Chapter = 09

TRANSFER OF HEAT

TRANSFER OF HEAT

Definition:- The flow of heat from hot region to cold region is known as transfer of heat. OR
The exchange of thermal energy between physical systems is known as transfer of heat. OR
The movement of heat from one substance or material to another is known as transfer of heat.

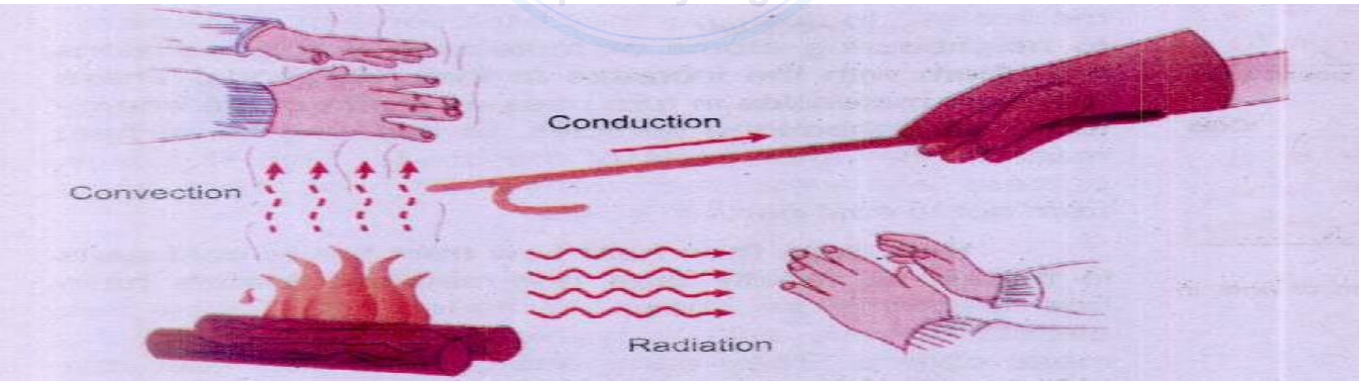
Cause:- It occurs due to **"Temperature difference".**

Explanation:- As we know that It is a natural process. It continues all the time as long as the bodies in thermal contact are at different temperature.

MODES OF TRANSFER OF HEAT

There are three different ways (modes) of heat transfer which are given below.

(1) Conduction of heat.
(2) Conviction of heat.
(3) Radiation of heat.



(1) CONDUCTION OF HEAT

Definition:- The process by which heat energy transferred from particle to particle by collision is called Conduction of heat. OR
The flow of thermal energy (Heat) through matter from places of higher temperature to places of lower temperature without movement of the matter as a whole is known as

conduction.

Causes of conduction of heat:-

(i) Vibrations of atoms in the metals**.**

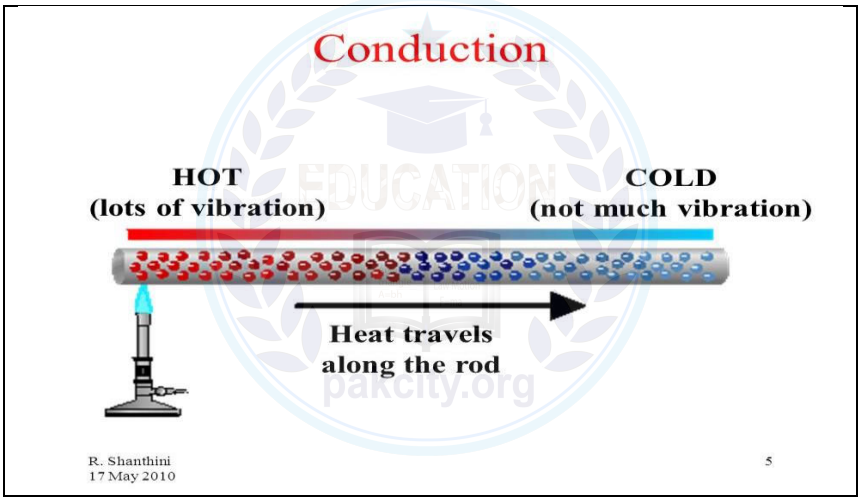
(ii) Motion of free electrons present in the metals.

Mechanism of conduction of heat: - The mechanism of conduction of heat can be explained by two ways, which are the following.

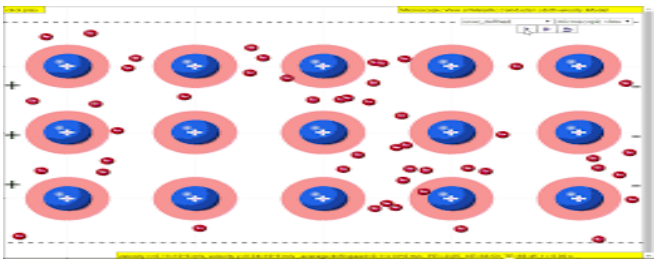
(1)Vibration of atoms in the metals:-

The solid iron rod (metal) is made of closely packed iron atoms as shown in figure.

Initially these atoms vibrates about their mean position. As the flame heats the rod, the iron atoms near the flame begin to vibrate with a greater speeds and wider distance. These widely vibrating atoms collide with their neighboring atoms and transfer some of their energy to these atoms. Which in turn pass thermal energy to their own neighbors and so on.



(2)Motion of free electrons in the Metals:- Iron is a metal and contain a large number of electrons that are free to move through the metal called free electrons. These electron plays a big part in the conduction of heat. For example, when one end of the metal rod is heated, the atoms in the heated part vibrate more with greater speeds as shown in figure. The free electrons that collide with these atoms gain kinetic energy and move faster. They diffuse into the colder part of the metal where collisions with other free electrons and atoms take place which result in the transfer of energy. So such type of heat transfer is known as conduction of heat.

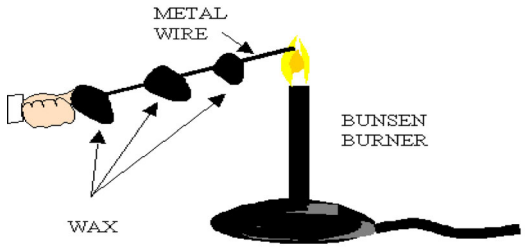


Note:- In figure the red colours represents the free electrons.

Explanation and Activity:-

It has been observed that the heat gets transferred from the hotter object to the colder object. To observe this situation we will perform the following an activity.

(i)Take a metal wire and put wax on it at regular interval points.
(ii)Hold one end of the wire by hand with the help of an insulator like cloth.
(iii)Heat the other end of the metal strip by burner.



We will observe that as the end being heated becomes hotter, it gradually transfers heat to the other end. This is shown by the melting of the wax pieces placed at intervals. This is because conduction of heat is taking place.

GOOD AND BAD THERMAL CONDUCTORS

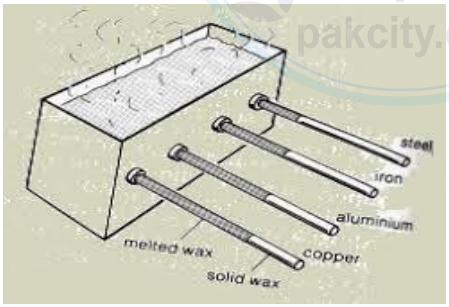
Good Conductors : -
Definition:- Materials that allow heat to pass through them easily are known as good conductors of heat. OR
Materials that are good conductors of thermal energy are known as thermal conductors.
Other Name:- They are also called heat conductors.
Explanation:- As we know that all the metals are the best heat conductors. They contain a large number of free electrons. They have high thermal conductivity value.
Examples: - Iron, Copper, Aluminium and silver etc.
Bad Conductors or Heat Insulator:-
Definition:-Materials that do not conduct heat as easily and quickly as metals do are called bad conductors. OR
Materials that are poor conductors of thermal energy are called thermal insulators.
Other Name:- They are also called **Heat Insulators.**
Explanation:- As we know that all the insulators are the poor heat conductors. They contain no free electrons. They have low thermal conductivity value.

Examples: - Rubber, Wood, Paper, Mica, Plastic and plastic etc.

GOOD CONDUCTORS	BAD CONDUCTORS
Materials that are good conductors of thermal energy are known as thermal conductors.	Materials that are poor conductors of thermal energy are called thermal insulators.
They are also called heat conductors.	They are also called **Heat Insulators.**
They contain a large number of free electrons.	They contain no free electrons.
They have high thermal conductivity value.	They have low thermal conductivity value.
Examples:- Iron, Copper, Aluminium and	**Examples: -** Rubber, Wood, Paper, Mica, and plastic etc.

COMPARISON OF CONDUCTING ABILITY OF DIFFERENT METALS

Explanation:- Take four rods, one each of Aluminium, Copper, Iron and Steel. Cover the rods with molten wax and the wax solidifies when it drops on the rods as shown in figure.



Now put one end of each rod into a hot water. After some time the wax will start to melts on the four rods to a different length. For example the length of wax melt on the copper rod is large as compared to the other three rods, which show that heat is easily conducted by copper.

The following table show materials for good and bad conductors.

Ser	Good Conductors	Bad Conductors
1	Silver	Glass
2	Copper	Asbestos
3	Aluminium	Wood
4	Brass	Water
5	Iron	Cork
6	Lead	Cotton wool
7	Mercury	Air

Conduction in Solid:- The metallic solid contain closely packed atoms and free electrons. These atoms and electrons play an important role in the conduction of heat from one place to another place. These atoms and electrons have greater rate of conductive collision, so the conduction is easily occur in metallic solid. For example copper is good conductor of heat.

Conduction in liquid:- In liquids, the intermolecular distance is larger as compare to solids. Thus the rate of conductive collision in liquids is smaller than that of metallic solids. So liquids are poor conductor of heat. For example water is poor conductor of heat.

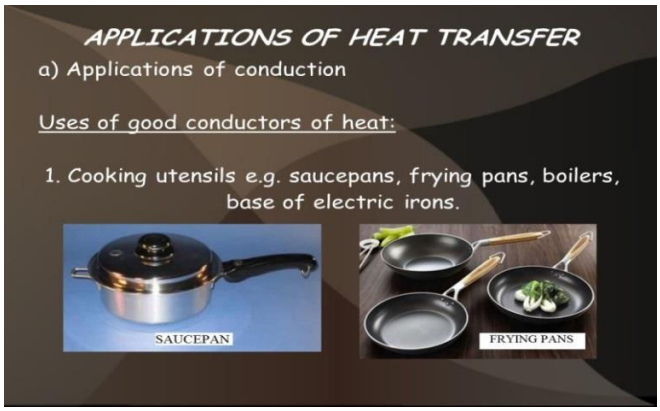
Conduction in gases: - In gases the intermolecular distance between the particles is very large. Thus the rate of collision in gases is very smaller is compare to solids and liquids. So the gases are the poorest conductor of heat. The conductivity of air is twenty times smaller than that of water.

Rate of conduction in solids > than liquids > than gases

PRACTICAL APPLICATIONS OF CONDUCTORS OF HEAT

The good as well as bad thermal conductors have many useful applications in our daily life which are given below.

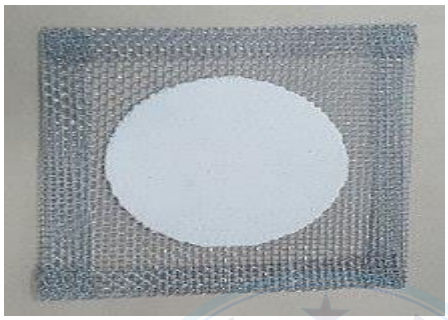
(A)Cooking pots and pans:- Cooking pots and pans are made of metals which are good thermal conductors. They conduct heat readily to the food inside and to spread it evenly.



(B) Plastic Foam:- Plastic foam and fibreglass insulators are used in the walls and ceilings of

our homes to keep them cool in summer and warm in winter seasons. These materials are good insulators because they contain tiny pockets of trapped air and the air is bad conductor of heat.

(C) Wire Gauze: - Wire gauze is often placed over a flame to conduct heat outwards from the flame. A glass beaker can safely be heated on the gauze because this protects it from the concentrated heat of the flame.



(D) Pot holders and table mates:- Pot holders and table mates for hot pans are made of poor conductors such as cloth and wood. Thus use of poor conductors avoid burning of hands.

(E) Woollen clothes: - Woollen clothes have fine pores filled with air. Air and wool are bad conductors of heat. Thus the heat from our body does not flow out to the atmosphere. Thus the woollen clothes' keep the body warm in winter.

(F) Igloos:- It is a type of shelter (house or hut) built of snow. They are made are constructed from the ice and snow to provide protection from wintery conditions. One reason that igloos do their job so well is that the and snow act as thermal insulation and minimize the loss of heat from the inside due to conduction.

(G) Ice box: - Ice box has a double wall, made of tin or iron. The space between the two walls is filled with cork which is poor conductors of heat. The cork prevents the flow of outside heat into the box, thus keeping the ice from melting.

(H) Soldering :- During soldering objects are in direct contact such as the soldering iron and the circuit board , heat is transferred by conduction.

RATE OF HEAT FLOW

Definition:- The amount of heat that flows in unit time is known as rate of heat flow.

Mathematical form:-

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

Unit:- Its SI unit is Joule per second (J/s or Js^{-1}).

Factors of rate of heat flow:- The rate of flow of heat through a medium depends upon the following factors.

(i) Length of solid substance.

(ii) Cross-section area of the solid substance.

(iii) Temperature difference between the ends.

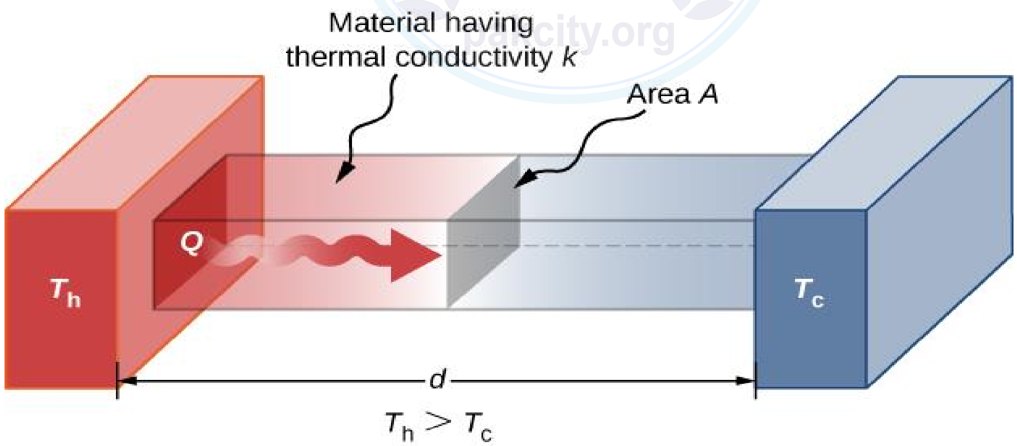
THERMAL CONDUCTIVITY

Definition: - It is the measure of the ability of a substance to conduct heat energy. OR

The rate of flow of heat across the opposite faces of a meter cube maintain at a difference of one kelvin is known as thermal conductivity.

Symbol: - It is denoted by **k**.

Explanation: - Consider a metal rod of length **"L"**, area of cross section **"A"** is heated to a temperature **"** T_h **"**. Heat **"Q"** flows on its length **"L"** opposite face at temperature " T_c" in **"t"** seconds.



From experiments:-

(1) Heat Q is directly proportional to the area of cross section A of the metal rod i.e.

$$Q \propto A \quad \text{......(1)}$$

(2) Heat Q is directly proportional to the temperature difference i.e.

$$Q \propto \Delta T \quad \text{...... (2)}$$

(3) Heat Q is directly proportional to the time difference i.e.

$$Q \propto t \quad \text{..... (3)}$$

(4) Heat Q is inversely proportional to the L i.e.

$$Q \propto \frac{1}{L} \quad \text{..... (4)}$$

By combining the above equations we get

$$Q \propto \frac{A\,\Delta T\ t}{L}$$

$$Q = \text{Constant}\ \frac{A\,\Delta T\ t}{L}$$

Constant = k

$$Q = k\ \frac{A\,\Delta T\ t}{L} \quad \text{----------} \quad (5)$$

In equation (5) k is constant of proportionality and is known as thermal conductivity of the metallic substance and its value depend upon the nature of the material.

For "k" Equation (5) can be written as

$$k = \frac{QL}{A\,\Delta T t} \qquad \text{Where} \quad \Delta T = T_1 - T_2$$

Unit: -

The SI unit of thermal conductivity is watt per meter per kelvin ($W\ m^{-1}\ K^{-1}$ or $J\ m^{-1}\ K^{-1}\ s^{-1}$).

The thermal conductivities of some materials at room temperature

Material	k, w/m°C
Diamond	2300
Silver	430
Copper	400
Gold	320
Aluminium	240
Iron	80
Glass	0.8
Brick	0.7
Water	0.61
Wood	0.17
Helium	0.15
Air	0.026

CONVECTION OF HEAT

Definition: - The process by which heat transfer from hot place to cold place due to the actual motion of the heated particles is known as convection. OR

The transfer of heat from one place to another by the bulk motion of fluids is known as convection. OR

The transfer of heat by the actual movement of molecules from hot place to cold place is known as convection.

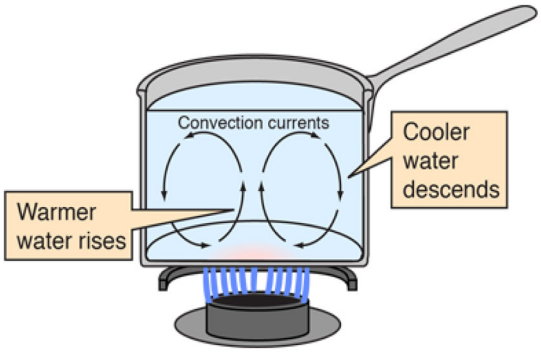
Explanation:- It occurs only in fluids. It cannot occur in solids as the atoms in a solid are located in fixed positions and cannot change place. For the same reason convection occur very easily in gases. This process also cannot occur in vacuum due to the absence of material medium.

Activity: - Take some water in a beaker and drop few crystals of potassium permanganate in it. Heat gently the water. We will be sea that streakes of purple colour of water begain to rise and cold water from the sides takes its place. The water will go on circulating and becomes hotter and hotter. In this way each part of water is heated in turn. The current set up in this process is known as convection current.

Convection Current: - A current in a fluid due to convection is called convection current.

Mechanism of heat convection: -

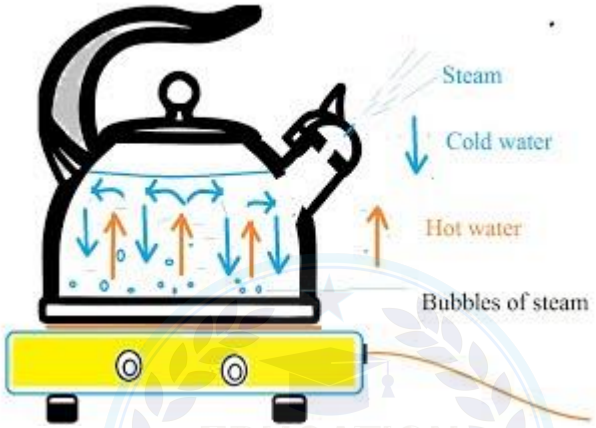
The heated portion of water at the bottom of the expands and becomes less dense. Since the warm water is less dense so it will moves upward to the surface of the water and its place take by a cold and dense water around it. The cold water which absorb heat energy from the hotter place will expand and moves upward. Thus a continuous flow is create from the bottom the top of the water which is known as convection current.



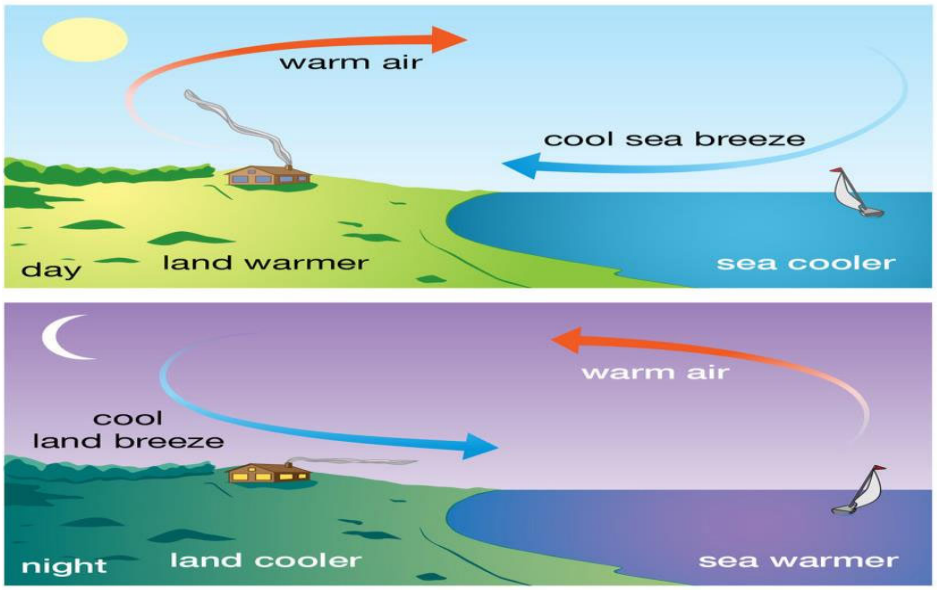
PRACTICAL APPLICATIONS OF HEAT CONVECTION

The following are few practical applications of heat convection.

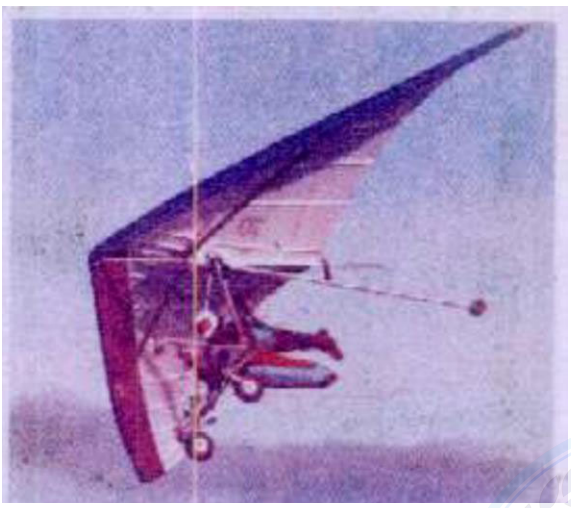
(A).Heating Water: - If it were not for convection currents, it will be very difficult to boil water. The lower layers of water in an electric kettle are warmed first. These heated water expands and move upward to the top because its density lowered. Meanwhile dense cool water replaces the warm water at the bottom of the kettle so that it can also be heated.

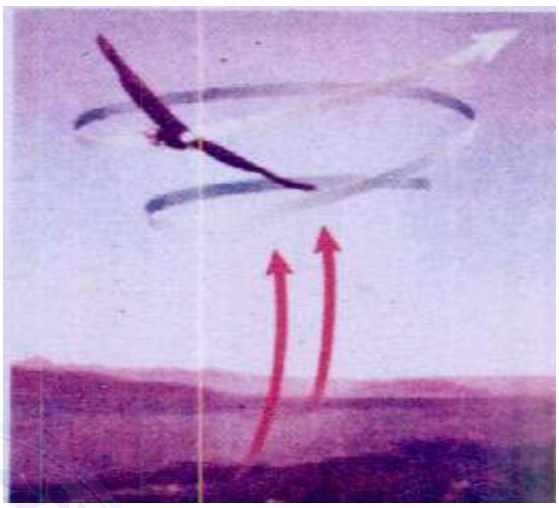


(B) Sea Breeze and Land Breeze: - Convection causes coastal breeze. During the day the land heats up more quickly than the sea. The hot air over the land rises and the cold air from the sea blows to replace it. Thus there is a sea breeze during the day. At night the reverse happens. The land cools more quickly than the sea. The hot air over the sea rises and the cold air from the land blows to replace it. This movement of air is called land breeze.



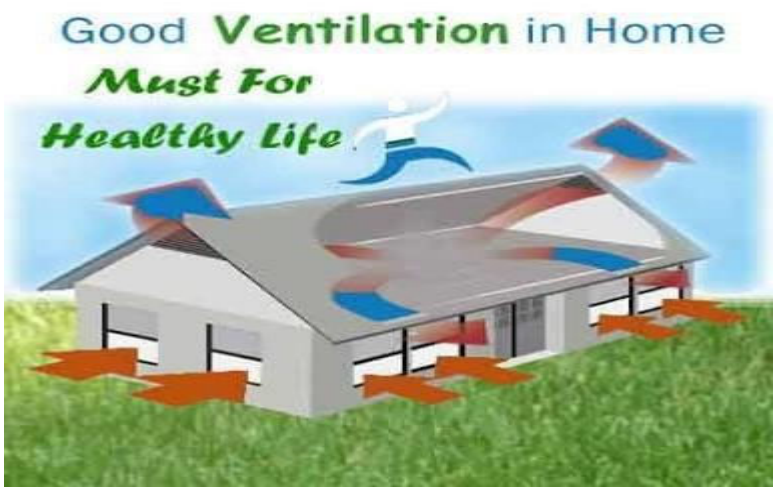
(C)Riding on Thermal: - Thermals are streams of hot air rising in the sun. They are convection current. Birds are able to fly for hours on thermals without flapping their wings. Similarly glider aeroplanes are able to rise by ridding on the thermals.





(D)Refrigerator: - In a refrigerator, convection is used to circulate cold air around the food. Air is cooled by the freezer compartment at the top of the refrigerator. As it sinks , it is replaced by the warmer air rising from the below. The circulating air carries heat energy away from all the food in the fridge.

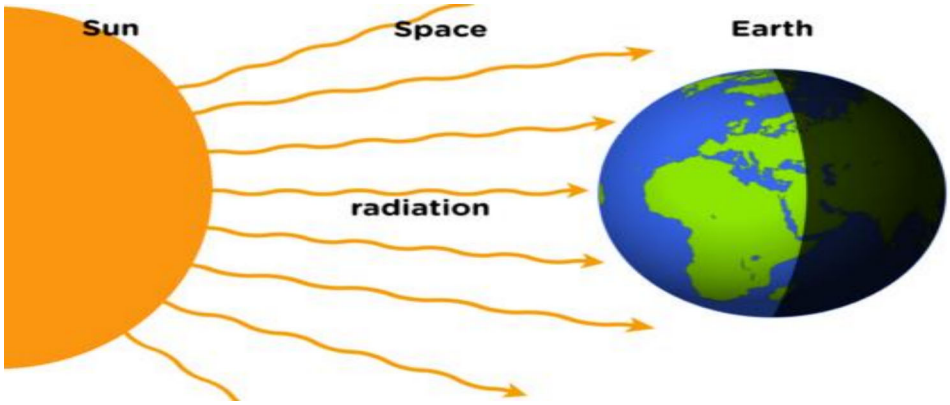
(E)Ventilation: - Convection currents are used in ventilation. The rooms or halls have ventilators installed near the ceiling. The warm and stale air inside the room rises and escapes through the openings near the ceiling. Fresh and cold air is drawn into the room or hall through the doors and windows. Similarly smoke and hot gas from the fires in houses and factories rise up and escape through chimneys.



Note:-
(i) The brown colour arrows represents the fresh and cold air.
(ii) The blue colour arrows represents the hot air.

RADIATION OF HEAT

Definition:- The process by which heat is transferred from one place to another with or without a material medium is known as radiation of heat.
Cause:- Electromagnetic waves.
Mechanisms of radiations of heat:- The mechanisms of radiation is energy transfer by electromagnetisms. Conduction and convection requires a material medium. Transfer of by radiation does not necessarily require a material medium. The mechanisms of radiation is transfer by electromagnetic waves. Radiation can transfer energy via a vacuum or empty space as well as via material medium like glass. The mechanisms of radiation is not molecular motion. It is an electromagnetic phenomenon.



Electromagnetic radiation comes from accelerating electric charges.

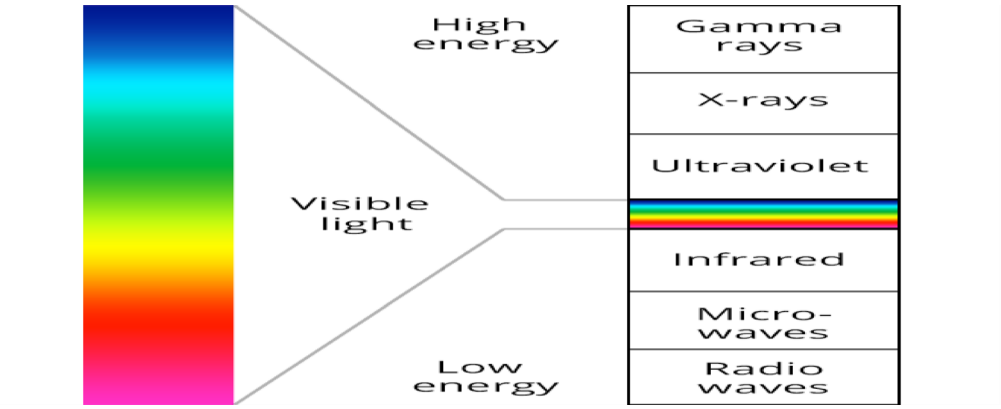
DIFFERENCE BETWEEN CONDUCTION, CONVECTION AND RADIATION

pakcity.org	CONDUCTION	CONVECTION	RADIATION
Energy Transfer	By direct contact	By matter motion	By electromagnetic waves.
Cause	Temperature difference	Density difference	From all hot objects at temperature > 0K
Need of path	No specific path	No specific path	Radiation travel in a straight line path
Medium	Need medium	Need medium	Does not medium
In vacuum	Not possible	Not possible	Possible
Laws of reflection and refraction	Not obeys	Not obeys	Obeys
Speed	Slow	medium	Fast

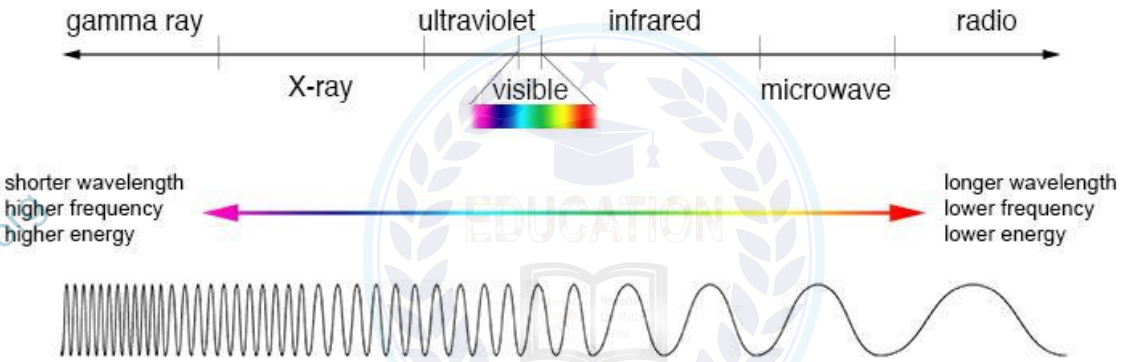
RADIATION OF HEAT

Definition: - Radiation emitted by a body due to its temperature is known as thermal radiation. Thermal radiation from a body takes place at all temperatures. In these radiations we define three of them which are given below.

i. **Light: -** The visible radiation is called light.
ii. **Infrared: -** Radiation less energetic than light is called infrared radiation.
iii. **Ultraviolet: -** Radiation more energetic than light is called ultraviolet radiation.



Every object radiate all the time, but we can see those radiation which are in visible region of the electromagnetic spectrum.



GOOD AND BAD EMITTERS AND ABSORBERS

Some surfaces are better absorbers of radiation than others, a black colour absorbs most and white reflects most. A dull black kettle absorbs heat better than a silver kettle. Standing in the sun, a black car warms up more quickly than car of any other colour.

Some surfaces are better at emitting radiation than others. A black saucepan cools down quickly than any other. Hot water in a kettle covered with soot cools faster than a similar kettle having shining surface.

So we can say that a good absorber is a good radiator and a poor absorber is a poor radiator.

The rate of energy transfer by radiation is affected by:

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

White clothes are worn in hot climates because white is a good reflector and a poor absorber.

Black or dark coloured clothes are worn in cold climates, because dark is a poor reflector and a good absorber.

Practical Applications of Radiation of Heat

Following are the examples of the application of radiation.

A. Colouring Materials: -

The cooling fins on the heat exchanger at the back of a refrigerator are painted black so that they lose heat more quickly. By contrast, saucepans that are polished are poor emitters and keep their heat longer. In general, surfaces that are good absorbers of radiation are good emitters when hot.

(B) One type of radiant barrier material, ARMA foil , produced by energy efficient solutions.

(C) Satellite Protecting Coating:-

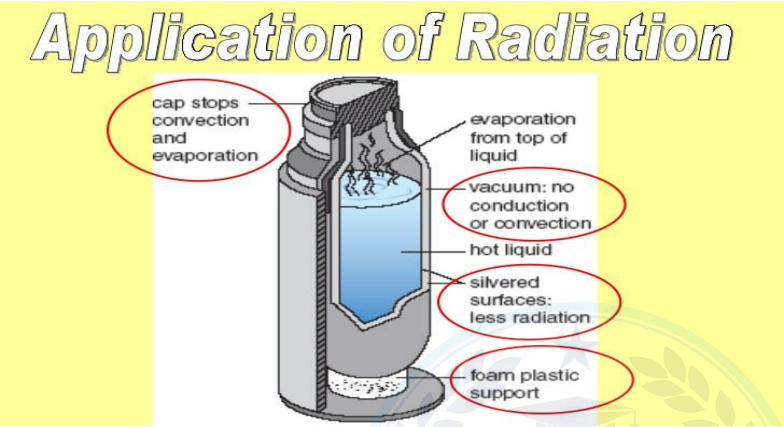
The highly reflective metal foil covering this satellite (the Hubble Space Telescope) minimizes temperature changes.

(D).Thermos Flask: -

Definition: - The vessel which is used to prevent heat transfer due to conduction, convection and radiation is known as thermos flask.

Construction:- It consist of a double-walled glass vessel silvered on the inside.

Working:-The vessel is silvered on the inside to prevent radiation from moving inside or coming outside. There is an evacuated space between the walls to prevent convection of heat. The glass is a poor conductor of heat, it prevent the conduction of heat. So in this way the thermos flask is able to keep cold things as cold and hot things as hot for many hours.



NOTE:-

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

GREEN HOUSE EFFECT AND GLOBAL WARMING

GREEN HOUSE:-

Definition: - It is a heat trapping system.

Constructed Material:- It is made from transparent glass or Polythene sheets.

Definition: - The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without its atmosphere.

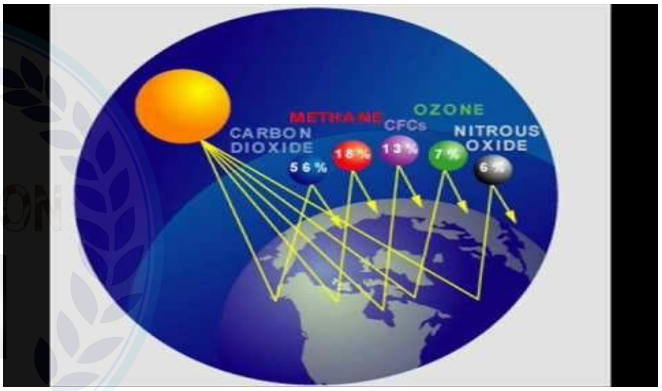
Dependence:-

The strength of the greenhouse effect depends upon the :-

(i) Atmosphere's temperature.

(ii) Amount of greenhouse gases like carbon dioxide (CO_2), Methane (CH_4) , Water vapours and Ozone (O_3).

Mechanism of Green House Effect :- Earth receives energy from the Sun in the form of ultraviolet , Visible and near-infrared radiation. The total amount of solar energy available at the top of the atmosphere, about 26% is reflected by the atmosphere and clouds and 19% is absorbed by atmosphere and clouds. Most of the remaining energy is absorbed at the surface of the earth.



As the temperature of sun is very high. So it emits high frequency and small wavelength radiations like ultraviolet rays etc. On the other hand the temperature of earth is very low as compare to that of the sun, so it emits low frequency and large wavelength radiations. These are absorbed by water vapour and CO_2 which are present in the atmosphere of earth.

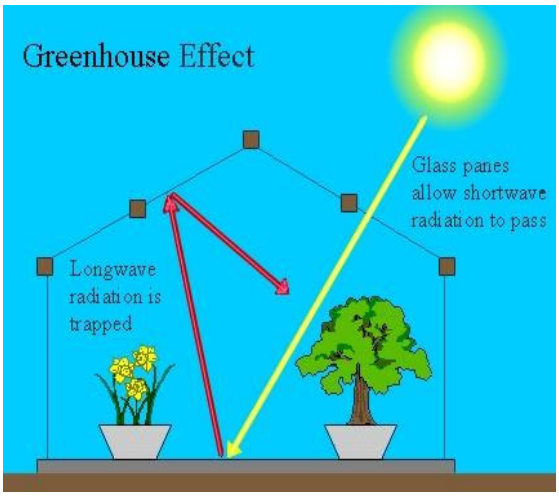
The atmosphere of earth radiates most of this energy (low frequency and large wavelength radiations) back to the earth. As a result the temperature of earth increases. The earth's globe warms gradually. This type of effect which gives rise to the global warming is known as greenhouse effect.

Importance of Greenhouse effect:-

Greenhouse effect is important for the survival of life on earth. On earth, an atmosphere containing naturally occurring amounts of greenhouse gases (water vapour, CO_2, CH_4, and ozone O_3) causes air temperature near the surface to be about 33 ^{0}C warmer than it would be in their absence. Without the earth's atmosphere, the earth's average temperature would be well below the freezing temperature of water.

In winter season farmer use glass greenhouse effect for warming purposes. In winter season the temperature is low due to which the plants cannot grow well in soil, so in order to supply the necessary temperature to plants a farmer use glass greenhouse effect to provide it a moderate temperature. The high frequency and small wavelength radiations from the sun passes through the glass and is absorbed by the soil and plants inside the enclosure.

When soil and plants emit these low frequency and large wavelength radiations, they cannot pass through the glass and absorbed in it and thus produced the warming effect.



Causes of Greenhouse gases :-

Human activity has increased the amount of greenhouses gases in the atmosphere leading to global warming. Due to human activities in the last thirteen decades (130years) the global average temperature has increased by 0.85 ^{0}C. The largest human influence has been the emission of CO_2 gas from factories and motor vehicles.

How to decrease Global warming :-

In order to decrease global warming we have to reduce the emission of greenhouses and to plant more vegetation to absorb the produced CO_2 and other greenhouses gases.

CONCEPTUAL QUESTIONS

Q1: - Why white clothes are preferred wearing in summer? Explain briefly.

Ans: - **Statement:** White clothes are preferred wearing in summer.

Reason: - It is because white colour is a

(i) Good reflector.

(ii) And bad absorber.

Explanation: - The white and light coloured clothes are worn in hot climate because they are good reflector and bad absorber in nature. They do not absorb any radiation and thus keep our body cool.

Conclusion:-As a result we conclude that white clothes are preferred wearing in summer than black clothes.

Q2: - Why is the freezer compartment kept at the top of a refrigerator? Explain briefly.

Ans: - Statement: The freezer compartment kept at the top of a refrigerator.

Reason:- To cool the surrounding air.

Explanation: - As we know that in refrigerator convection is used to circulate cold air around the stuffs. Air is cooled by the freezer compartment at the top of the refrigerator. As it sinks it is replaced by warmer air rising from below. The circulating air carries heat energy away from all the stuffs in the fridge.

Conclusion:- As a result we conclude that the freezer compartment kept at the top of a refrigerator.

Q3:- A black car standing in the sun warms up more quickly than other. Why?

Ans:- Statements:- A black car standing in the sun warms up more quickly than other.

Reason:- Because black colour is a

(i) Good absorber.

(ii) Bad reflector.

Explanation: - As we know that black surfaces or black colour is a good absorber of thermal radiations. When the thermal radiations from the sun falling on the black surfaces are completely absorbed. Therefore a black car standing in the sun warms up quickly than other cars.

Conclusion:- As a result we conclude that a black car standing in the sun warms up more quickly than other.

Q4:- Why a tile floor feels colder to bare feet than a carpeted floor?

Ans# Statement:- A tile floor feels colder to bare feet than a carpeted floor.

Reason:- It is because a carpet is a bad conductor of heat than a tile floor.

Explanation: - The tile floor has a good conductivity as compared to the carpeted floor. When we put bare feet on a tile floor, it absorb more heat from our feet as compared to the carpeted floor because the carpet floor is a bad conductor of heat.

Conclusion: - As result we that the tile floor feels colder than a carpet floor.
Q5# How woolen sweaters keep us warm in winter?
Ans. Statement: Woolen sweaters keep us warm in winter.
Explanation: -As we know that the woolen sweaters and clothes contain a large number of pores filled with air. The air and wool are bad conductors of heat. Thus heat from our body does not flow out and our body remains warm in winter.
Conclusion:-As a result we conclude that the woolen sweaters keep our body warm in winter.
Q6# In certain places the birds are fly for hours without flapping their wings. Explain
Ans:- Statement:- In certain places the birds fly for hours without flapping their wings.
Reason:- It is because of Riding on thermals.
Explanation: - As we know that the thermals are streams of hot air rising in the sun. They are convection currents. They arise due to the replacement of hot and cool air in the atmosphere. Birds are able to fly for hours on thermals without flapping their wings. Similarly gliders aeroplanes are able to rise by riding on the thermals.
Conclusion:- As a result we conclude that in certain places the birds are fly for hours without flapping their wings.
Q7# Good-quality thermos bottle is double walled and evacuated between these walls, and the internal surfaces are like mirrors with a silver coating. How does this configuration combat heat loss from all three transfer methods and keep the bottle's contents your coffee hot?
Ans# Statement:- Good-quality thermos bottle is double walled and evacuated between these walls, and the internal surfaces are like mirrors with a silver coating.
Reason: - To reduce the heat loss in the thermo-bottle.
Explanation:- It is a vessel used to prevent heat transfer due to conduction, convection and radiation. It consists of a double walled glass vessel silvered on the inside. The purpose of the silvering is to reflect all the heat radiation. The space between the walls has vacuum that prevent convection of heat. The glass is a poor conductor which minimizes conduction of heat. In this way thermos bottle combat heat loss from all three transfer methods and keep our coffee hot.
Conclusion: - As a result we conclude that Good-quality thermos bottle to reduce the heat loss.
Q8#: A piece of wood lying in the sun absorbs more heat than a piece of shiny metals. Yet the metals feels hotter than the wood when you pick it up. Explain.
Ans# Statements:- A piece of wood lying in the sun absorbs more heat than a piece of shiny metal. Yet the metals feels hotter than the wood when you pick it up.
Reason: - It is because wood has smaller thermal conductivity as compared to the shiny

metal.

Explanation:- As we know that metal a piece of wood lying in the Sun absorbs more heat than a piece of shining metal, but on touching the wood feels less hot than the metal. When you pick it up because the metal being a good conductor of heat conducts all the heat present in it to your hands whereas wood being a bad conductor conducts very little heat from its surface to your hands and hence feels less hot than the metal.

Conclusion:- As a result we conclude that a piece of wood lying in the sun absorbs more heat than a piece of shiny metal. Yet the metals feels hotter than the wood when you pick it up.

Q9#: Some pot handles remain cool during cooking while others become unpleasantly hot. What determines which handles remain cool and which became hot?

Ans:- Statement:- Some pot handles remain cool during cooking while others become unpleasantly hot.

Reason: - It is because of thermal conductivity.

Explanation:-The pot handles will become unpleasantly hot which have high value of thermal conductivity, because it will conduct heat easily and more quickly. For example when a pot handle is made of metal, then it becomes, hot quickly. On the other hand if the handle is made of bad conductor like wood, it will not get hot because of its poor thermal conductivity.

Q10: When sun light warms the land beside a cool body of water, a breeze begins to blow from the water towards the land. Explain.

Ans# Statement: - When Sun light warms the land beside a cool body of water, a breeze begins to blow from the water towards the land.

Reason: - Because of the difference between specific heat capacity of water and land.

Explanation:- As we know that convection causes coastal breeze. During the day when the sun light shine equally on land and sea the land become hot more quickly due to its low specific heat capacity. The hot air over the land rises and the cold air from sea water blows to replace it. Thus there is a sea breeze during the day due to difference in specific heat capacity of water and land.

Conclusion:- As a result we conclude that When Sun light warms the land beside a cool body of water, a breeze begins to blow from the water towards the land.

NUMERICAL PROBLEMS

Q1# A person's body is covered with 1.6 m^2 of wool clothing. The thickness of wool is 2.0×10^{-3}. The temperature at the outside surface of the wool is 11^0C, and the skin temperature is 36^0C. How much heat per second does the person lose due to conduction? Thermal conductivity of wool is k= 0.04$Wm^{-1}K^{-1}$.

Ans:-Solution:-

Given data:-

Area of wool =A= 1.6 m^2

Thickness of wool =L= 2.0×10^{-3}m

Temperature on the surface of wool = $T_1 = 11^0$C

Temperature of the skin= $T_2 = 36^0$C

Change in temperature = $\Delta T = T_2 - T_1 = 36-11 = 25^0$C

Thermal conductivity =k= 0.04$Wm^{-1}K^{-1}$

Required Data :- Rate of flow of heat = $\frac{Q}{t}$ = ?

Formula:- As we know that $Q = \frac{kA\,\Delta T\,t}{L}$ .....(1)

Calculation:- By putting values in equation (1) we get

$$\frac{Q}{t} = \frac{0.04\times1.6\times25}{2\times10^{-3}} = \frac{1.6}{2\times10^{-3}} = 0.8\text{x}\ 10^3 \text{ J/sec} = 800 \text{ J/sec} = 800 \text{ watt}$$

Q2# The external wall of a brick house has an area of 16m^2 and thickness 0.3m. The temperatures inside and outside the house are respectively 20^0C and 0^0C. Calculate the rate of heat loss through the wall? Thermal conductivity of bricks is k= 0.84$Wm^{-1}K^{-1}$.

Ans: Solution:-

Given Data:

Area of wall =A= 16m^2

Thickness of wall =L=0.3m

Temperature inside the house= $T_1 = 20^0$C

Temperature inside the house = $T_2 = 0^0$C

Change in temperature = $\Delta T = T_1 - T_2 = 20 - 0 = 20^0$C

Thermal Conductivity of brick = k= 0.84$Wm^{-1}K^{-1}$

Required Data:- Rate of flow of heat = $\frac{Q}{t}$ = ?

Formula:- As we know that

$$Q = \frac{kA\,\Delta T\, t}{L} \quad OR \quad \frac{Q}{t} = \frac{kA\,\Delta T}{L} \quad \ldots\ldots\ldots\ldots (1)$$

Calculation:-By putting values we get

$$\frac{Q}{t} = \frac{0.84\times16\times 20}{0.3} = \frac{268.8}{0.3} = 896 \text{ J/s} \quad OR \quad \frac{Q}{t} = 896 \text{ watt}$$

Negative sign indicates that heat is losses. Also the book answer is wrong.

Q3# Window glass has thermal conductivity of $0.8 Wm^{-1}K^{-1}$. Calculate the rate at which heat is conducted through a window of area $2.0mm^2$ and thickness 4.0mm . The temperature inside an air-conditioned room is $20\ ^0C$. The outdoors temperature is 35^0C.

Ans: Solution:-

Given data :-

Area of window =A= $2m^2$

Thickness of window =L=4.0mm= $4.0x10^{-3}m$

Temperature inside an air conditional room=$T_1 = 20^0C$,

Outdoors temperature = $T_2 = 35^0C$

Change in temperature = $\Delta T = T_2 - T_1 = 35-20 = 15^0C$

Thermal conductivity =k= $0.8 Wm^{-1}K^{-1}$

Required Data:-

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

Formula:- As we know that

$$Q = \frac{kA\,\Delta T\, t}{L} \quad OR \quad \frac{Q}{t} = \frac{kA\,\Delta T}{L} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Calculation: - By putting values in equation (1) we get

$$\frac{Q}{t} = \frac{0.8\times2\times 15}{4.0x10^{-3}} = \frac{24}{4.0\times10^{-3}} = 6 \text{ x } 10^3 \text{ J/s} = 6 \text{ x } 10^3 \text{ watt .}$$