windows panes have air between glass sheets that provides good insulation.

9.6 Why transfer of heat in fluids takes place by convection? ***(K.B)*** **(GRW 2015)**

Ans: **CONVECTION IN FLUID**

Liquids and gases are poor conductors of heat due to large distances among their molecules. However, heat is transferred through fluids (liquids or gases) by a method called convection. Heat transfer of heat in fluids takes place by convection because movement of molecules is easy in fluids.

9.7 What is meant by convection current? ***(K.B)*** **(LHR 2013, GRW 2014, 2015)**

Ans: **Given on Page # 341**

9.8 Suggest a simple activity to show convection of heat in gases not given in the book. ***(K.B+U.B)***

Ans: **CONVECTION IN GASES**

In summer, the intense radiations of sun warm the surface of Earth. The air near the surface is also heated and expands. Its density decreases due to increase of volume and it rises up. A colder air comes to fill this gap, due to which conventional currents of air are produced.

9.9 How does heat reach us from the sun? ***(K.B)***

Ans: **HEAT FROM THE SUN**

Heat reaches us neither by conduction nor by convection, because the space between the Sun and Earth's atmosphere is empty. Heat reaches us through a mode called radiations (light waves) from the sun.

9.10 How various surfaces can be compared by Leslie cube? *(K.B)*

Ans: Given on Page # 247

9.11 What is greenhouse effect? **(LHR 2015, GRW 2018)**

Ans: Given on Page # 248

9.12 Explain the impact of green-house effect in global warming.

Ans: Given on Page # 248

NUMERICAL PROBLEMS

9.1 The concrete roof of a house of thickness 20 cm has an area 200 m^2. The temperature inside the house is 15^0 C and outside is 35^0 C. Find the rate at which thermal energy will be conducted through the roof. The value of k for concrete is 0.65 $Wm^{-1}K^{-1}$. (U.B + A.B)

Solution:

Given Data:

Thickness of the roof = L = 20 cm = 0.2 m

Area of the roof = A = 200 m^2

Temperature outside the house = $T_1 = 35^0$ C = (35 + 273) K = 308 K

Temperature inside the house = $T_2 = 15^0$ C = (15 + 273) K = 288 K

Coefficient of thermal conductivity = k = 0.65 $Wm^{-1}K^{-1}$

To Find:

Rate of conduction of energy through the roof = Q/t = ?

Calculations:

As we know that

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

By putting the values, we have

$$\text{Rate of flow of heat} = \frac{Q}{t} = \frac{0.65 \times 200 \times (308 - 288)}{0.2}$$

$$\text{Rate of flow of heat} = \frac{Q}{t} = \frac{130 \times 20}{0.2}$$

$$\text{Rate of flow of heat} = \frac{Q}{t} = \frac{2600}{0.2}$$

$$\text{Rate of flow of heat} = \frac{Q}{t} = 13000 Js^{-1}$$

Result:

Hence, the rate of conduction of energy through the roof will be 13000 Js^{-1}.

9.2 How much heat is lost in an hour through a glass window measuring 2.0 m by 2.5 m when inside temperature is 25°C and that of outside is 5°C, the thickness of glass is 0.8 cm and the value of k for glass is 0.8 $Wm^{-1}K^{-1}$?

Solution:

Given Data:

Area of the window = A = 2.0 m x 2.5 m = 5.0 m^2

Thickness of the glass = 0.8 cm = 0.0008 m

Temperature inside the window = T_1 = 25° C

Temperature outside the window = T_2 = 5° C

Coefficient of thermal conductivity = k = 0.8 $Wm^{-1}K^{-1}$

To Find:

Heat lost through the glass = Q = ?

Calculations:

As know that,

$$Q = \frac{kA(T_1 - T_2) \times t}{L}$$

By putting the values, we have

$$Q = \frac{0.8 \times 5 \times (298 - 278) \times 3600}{0.008}$$

$$Q = \frac{4 \times 20 \times 3600}{0.008}$$

$$Q = \frac{288000}{0.008}$$

$$Q = 36000000 \text{ J}$$

$$Q = 3.6 \times 10^7 \text{ J}$$

Result:

Hence, the heat lost through a glass will be 3.6×10^7 J.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. (6×1=6)

1. What happens to the thermal conductivity of a wall if its thickness is doubled?

(A) Becomes double (B) Remains the same

(C) Becomes half (D) Becomes one fourth

2. Land breeze blows from:

(A) Sea to land during night (B) Sea to land during the day

(C) Land to sea during night (D) Land to sea during the day

3. Air & water are:

(A) Poor conductor (B) Good conductor

(C) Excellent conductor (D) All of these

4. Flow of thermal energy from hot body to cold body is called:

(A) Specific heat (B) Latent heat

(C) Transfer of heat (D) Heat capacity

5. Which surface reflected more radiations?

(A) White (B) Coloured

(C) Black (D) Rough

6. Leslie's cube is a box of:

(A) Metal (B) None-metals

(C) Wood (D) Metalloids

Q.2 Give short answers to following questions. (5×2=10)

i. What causes a glider to remain in air?

ii. The rate at which radiations emitted by a body, depends upon which factors?

iii. How do the land and sea breezes help to keep the temperature moderate in coastal areas?

iv. Why conduction of heat does not take place in gases?

v. Why deserts soon get hot during the day and soon get cold after sunset?

Q.3 Answer the following questions in detail. (4+5=9)

a) What are the applications and consequences of radiation?

b) The exterior brick wall of a house of thickness 25 cm an area 20 m^2. The temperature inside the house is 15^o C and outside is 35^o C. Find the rate at which thermal energy will be conducted through the wall, the value of k for bricks is 0.6 $W\,m^{-1}\,K^{-1}$.

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.