Transfer of Energy

Energy moves away from a region of high concentration, or source, to a region of low concentration, or sink. Energy transfer from a region of higher temperature to a region of lower temperature is called **heat energy.** Heat transfers thermal energy, the energy of the motions of atoms and molecules.

Achieving Dynamic Equilibrium

Heat will continue to move from the source to the sink until their energies are equal, establishing a dynamic equilibrium. At dynamic equilibrium a region loses and gains equal amounts of energy. If the dynamic equilibrium is between all forms of energy, then the temperature of the region or system will remain constant.

Digging Deeper

The portion of space that separates regions of different properties is called an interface, or boundary. Energy is transferred across interfaces, such as the metal bar shown in Figure 5-3, or the region of space between the sun and Earth.

Methods of Energy Transfer

Heat is transferred from an area of high concentration to an area of low concentration by one of three methods—conduction, convection, or radiation.

Conduction The transfer of heat energy from atom to atom or molecule to molecule when vibrating atoms or molecules collide is **conduction.** Conduction is most effective in solids—especially metals—because the atoms or molecules are closer together than in gases and liquids. However, some heat conduction can take place in liquids and gases. In Figure 5-3 conduction is the main method of heat transfer from the source to the sink through the metal bar.

Convection The transfer of heat by movement in fluids—gases and liquids—caused by differences in density within the fluids is **convection.** Warmer portions of the fluid usually have lower density and tend to rise above the cooler portions. The reason for the rise of less dense fluids is that gravity pulls less on objects that are lower in density and pulls more on objects of higher

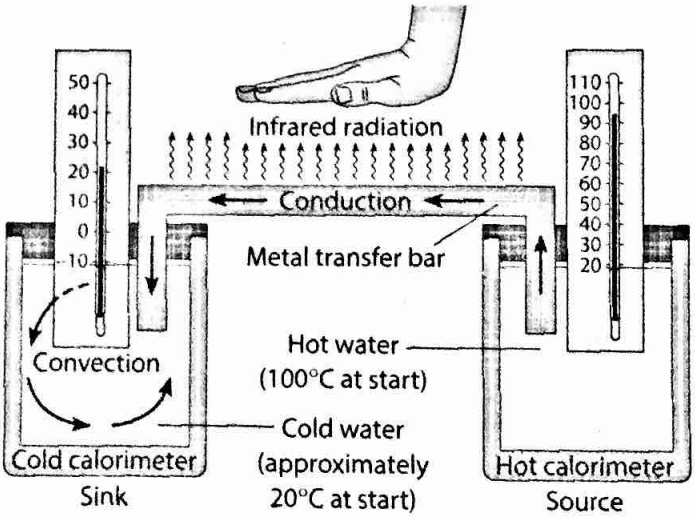


Figure 5-3. An experiment in heat energy transfer: In this experiment, the amounts of heat transferred from the hot calorimeter (the source) to the cold calorimeter (the sink) and the methods of that transfer are investigated. A calorimeter is an insulated container used in energy experiments.

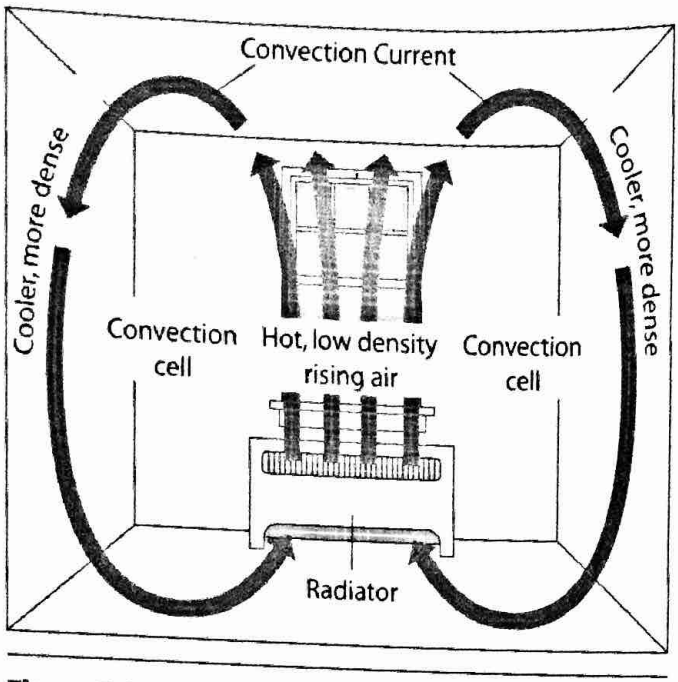


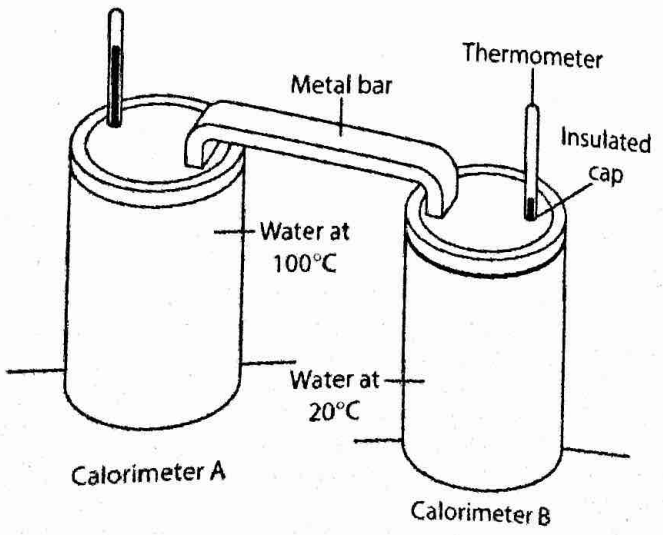
Figure 5-4. Heating a room by convection: The air around a radiator is heated by conduction and by infrared radiation emitted by the radiator. Greenhouse gases (carbon dioxide and water vapor) in the room absorb the radiation. The heat is then carried around the room by convection currents.

density. Higher-density portions of a fluid are pulled down and displace less dense objects, pushing them upward. The result is a convection current—a circulatory motion—that transfers heat energy from one place to another. (See Figures 5-3 and 5-4.) Convection currents transfer heat throughout Earth's atmosphere, hydrosphere, and most likely below the lithosphere.

Radiation The method by which heat is transferred via electromagnetic waves is **radiation.** No medium is needed to transfer the transverse waves that carry electromagnetic energy; this energy can radiate from its source across empty space. Radiation can also occur in liquids, solids, and gases—such as sunlight being transmitted through the atmosphere (gas) or through window glass (solid). X-ray electromagnetic radiation can pass through all but the densest materials. Radiation is also the method by which the sun's electromagnetic energy moves through space to other objects in the solar system. The higher an object's temperature, the more electromagnetic energy it gives off. In Figure 5-3, the higher the temperature of the metal bar, the more infrared energy it will radiate to the hand. (See Figure 5-2 and the Electromagnetic Spectrum in the Ⓡ *Earth Science Reference Tables.*)

Review Questions

For questions 13 through 16, refer to the following diagram. A student is using the apparatus shown to perform an investigation. The two calorimeters contain equal amounts of water, and the metal bar is touching the water inside each calorimeter. At the beginning of the investigation, the temperature of the water was 100°C in calorimeter A and 20°C in calorimeter B. The room temperature is 20°C.



13. If this were a closed system, what would be the temperature when the system reaches equilibrium?

(1) 100°C (2) 75°C (3) 60°C (4) 40°C

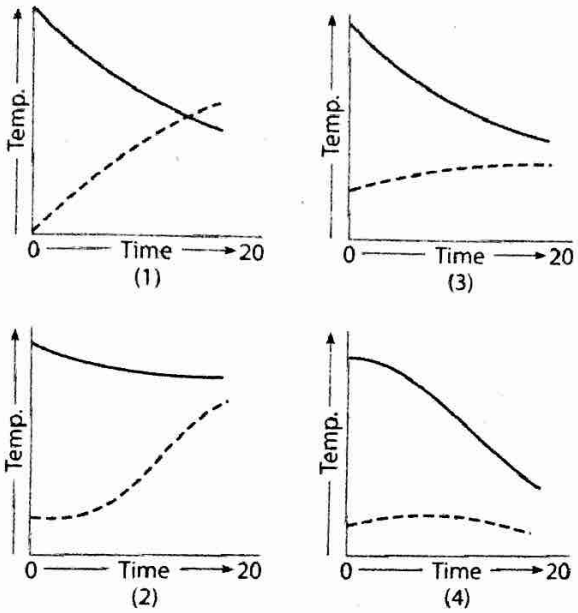
14. Which conclusion should the student make after performing this investigation?

(1) The energy gained by the cold water equaled the energy lost by the hot water.
(2) The energy gained by the cold water was less than the energy lost by the hot water.
(3) The change in temperature of the cold-water thermometer equaled the change in temperature of the hot-water thermometer.
(4) Energy was transferred between the two calorimeters primarily by radiation.

15. Which procedure would best increase the amount of heat energy that is actually gained by calorimeter B?

(1) increasing the length of the metal bar
(2) increasing the thickness of the metal bar
(3) circulating air over the metal bar
(4) placing insulation around the metal bar

16. Which graph best represents the probable relationship between the temperatures of the two calorimeters and the time for this heat transfer investigation?



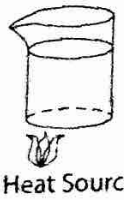
17. The environment is in dynamic equilibrium when it is gaining

(1) less energy than it is losing
(2) more energy than it is losing
(3) the same amount of energy it is losing

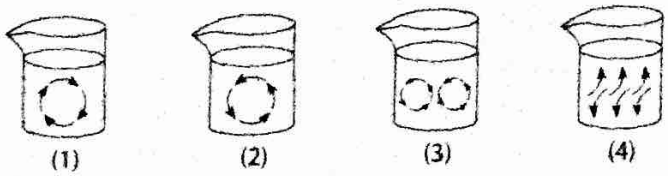
18. Differences in density cause energy to be transferred by which method?

(1) absorption
(2) conduction
(3) convection
(4) radiation

19. Water is being heated in a beaker as shown.



Which of the following drawings shows the most probable movement of water in the beaker due to the heating?



20. At which temperature will an object radiate the greatest amount of electromagnetic energy?

(1) 0°F
(2) 5°C
(3) 10°F
(4) 230 K

21. What method of energy transfer requires no medium for transfer?

(1) conduction
(2) convection
(3) refraction
(4) radiation

22. By which process does starlight travel through space?

(1) absorption
(2) conduction
(3) vaporization
(4) radiation

23. By which process do light rays pass through window glass?

(1) conduction
(2) convection
(3) radiation
(4) compression

24. Which diagram correctly indicates why convection currents form in water when water is heated?