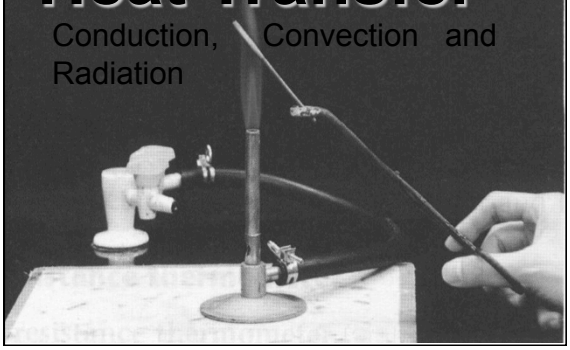
Heat Transfer

Conduction, Convection and Radiation



Heat Transfer

- **Heat is a form of energy.**
- **Heat travels from higher temperature(hotter) region to lower temperature(cooler) region.**
- **Two bodies are in thermal equilibrium when there is no net transfer of thermal energy.**

http://www.physicslessons.com/exp12b.htm

Thermal Equilibrium

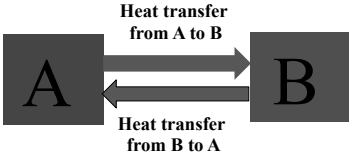
Body A is at a **higher temperature** than body B.

When bodies A and B are in contact, A loses thermal energy at a rate higher than the rate at which it absorbs thermal energy from B.

Thermal Equilibrium

This causes a temperature **drop** in body A and an **increase** in temperature in body B.

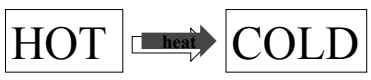
Finally, the two bodies A and B have the **same temperature.**



They are in thermal equilibrium.

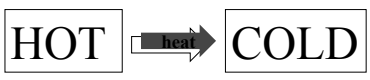
Thermal Equilibrium

- Heat always travels from a region of **higher temperature** to a region of **lower temperature**



Thermal Inequilibrium

- **If two bodies are in thermal inequilibrium, it means their temperature are not the same.**
- **When they are placed in contact, the thermal transfer occurs.**

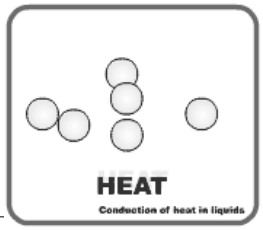


Heat Transfer Methods

- The three methods of heat transfer are
  - –Conduction
  - –Convection
  - –Radiation

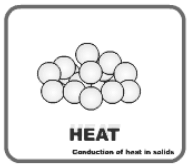
Heat Transfer Methods

- Liquids get heated up by convection currents.



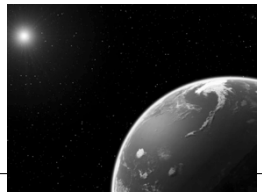
Heat Transfer Methods

- In solid, heat is transferred as vibrations of atoms or molecules in fixed positions spread over the entire solid.



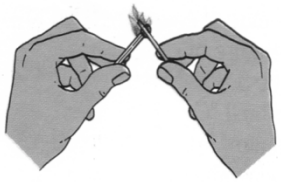
Heat Transfer Methods

- In vacuum, heat is transferred by radiation. Example: Heat from the Sun reaches the Earth by Radiation.



Conduction

- Get a piece of stiff copper wire about the same length as a match.
- Strike the match and hold the copper wire in the flame.



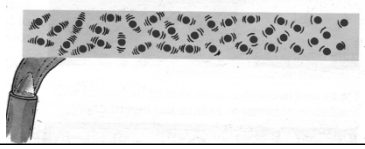
Conduction

- What happens?

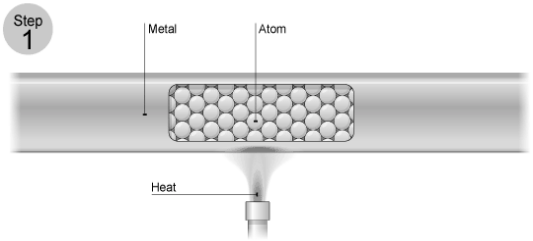
  The copper wire is heated up.
- Does the energy get to your hand quicker through wood or through copper?
- We say that copper is a better conductor than wood. The energy has traveled from atom to atom through the copper.

Conduction

- Conduction is heat flow through **SOLIDS** without **any visible** movement.
- It is due to temperature differences.
- Heat flows from high temperature region to a slower temperature region.

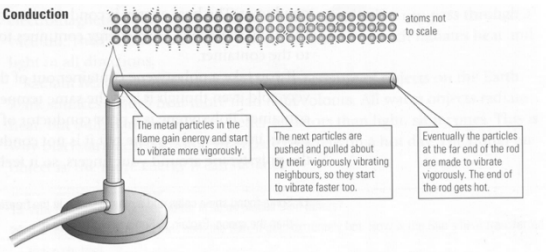


Conduction



Conduction

Conduction is the process by which heat is transmitted through a medium from one particle to another.



Conduction

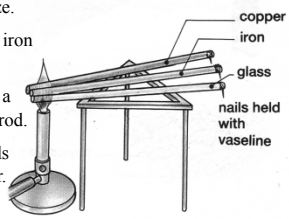
Get three rods of the same size.

The rods are made of copper, iron and glass.

Rest them on a tripod and fix a small nail at one end of each rod.

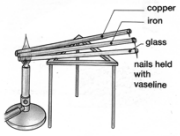
Heat the other ends of the rods equally with a Bunsen Burner.

What happens?



The nails from different materials dropped off from the rod at different time.

Conduction



Material	Time taken for pin to drop(s)
copper	14
iron	73
glass	Did not drop

From the experiment it shows that nail from the copper drops off first at 14 seconds.
This is because heat travels faster through copper than iron and glass.
We say that copper is a good conductor of heat.

Conductors

Good conductors of heat refer to objects that can conduct heat very fast.

All metals are good conductors of heat.

Examples:
Copper, silver, iron, mercury are good conductors.

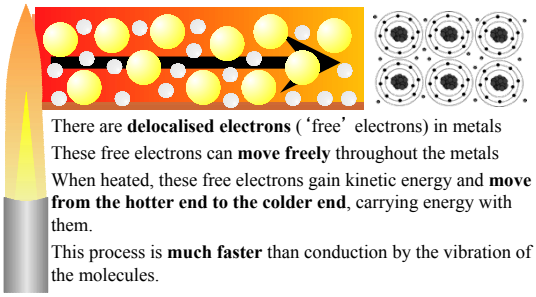
Insulators

Insulators are materials that heat cannot travel through.
They are poor conductors of heat.
Poor conductors are good insulators.

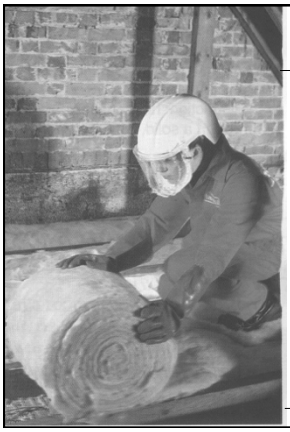
Non-metals, such as plastic and air, are poor conductor.

Liquids and gases are usually poor conductors
The poorest conductor is vacuum.

Why are metals good thermal conductors?



There are **delocalised electrons** ('free' electrons) in metals
These free electrons can **move freely** throughout the metals
When heated, these free electrons gain kinetic energy and **move from the hotter end to the colder end**, carrying energy with them.
This process is **much faster** than conduction by the vibration of the molecules.



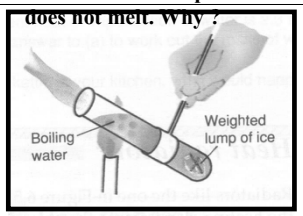
Insulators

Insulators are used to lag pipes, lofts, hot water tanks and many other objects.

Fibre glass insulation is a popular choice for home insulations.

Test Yourselves

- **Heat a test tube of water near the top with a 'weighted' ice cube near the bottom. Even when the water at the top starts boiling, the ice cube does not melt. Why ?**

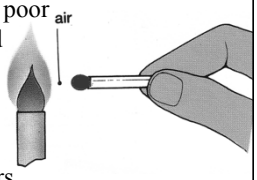


Ans.: Water is a poor conductor of heat.

Is air good conductor or insulator

Hold a match about 1 cm away from a very hot Bunsen flame.
Does the match get hot enough to burst into flame?

This shows that air is a very poor conductor – it is a very good insulators.



All gases are poor conductors.

Application of conduction

Soldering iron

- Iron rod is a good conductor of heat with copper tip.
- The handle is made of plastic which is a good insulator.

Application of conduction

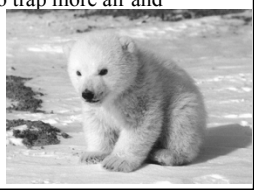
Home electrical appliances

- The handles of kettles, hot iron, cooking utensils are made of wood and plastics which are the good insulators of heat.



Insulation

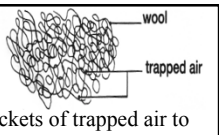
- The air trapped in the fur and feather to keep animals warm.
- Birds fluff up their feathers in winter to trap more air.
- Polar bears have thick fur to trap more air and keep them warm.

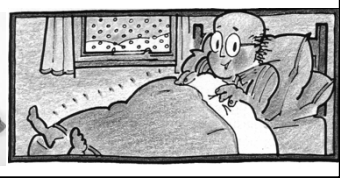
Insulation

- A refrigerator has insulation material round it to keep it cold.
- The insulation reduces the amount of heat conducted to the inside from the warmer room.

Insulation



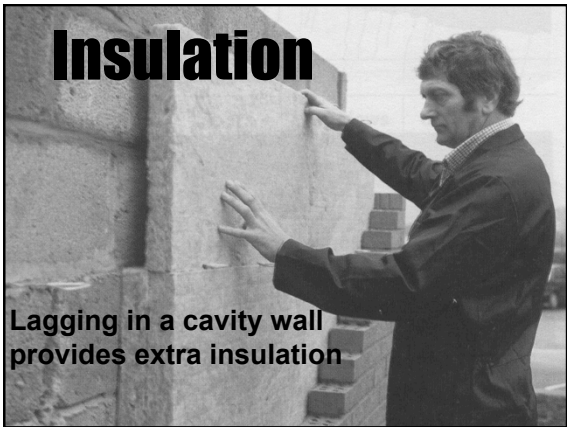
- Many insulators contain tiny pockets of trapped air to stop heat conducted away.
- Wool feels warm because it traps a lot of air.
- The air trapped in and between our clothes and blankets keeps us warm.

Insulation

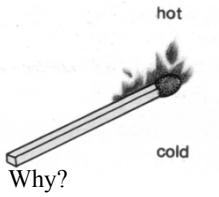
Pipes and hot-water tanks are lagged with insulation material to reduce the loss of **energy.**

Insulation



Lagging in a cavity wall provides extra insulation

Convection



Hold your hand over and under the flame of a match.

What do you notice?

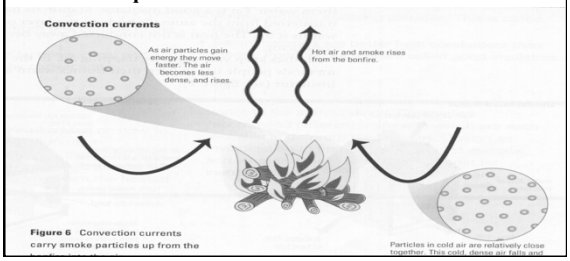
Why?

Hot air expands, becomes less dense and then rises.

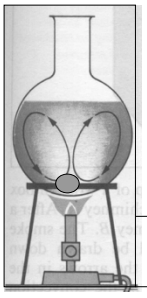
Heat is convected upwards.

Convection

Convection is the process by which heat is transmitted from one place to another by the movement of heated particles of a gas or liquid.



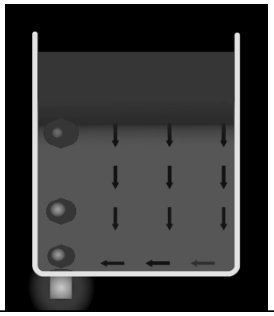
Convection
in Liquids



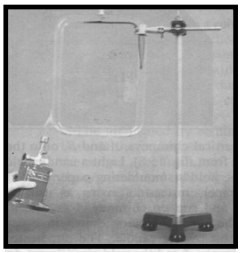
- **To demonstrate convection in water, drop a few tiny crystals of potassium permanganate into a flask filled with water.**
- **Gently heat the flask, purple streaks of water will rise upwards and then fan outwards.**
- **The water becomes uniformly purplish after some time.**
- **The circulation of a liquid in this matter is called a convection current.**

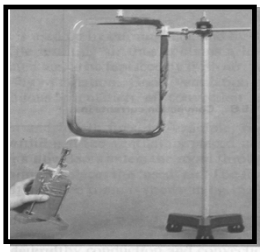
Thinking :
Why hot water rises and cold water sinks ?

Convection in Liquids



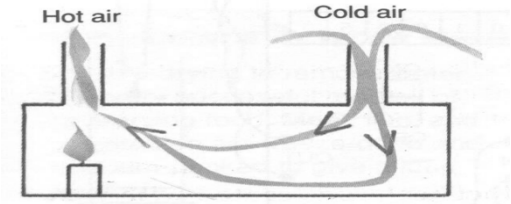
Convection in Liquids



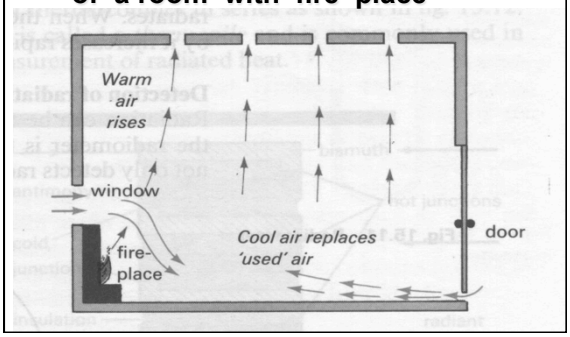


Convection
in Gases

The fig. shows a simple demonstration of convection of gas. The hot gases from the burning candle go straight up the chimney above the candle. Cold air is drawn down the other chimney to replace the air leaving the room.

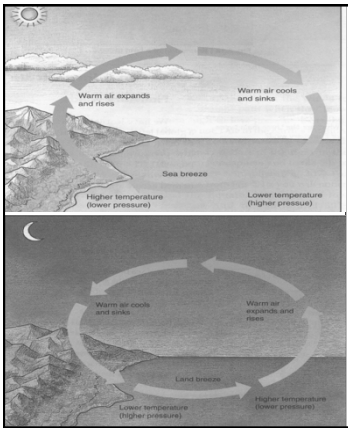


Concept on ventilation
of a room with fire place



Test Yourselves

1. **Usually, it is better to install air conditioner in the higher portion of the wall. Please explain this statement with reasons.**
2. **How are winds forms ?**
3. **Why is the heating coil of an electric kettle placed near the bottom of the vessel ?**



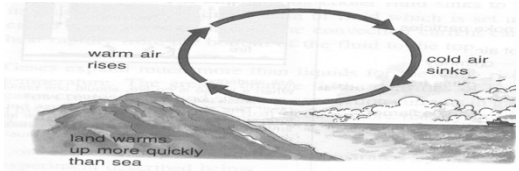
Application of convection

Sea Breeze

Land Breeze

Sea Breeze

- **During the day the sun heats the land much faster than the sea.**
- **The air above the land is heated, expands and rises.**
- **Cold air from the sea moves inland to take its place.**
- **Hence, sea breeze is obtained.**

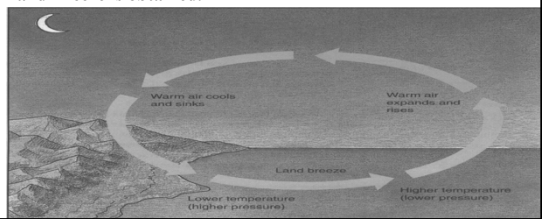


Discussion : How land breeze is produced ?

Land Breeze

At night:

- **Land loses heat faster than the sea.**
- **Hot air above the sea which is less dense, expands and rises.**
- **Cold air from the land moves towards the sea.**
- **Convection current is formed.**
- **Land Breeze is obtained.**



Application of convection

Electric kettle

- The heating element is always placed at the bottom of the kettle.
- So that hot water at the bottom which is less dense will rise up.
- Cooler water at the top which is denser will sink to the bottom.
- Convection current is set up to heat up the water.

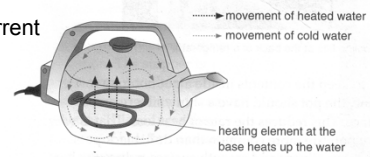


Figure 9.9 Kettle

Application of convection

Refrigerator

- **The freezer is always placed at the top of the refrigerator.**
- **So that cold air at the top will sinks to the bottom.**
- **Warmer air at the bottom will rise to the top.**
- **Convection current is set up to cool down the refrigerator.**

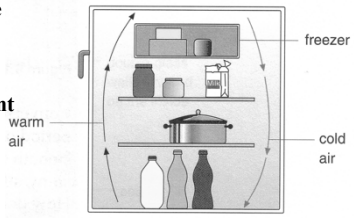
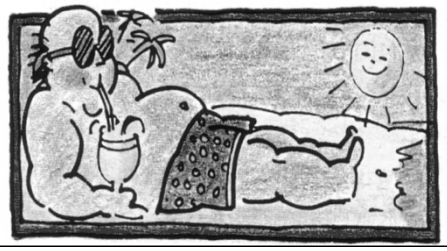


Figure 9.10 Refrigerator

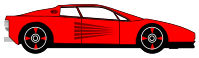
Radiation

- The heat energy from the sun is radiated to us.



Radiation

Radiation is a method of heat transfer that does not require any medium.
It can take place in a vacuum.
In radiation, heat transmits energy in the form of waves.

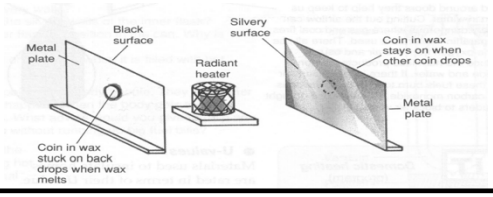


Emit Heat Radiatio

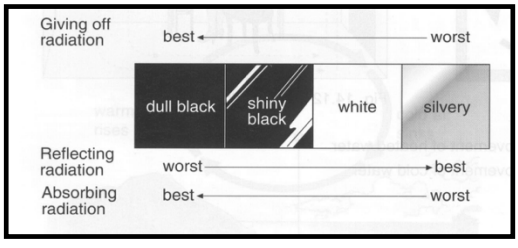
- **All objects emit /radiate or absorb heat.**
- **The heat is transferred in a form of infra-red radiation.**
- **Heating an object up make it radiate more energy.**
- **A dull dark surface is a better emitter or radiator than a shiny one.**

What type of surface is the best absorber of heat

- **Fig. below shows one way to test different surfaces.**
- **Results from this type of test show that,**
  a dull black surface is the best absorber of radiation,
  a shiny silvery surface is the worst absorber of radiation.



What type of surface is the best absorber of heat



Test Yourselves

1. Brightly polished kettle do not lose much energy by radiation. Why ?

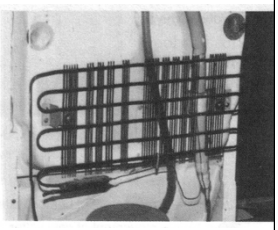
Silvery surface is the worst radiator of heat

2. The cooling fins on the back of a refrigerator, in a car radiator should be dull black. Why ?

Application of Radiation

Cooling fins at the back of a refrigerator

- Is rough and painted in black.
- A black and rough surface is a good radiator of heat.
- The motor of the refrigerator can be cooled down quickly by the cooling fins.



Application of Radiation

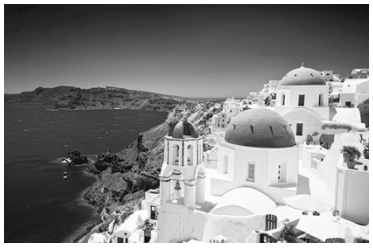
teapot

- Has smooth, shiny and silvery surface.
- Smooth, shiny and silvery surface is a bad radiator of heat.
- This reduces rate of heat loss. Tea or coffee can be kept warm in the teapot.

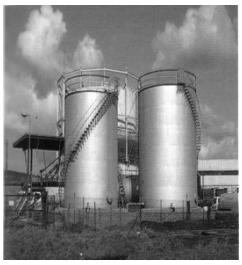
Application of Radiation

White paint for houses

- In hot countries, houses are painted in white to reduce absorption of heat energy from the Sun



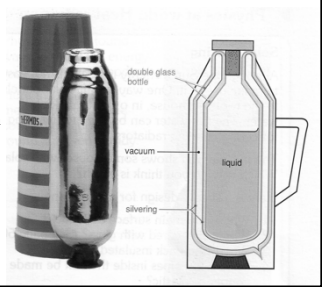
Application of Radiation



Application of Radiation

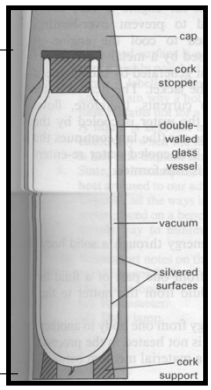
Vacuum Flask

- A vacuum Flask is used to keep hot water hot or keep ice-cream cold.
- It does this by reducing or stopping conduction, convection and radiation.



Vacuum Flask

- It is a double-walled glass bottle. The space between the two walls is a vacuum. This can stop energy transfer out by conduction and convection.
- It cannot stops radiation, as radiation can takes place in the vacuum.



Vacuum Flask

- The shiny bright silvering surface on glass wall reduces heat loss by radiation.
- cork stopper which is made of poor conductors reduces heat loss by conduction and convection