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## **Heat: a Transfer of Energy**

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What does the word heat mean? Does it mean the same thing as temperature? A simple example may help us to see a difference between these two. If we roast a hot dog on a metal rod, we hold one end of the rod and put the other end over a fire. In a few minutes, the end we are holding gets hot. This example can serve as a model for what scientists call heat.

Why does the end of a metal rod get hot? To find out, look at a model showing the molecules that make up the rod. See Figure 1 A. The molecules in a solid rod or in any form of matter are moving. All molecules have certain amount of kinetic energy, the energy of motion. Temperature is a measure of the average kinetic energy of the molecules in a material [1].

The flame is a source of kinetic energy. The tip of the rod held over the flame absorbs kinetic energy. The molecules in the tip move faster and faster. The temperature of the tip increases. See Figure 1 B. The faster molecules begin to collide with slower molecules to the left. When they collide, the faster molecules transfer kinetic energy to the slower molecules, making them speed up. As the slower molecules speed up they, in turn, collide with their neighbors.

The collisions continue along the rod toward the end we are holding. The temperature at that end is much lower than the temperature of the tip in the flame. But as kinetic energy is transferred to the end we are holding, the molecules speed up. See Figure 1 C. And the temperature increases.

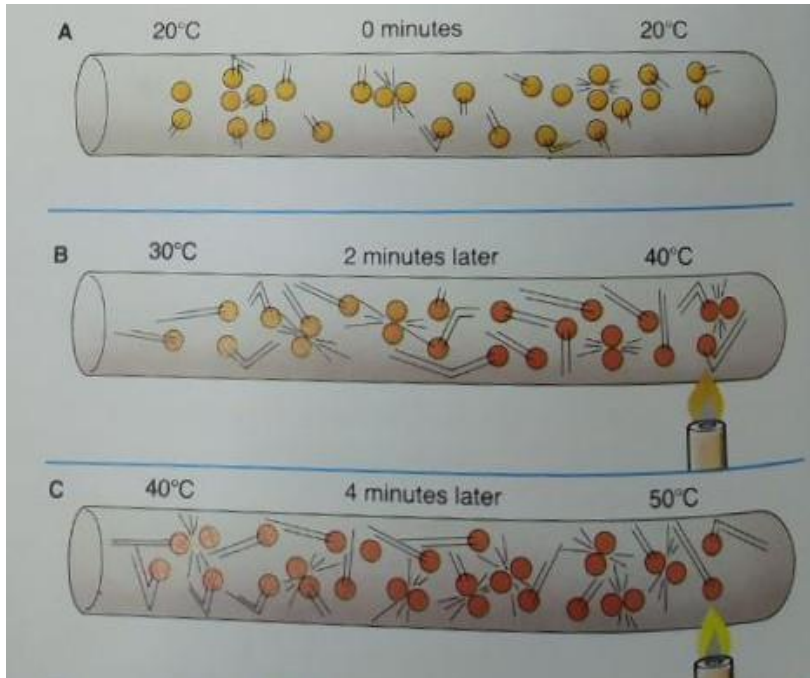


Fig. 1 – The Movement of Molecules Transfers Energy from the Flame through the Rod

So the end we hold gets hotter because of a transfer of energy. Transfer is the basis for understanding what is meant by heat. The latter is the energy transferred between materials (or parts of a material) that have different temperatures [1]. See Figure 2.

The collisions in a solid rod are only one model of energy transfer. Energy can be transferred through various forms of matter in three different ways, such as conduction, convection and radiation.

The kind of energy transfer that took place in the solid rod is conduction. The latter is the transfer of energy from molecule to molecule by collisions. See Figure 3.



Fig. 2 – Heated Air Rises, Transferring Energy upward

Molecules of gases absorb kinetic energy from the flame. These molecules speed up and collide with molecules of the beaker. Molecules of the beaker, in turn, collide with the water molecules along the bottom of the beaker. The collisions transfer kinetic energy from one substance to the next.

Most of the water in the beaker is heated by a second kind of energy transfer, convection. It is the transfer of energy by the flow of a liquid or gas. In Figure 3 convection starts where water is heated by the flame at the bottom of the beaker. As the molecules are heated, they move faster and spread apart, or expand. When the molecules expand, the density of the water decreases. The warm water, less dense than cooler water around it, rises [2].

The rising water carries energy to the top. A constant flow is set up as cooler, denser water sinks to the bottom and is heated. The flow within a fluid due to changes in density is a convection current.

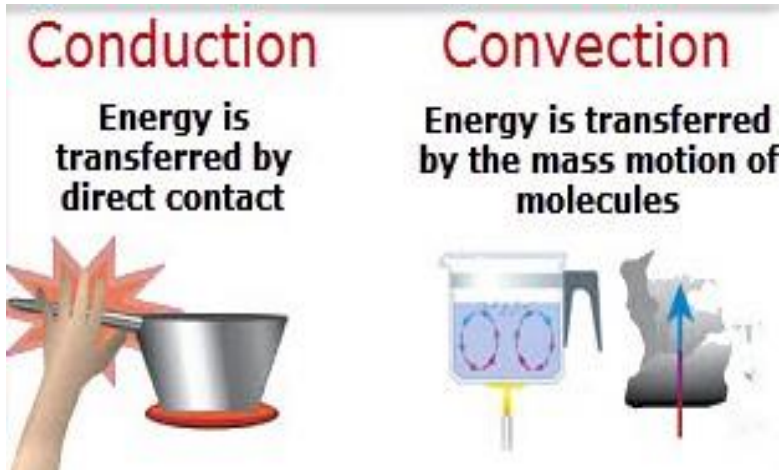


Fig. 3 – Conduction and Convection

A fireplace provides another kind of energy transfer, radiation. The latter is the transfer of energy by electromagnetic waves [2]. Electromagnetic waves can travel through space as well as through air and other kinds of matter. When sunlight warms us, the sun's energy is reaching us by radiation through 15 million kilometers of space. The warmth we feel when we stand in front of an electric heater is also due to radiation.

References:

1. Difference between Heat and Temperature [Electronic resource]. – Mode of access: <https://oxscience.com/heat-and-temperature/>. – Date of access: 13.03.2022.
2. Energy Transfers and Transformations [Electronic resource]. – Mode of access: <https://www.nationalgeographic.org/article/energy-transfers-and-transformations/>. – Date of access: 25.02.2022.