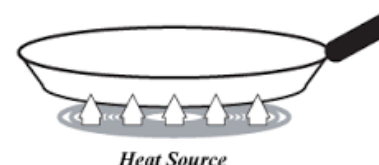


Modes of heat transfer

There are three ways in which heat energy can travel. They are conduction, convection and radiation. Together they are known as thermal energy transfer.

Conduction:

In conduction, the heat energy is passed from one particle to the next particle without actual movement. For example, when a metal pan of water is put on a hot plate of a cooker the atoms in the metal close to the hot plate receive heat energy and vibrate more vigorously. They knock against the atoms a little further into the bottom of the pan and make them vibrate more strongly too. These atoms knock against other atoms a little further up and the kinetic energy is passed on. Eventually the inner surface of the pan, which is next to the water, becomes hot too.



COOKING BY CONDUCTION

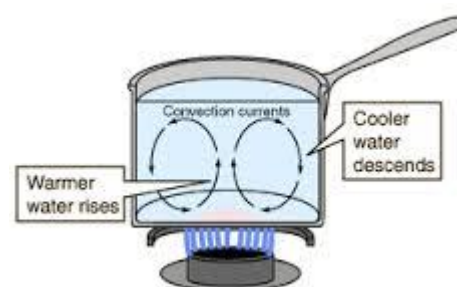
Conduction can occur easily in solids, less easily in liquids but hardly at all in gases because the gas atoms are too far apart to affect each other. It cannot occur in vacuum, where there are no particles to pass on heat energy. Conduction is fastest in metals because they have electrons that are free to move.

Materials that allow heat to pass through them easily are called conductors of heat. Materials that do not allow heat to pass through them easily are called insulators.

Insulators are useful in reducing loss of heat energy. For example, a woollen sweater is a good insulator because the wool fibres trap air, which is a poor conductor. Insulation materials are used in attics and lofts to reduce the escape of heat through the roofs of houses. These materials are not only poor conductors of heat themselves, but they also trap air, which is an excellent insulator.

Convection

In convection, the heat energy is carried away by the particles of the material changing position. For example, the water next to the hot surface at the bottom of the pan receives heat from the metal. The molecules of water next to the metal move faster and further apart as kinetic energy increases. This makes the water next to the pan bottom less dense than the water above it and the warm water rises. Cooler water from above moves in to take the place of the rising warmer water and convection currents are set up.



Convection can occur in liquids and gases. It cannot occur in solids where the particles are not free to move about, nor in vacuum.

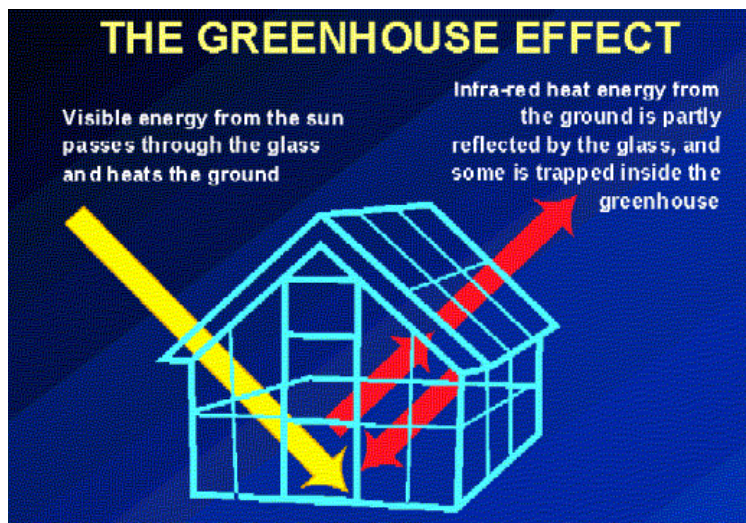
Radiation

Energy can travel through air or through vacuum as electromagnetic waves by radiation. For example, as the pan of water gets hotter you can put your hand near its side and feel the heat on your skin even though you are not touching the metal. The sides of the pan are radiating infrared waves. These carry the heat energy from the surface of the pan to the surface of your skin, which is warmed by them.



All objects radiate infrared radiations, but the hotter the object the more infrared energy it radiates and the shorter the wavelength of the waves.

Some infrared radiation can pass through certain solids such as glass. For example, the infrared radiation from the sun can pass through glass in a greenhouse but the longer wavelength radiations from the ground and the plants inside the greenhouse cannot pass back through the glass. The infrared radiation is trapped and warms the content of the greenhouse.

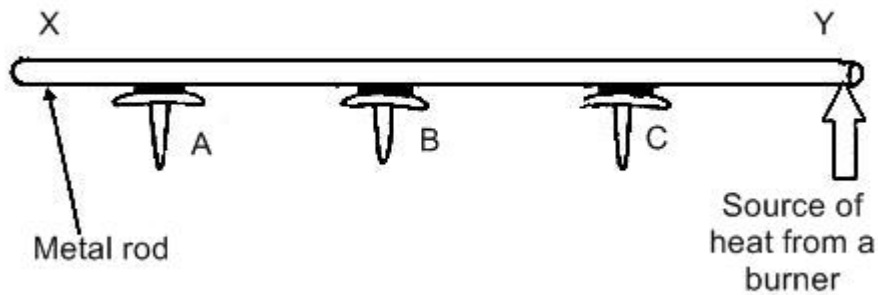


The type of surface affects the amount of heat energy radiated from an object in a given time. Darker colours radiate energy more rapidly than lighter colours, and black surfaces radiate heat most rapidly. The surfaces that radiate energy least rapidly are light, shiny surfaces like polished metal.

The type of surface also affects the amount of radiated energy absorbed by the surface in a given time. For example, a light, shiny surface absorbs energy the least rapidly, while a dull, black surface absorbs energy most rapidly.

Answer the following

1. A metal rod has drawing pins stuck to it with wax and is heated at one end as shown in the figure.



a. What do you think will happen in this experiment? Explain your answer.

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b. How could this experiment be adapted to compare the conducting properties of different materials?

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2. Imagine that a football represents heat energy and football players represent particles in a material. Which of the following events is like conduction and which is like convection? Explain your answer.

a. The players pass the ball to each other to move it up the field.

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b. A defender receives the ball and runs up field with it into an attacking position

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3. When coal burns, particles of soot rise up above the fire and make smoke. Why doesn't the smoke move along the ground?

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4. a. The temperature of the land surface is higher than the temperature of the sea surface during the day. Use the idea of convection currents to suggest what happens to air above the land and above the sea.

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b. At night the land surface is cooler than the sea surface. Does this affect the wind direction? Explain your answer.

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5. In question 2 the energy was transferred by particles (particles). How is the transfer of heat energy by radiation different?

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6. How does the type of surface of an object affect the way it radiates and absorbs heat energy?

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