



Dr. Bbosa Science

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Uganda East Africa
Senior one to senior six
+256 778 633 682, 753 802709
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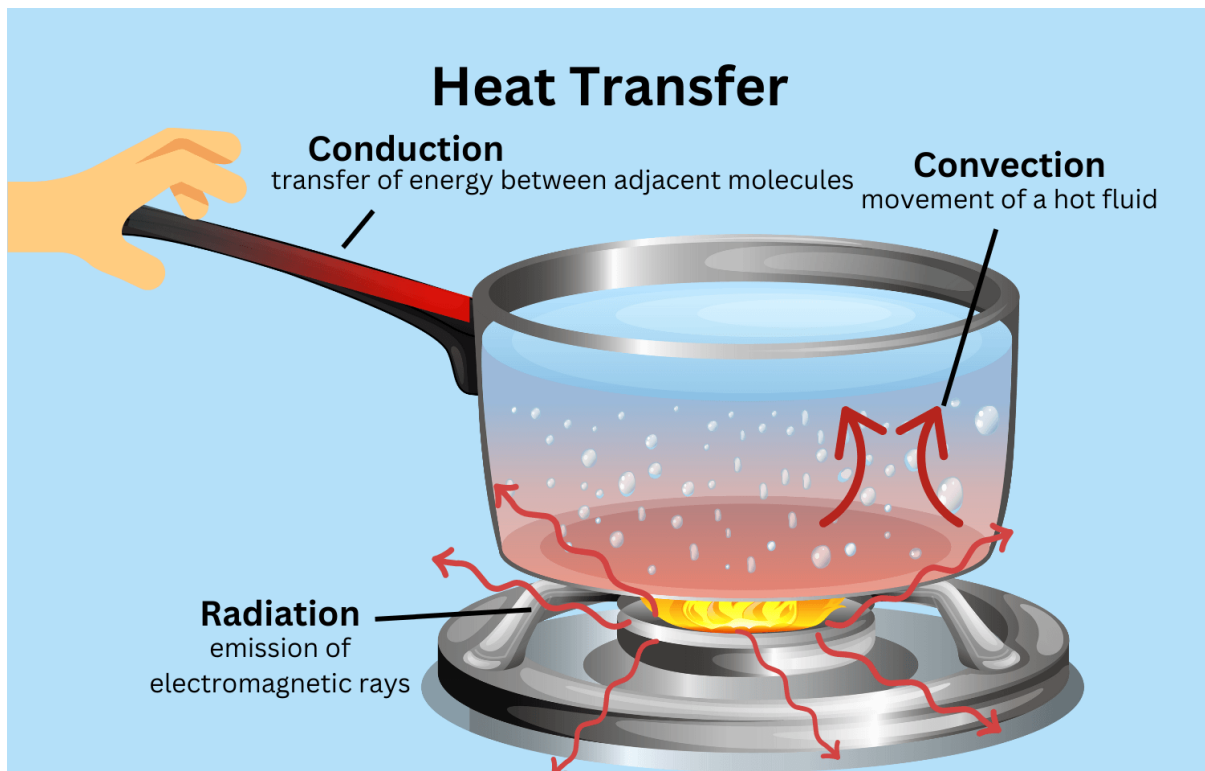


Nurture your dreams

S1 New Curriculum Physics

Theme: Heat

Chapter 6 –Heat transfer



Heat transfer

Heat transfer is the flow of heat energy from a region of high temperature to a region of low temperature. There are three ways by which heat can be transferred namely;

- Conduction
- Radiation
- Convection.

Conduction

Conduction is the flow of heat through matter from a region of higher temperature to one of lower temperature without movement of matter as a whole

Conduction in Solids

Heat transfer in Solids can occur as a result of;

- (i) Excess energy of vibrations being passed from one atom to another.
- (ii) The excess Kinetic energy given to the free electrons near the source of heat being carried by these electrons as they move in colder region.

Note:

For heat to be transferred by conduction there should be a material medium. Metals are good conductors of heat because metals are made up of atoms having free electrons that are loosely held.

Examples of metals which are good conductors are:

1. Aluminum 2. Iron 3. Copper.

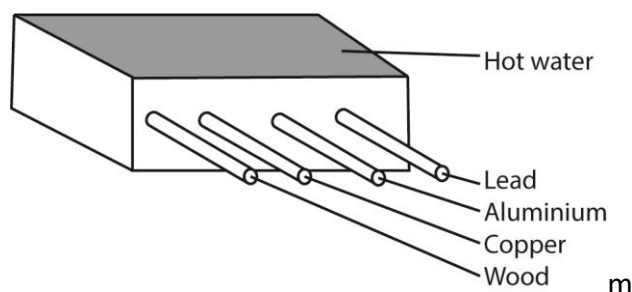
- New utensils or kettles, Saucepans boilers, radiators are made of metals because metals are good conductors of heat as their atoms have free electrons that are loosely held.
- Non-metals, according to Kinetic theory do not have free electrons that are loosely held so that heat does not pass through them easily.
- This is why non-metals are called bad conductors or insulators e.g. plastics, cork, wood.

Rate of heat transfer

The rate of heat transfer along a metal bar depends on the following factors:

- (i) Type of metal: Some metals are better conductors of heat than others.
- (ii) The temperature difference (gradient) between the ends.
- (iii) The length; short metals conduct faster than long metal
- (iv) Cross section area of the metal bar. Metals with large cross section area conduct heat much faster than metal with small cross section area.

Comparing the conductivities of different metals.



The rate of conduction is compared by dipping the ends of four rods coated with wax in hot water. The rods are identical but made of different materials.

After a short while, the wax begins to melt along the rods. It melts fastest along the copper rods and slowest along wood.

This shows that copper is the best conductor and wood is the poorest of them.

Bad and Good conductors and their applications



- (i) Good conductors are materials that allow heat or electricity to pass through them easily.

Applications of good conductor of heat

Good conductors of heat play a crucial role in many every day and industrial applications. Here are some key uses:

- **Cooking utensils and cookware:** Materials like copper and aluminum are used in pots, pans, and kettles to ensure quick and even heating. Copper is one of the best conductor but aluminium is usually used in making cooking utensils because it is much cheaper.
- **Heat exchangers:** Used in air conditioning, refrigeration, and power plants to efficiently transfer heat between two mediums.
- **Electronics cooling:** Metal heat sinks in computers and other electronic devices help dissipate heat to prevent overheating.
- **Automobile engines:** Engine components, including radiators, use metals like aluminum to effectively manage and dissipate heat.
- **Manufacturing and metalworking:** Industries use heat-conductive materials for welding, forging, and molding processes.
- **Solar energy systems:** Copper and aluminum play an essential role in solar panels and water heating systems, helping absorb and transfer heat efficiently.
- **Medical applications:** Devices like surgical tools and heat therapy equipment rely on excellent heat conduction for functionality.

A metal always feels cold when touched on a cold day because it loses heat from the body and transfers it to the surrounding very fast.

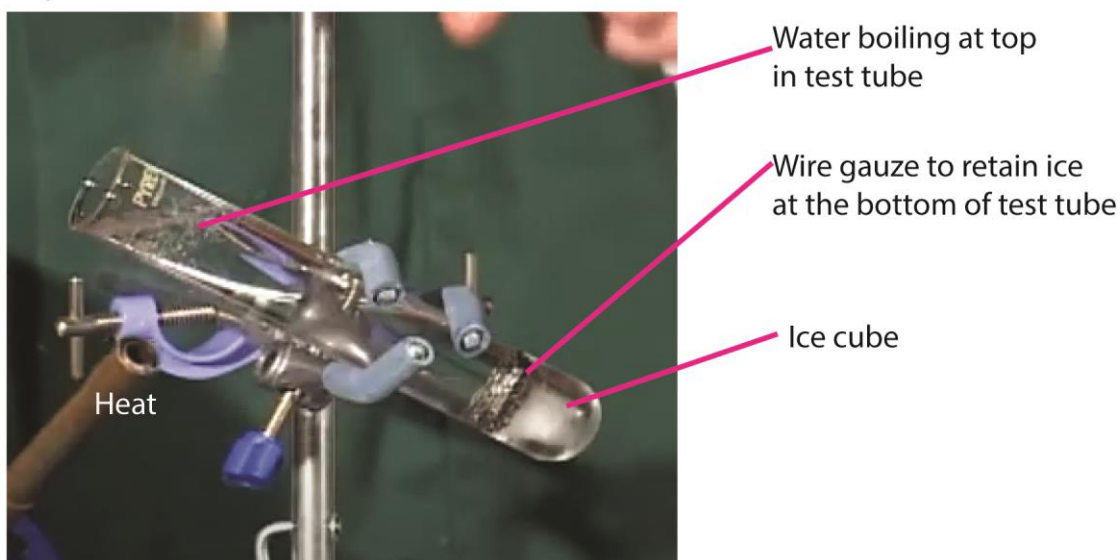
- (ii) Bad conductors also called Insulators are materials that do not allow heat or electricity to pass through them easily.

Application of insulators in daily life

Insulators play a crucial role in protecting us from heat, electricity, and sound in everyday life.

- **Cooking utensils:** Handles of pots and pans are often made of wood or plastic to prevent burns.
- **Home insulation:** Materials like fiberglass and foam help maintain indoor temperatures by reducing heat transfer.
- **Clothing:** Wool, fleece, and thermal fabrics trap body heat, keeping us warm in cold weather.
- **Automobile interiors:** Special insulating materials help reduce heat and noise inside vehicles.
- **Building construction:** Walls, ceilings, and floors use insulators to improve energy efficiency and soundproof rooms.
- **Refrigerators and freezers:** Insulated walls help retain cold temperatures and save energy.
- **Soundproofing:** Foam and other materials are used in studios, theaters, and homes to minimize noise pollution.
- **Medical applications:** Insulating materials are used in protective gloves, surgical tools, and medical storage.

Experiment to show that water is a bad conductor of heat



Ice is placed in a test tube, followed a wire gauze and water and heated as shown above

Observations

Water boils at the top while ice remains at the bottom

Conclusion

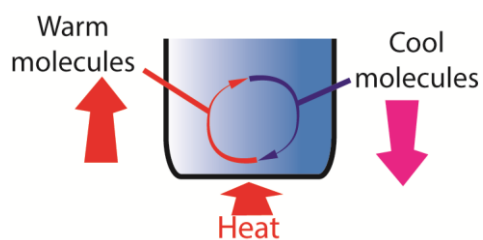
Water is a poor conductor of heat because heat transfer does not occur between boiling water to melt the ice

Convection

Convection is the flow of heat through fluid from a region of higher temperature to one of lower temperature by the movement of the fluid itself. Heat transfer by convection occurs in liquids and gases or fluids.

Convection current

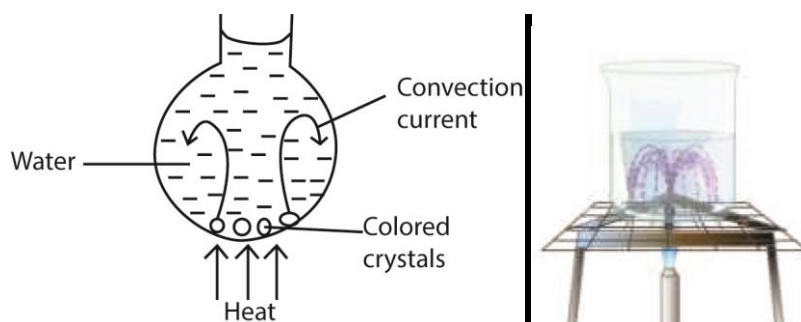
Convection current is the cyclic motion of rising hot fluid and falling cold fluid.



Explanation of convection current.

When the fluid is heated it expands and becomes less dense. The heated fluid is forced upward by the surrounding cooler fluid which moves under it. As the warm fluid rises, it gives heat to the surrounding cooler fluid.

Experiment to demonstrate convection current in liquids

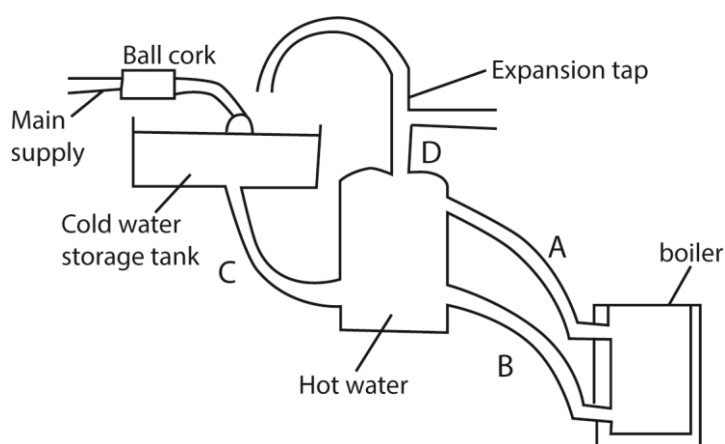


When the flask is heated from the bottom as shown, the colored solution of water raises upwards from the crystals and on reaching the top, it spreads as shown in the diagram. The solution raises because on heating, it expands and becomes less dense, so it is forced upwards by the nearby cooler water,

Difference between convection and conduction

Conduction	Convection
Heat is transferred from a region of higher temperature lower without the movement of matter itself	Heat is transferred from a region of higher to one of lower the temperature by movement of matter as a whole.

Application of convection current to Hot water Domestic supply system.



How it works

(a) Boiler

When working a convection current of less dense hot water from the boiler raises up through pipe A to the hot water tank. At the same time the more dense cold water flows through pipe B from the hot water tank to the boiler.

(b) Circulation

A circulation is set up in the hot water tank involving filling hot water from top downwards. When a volume of hot water flows to the hot water tank through pipe A, an equal volume of cold water flows to the boiler through pipe B. At the same time an equal volume flows through pipe C to the hot water tank.

Pipe A leaves the boiler at the top and enters the hot water tank at the top because it carries less dense hot water

Pipe B is connected to the bottom of the hot water tank and to the bottom of the boiler because it carries more dense cold water,

The expansion pipe D allows escape:

- (i) of dissolved air which comes out of the water when it is heated.
- (ii) of steam, if the water is boiled.

If the expansion pipe is not there;

- (i) The dissolved air which comes out when water is heated causes air-lock in the pipe,
- (ii) The steam if the water is boiled causes explosion.

Convection in gases

Convection in gases produces wind, sea and breezes

Radiation

Radiation is the flow of heat from one place to another by means of electromagnetic waves. Heat energy is transferred from the sun to the earth by means of radiation. Radiation is the means by which heat can travel through the vacuum.

Note

The energy from the hot body is called Radiant energy.

The heat transfer by radiation does not need a material medium,

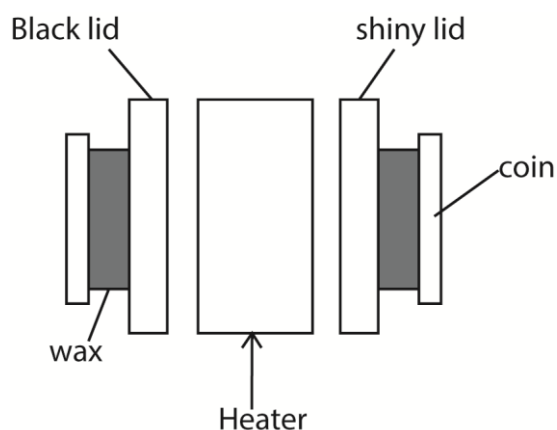
Radiation is emitted by all bodies above absolute Zero.

Good and bad absorbers

Shiny surfaces are bad absorbers of radiation while dull black surfaces are good absorbers.

This implies that shiny surfaces reflect most of the heat radiations instead of absorbing. The dull black surfaces absorb most of the heat radiations and reflect very few.

Experiment to show absorbing of radiations in surfaces

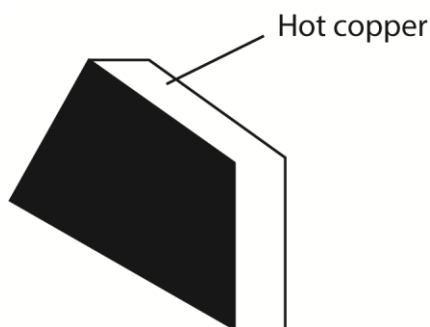


When the heater is placed midway as shown above so that the same amount of radiations are received by the two surfaces. It will be observed that after a few minutes the wax on the black lid melts and the coin falls off before that of the shiny lid. This indicates that dull black surfaces are better absorbers.

Application of absorbers

- (1) Buildings in hot countries are painted white and roof surfaces are shiny because white and shiny surfaces are bad absorbers of heat radiation.
- (2) Reflectors on electric devices are made up of polished metals because they have good reflecting properties.

Good and Bad emitter



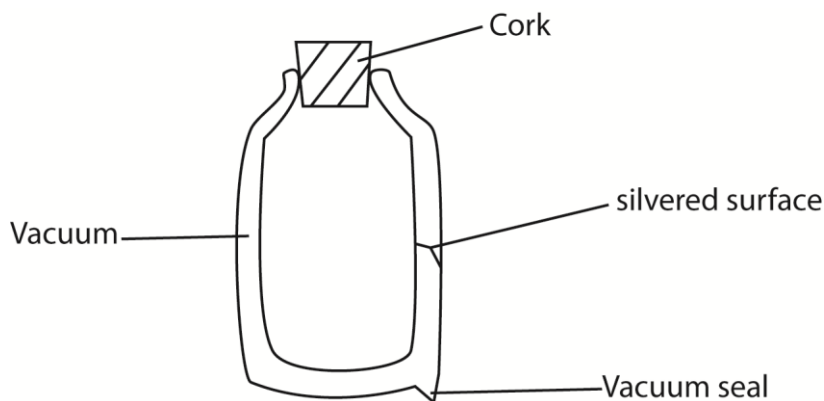
If the backs of the hands are held on either sides of the sheet, one first feels much heat from the black surface. This shows that a black surface is a better emitter of heat than a shiny one.

In short, black surfaces are good absorbers as well as good emitters of heat radiations. Shiny surfaces or polished surfaces are poor absorbers as well as poor emitters of heat radiations.

Applications

- (i) Cooling fins on the heat exchanger of refrigerators are painted black so that they emit heat more quickly,
- (ii) Tea pots and kettles are polished so that they keep heat longer as polished surfaces are poor emitters of heat radiation.

Vacuum flask



A thermos flask also called vacuum flask keeps hot liquids hot and cold liquids cold. This is because heat losses and gain are minimized.

Heat losses by conduction; convection and radiation are minimized by the Vacuum flask as follows:

- Conduction and Convection are minimized by the Vacuum since for heat to be transferred by these ways, a material medium is required.
- Convection from the hot liquid upward to the outside is reduced by the cork which also reduces heat losses by conduction because it is a poor conductor of heat.
- Radiation is also minimized by the two silvered surfaces since they are poor emitters.

However when a hot liquid is kept in the vacuum flask for a long time, it cools because at a small rate, heat is lost by conduction convection and radiation.

Greenhouse effect

The **greenhouse effect** is the process by which certain gases in Earth's atmosphere trap heat from the sun, preventing it from escaping into space. This natural phenomenon helps maintain Earth's temperature, making it **habitable**. However, human activities—such as burning fossil fuels—have increased greenhouse gas concentrations, leading to global warming

Global warming

Global warming refers to the long-term increase in Earth's average surface temperature due to human activities, primarily the burning of fossil fuels, deforestation, and industrial emissions. This leads to the accumulation of greenhouse gases like carbon dioxide and methane, which trap heat in the atmosphere.

Consequences of global warming

The consequences of **global warming** are far-reaching and impact ecosystems, weather patterns, and human societies. Some key effects include:

- **More frequent and severe weather:** Rising temperatures intensify storms, heat waves, floods, and droughts, leading to widespread damage.
- **Melting ice and rising sea levels:** The Arctic is warming **four times faster** than the rest of the planet, causing ice loss and unpredictable weather patterns.
- **Threats to biodiversity:** Many species struggle to adapt to changing climates, leading to habitat loss and extinction risks.
- **Food and water shortages:** Droughts and extreme weather disrupt agriculture and freshwater supplies, affecting food security worldwide.
- **Health risks:** Increased heat waves, air pollution, and disease outbreaks pose serious health concerns for vulnerable populations.
- **Economic impacts:** Climate-related disasters cost billions in damages, affecting infrastructure, agriculture, and global economies.

Revision questions

1. (a) Differentiate between conduction and radiation.

(b) Describe an experiment to show convection in liquids
2. Explain how vacuum flask minimizes heat losses.

3. Describe an experiment to show how the heat radiated from hot object depends on the nature of the surface.
4. Explain the followings
 - (a) Metals feel colder on touch
 - (b) A cool breeze blows from the sea on hot day

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