II. OTHER FORMS OF ENERGY

Energy is found in many forms. Whatever its form, energy is the ability to do work. Heat energy, **chemical energy**, and **atomic energy** are three forms of energy considered in this section.

SECTION OBJECTIVES

Review these objectives. When you have completed this section, you should be able to:

3. Define heat in terms of work and friction.
4. Explain conduction and convection.
5. Discuss radiation and distinguish it from regular heat energy.
6. Explain chemical energy.
7. Label a simple atom.
8. Explain fission and fusion.

VOCABULARY

Study these words to enhance your learning success in this section.

atmosphere (at' mu sfir). The air around the earth.
atom (at' um). The smallest part of an element that has the characteristics of the element.
atomic energy (u tom' ik en' ur jē). The energy of atoms.
atomic reaction (u tom' ik rē ak' shun). The splitting or fusing of atomic nuclei.
atomic mass unit (u tom' ik mas yü' nit). The mass of one proton or one neutron.
burning (bėr ning). Rapid oxidation; combustion.
chain reaction (chān rē ak' shun). Splitting one after the other.
chemical energy (kem' u kul en' ur je). The energy possessed by a substance by virtue of its make-up.
combustion (kum bus' chun). Rapid oxidation.
conduction (kun duk' shun). The transmission of heat by the transferring of energy from one particle to another.
convection (kun vek' shun). The transfer of heat by the motion of the particles of a fluid.
current (kėr' unt). A flow.
Dewar flask (dü' ur flask). A "thermos" bottle.
electron (i lek' tron). The negative particle in orbit around an atomic nucleus.
element (el' u munt). One of the simple substances made up of one kind of atom.
explosion (ek splō zhun). The action of blowing up.
fission (fish' un). The splitting of atomic nuclei.

fluid (flü' id). A liquid or gas. Something that will flow.
friction (frik' shun). Rubbing.
fuel (fyü ul). Any substance that will burn.
fusion (fyü shun). Melting together; the joining of atomic nuclei at high heat.
gas (gas). A state of matter in which the molecules are far apart.
insulation (in su lā' shun). A process or substance used to regulate the movement of heat.
insulator (īn' su lā' tur). Something that prevents the passage of heat, electricity, or sound.
isotope (i' su tōp). An atom of an element having a different number of neutrons.
liquid (lik' wid). A state of matter in which molecules are touching but still free to flow.
mass (mas). The quantity of matter something contains.
matter (mat' ur). Anything that takes up space.
neutron (nü' tron). The uncharged particle in the nucleus of an atom.
nuclear reaction (nü' klē ur rē ak' shun). The fission or fusion of atomic nuclei.
nucleus (nü' klē us). The center or core of the atom.
oxidation (ok' su da' shun). The joining of oxygen with another substance.
piston (pis' tun). A movable cylinder in a tube.
proton (prō ' ton). The positive particles of the atomic nucleus.
radiation (rā' dē ā' shun). Energy that moves in waves.
temperature (tem' pur u chur). The degree of heat.
thermonuclear reaction (thėr' mo nü klē ur rē ak' shun). Atomic fusion.

HEAT ENERGY

Heat is the energy of moving molecules. Thus, heat is really a form of kinetic energy. The faster the molecules of a substance move, the hotter is the substance. This fact makes heat one of the most common forms of energy.

Product of work. Whenever work is done, heat is produced. For work to be done, an object must move. Whenever an object moves, it rubs against something else. This statement may not seem true, but we must remember that air is everywhere except in a vacuum. Whenever an object moves, at the very least it will rub against air molecules. The rubbing of molecules against one another is termed **friction**. Friction produces heat. When friction is increased, more heat is produced. When work is done, friction occurs and heat is given off. The heat caused by friction is transferred from one substance to another substance, from one place to another. Wherever energy is used, some of that energy is "lost" by being changed into heat. Heat energy frequently cannot be recaptured and made usable. We shall discuss this unusual fact later in this LIFEPAC.

Complete these sentences.

2.1 A product of work is_____.
2.2 The rubbing of one substance against another causes_____.

Measurement. Heat causes the molecules of a substance to vibrate faster. The speed of the molecules is measured in degrees. As the speed of the molecules increases, the degrees of the substance increase. This measurement is called **temperature**. Often temperature and heat are confused. Heat is the energy causing the molecules to vibrate. The amount of vibration is the temperature.

Conduction. Heat energy is transferred from one object to another or through an object by **conduction**. In conduction the following process occurs:

1. A molecule vibrates.
2. More heat energy is given to the molecule.
3. The molecule vibrates faster.
4. The molecule causes its neighboring molecule to start vibrating.
5. The second molecule starts its neighbor vibrating.
6. Soon many molecules are vibrating and transmitting the heat through a substance or from one object to another.

An example of how heat is conducted is a silver spoon. Silver is a good conductor of heat. If a silver spoon is placed in a cup of hot coffee, the **atoms** of silver begin to vibrate faster and faster. The moving atoms cause their neighboring atoms to vibrate faster. Soon the atoms throughout the spoon are vibrating at the faster speed. When a hand touches the spoon, the molecules of the hand are caused to vibrate at high speed. This vibration causes a nerve impulse to reach the brain. The impulse registers: "Hot!"

Answer *true* or *false*.

2.3 _____ Heat is transferred from one molecule to another.
2.4 _____ Heat causes molecules to vibrate more slowly.
2.5 _____ Silver is a poor conductor of heat.

Convection. Heat is transferred not only by conduction but also by a process called **convection**. Convection occurs only in substances which can flow from place to place. These substances are called fluids. The two kinds of **fluids** are **liquids** and **gases**. In convection the following steps occur:

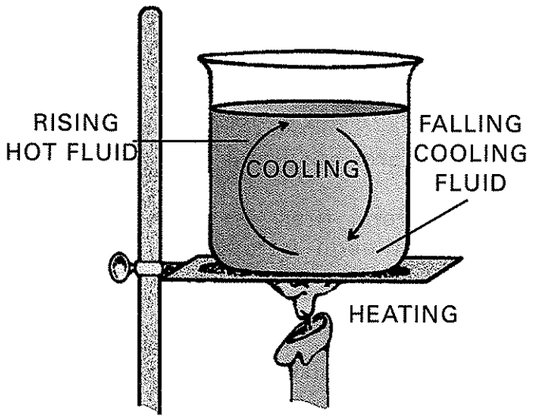
1. A fluid is heated.
2. The molecules vibrate faster.
3. The hotter fluid is lighter in density and rises.
4. The cooler fluid moves to fill the void left by the rising hot fluid.
5. The cooler fluid is heated and tries to rise.
6. The fluid that was heated cools and falls.
7. The cooling fluid is pushed aside by the newly heated fluid.
8. The fluid heats, rises, cools, and falls in a circular motion.
9. Gradually the whole fluid is heated to a fairly even temperature.

Convection is an important part of life on earth. We will study three ways that convection affects our lives.

The **atmosphere** is the air surrounding the earth. Energy from the sun heats the surface of the earth. The heated surface of the earth warms the air molecules that are touching it. These heated air molecules rise and cool air rushes down. A convection current is set up. The earth's convection is the primary way the atmosphere is heated. We feel this convection current of the atmosphere as a breeze or wind.

In homes, heaters warm the air near them. The warm air rises and a convection current results. Soon the heat is spread throughout the room.

Convection currents are also used in cooking. A pan of water on a stove is heated only at the bottom. The warmed water rises and cool water falls. The cool water is heated and rises. The resulting convection current causes all the water to be heated.



Convection

We can see that life on earth would be very different, if not impossible, without the transfer of heat by convection.

Write the best answer on the line.

2.6 The movement of a fluid because of heat is called a_____.
a. convection current
b. conduction current
c. heat current

2.7 Convection occurs only in_____.
a. solids and liquids
b. solids and gases
c. liquids and gases

2.8 A_____fluid rises.
a. hot
b. cold
c. solid

Radiation. Another way heat is transferred from place to place is by **radiation**. When heat is radiated, it travels in waves as light does. These heat waves travel at the speed of light. Heat waves travel on their own, are independent of molecules, and can move through a vacuum where no molecules are. The sun's heat reaches the earth across the vacuum of space by means of radiation. The sun gives off tremendous quantities of radiant heat. Many of the waves of radiation that reach the earth are reflected (bounced back) off the earth's atmosphere. A few of these rays are absorbed by the atmosphere. The remaining rays of radiation are absorbed by the earth's surface.

Heat from fires is transmitted by radiation (though it may travel in other ways as well). A fireplace heats by radiant energy. As the heat waves flow from the fireplace, the molecules of air and the molecules of other surfaces are heated. The heated molecules in turn heat other air molecules and the room is slowly warmed.

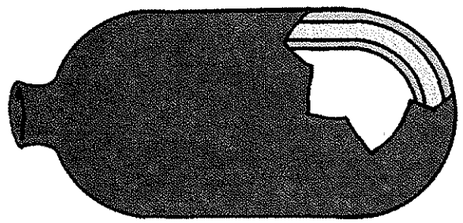
Radiant energy from the sun is being considered more and more as an alternate source of energy for the jobs that need to be done on earth. New methods of harnessing the sun's radiation are being developed. Many fairly efficient means are already in use. One way of trapping the sun's radiation is by means of a slanted pane of darkened glass. The dark surface absorbs the waves of radiation. The heat is used to heat water. Pipes carry the heated water throughout the building. Steam from the water heats the building effectively.

Answer *true* or *false*.

2.9 _____ Radiant heat can travel through a vacuum.
2.10 _____ Most of the sun's radiation reaches the earth's surface.
2.11 _____ The sun's radiation is the main way the atmosphere is heated.
2.12 _____ Radiant heat can come from sources other than the sun.
2.13 _____ Solar radiation can be used to heat buildings.

Insulation. Many substances do not conduct heat well. These substances are used to prevent the loss of heat. The process of preventing heat loss is called **insulation**. One substance which does not conduct heat efficiently is air. Air molecules are too far apart for one molecule to cause its neighbor to vibrate. This fact enables air to be used as an **insulator**. An insulator is a substance that prevents the passage of heat, electricity, or sound.

Air is used as an insulator in many homes. The homeowner places two panes of glass in the window frames instead of just one. A layer of air is left between the two windows. When the home is heated, the inside glass becomes warm. The nearest air molecules are heated, but they do not heat their neighbors. The outside glass receives little or no heat. Thus, the heat is efficiently trapped within the home.



Another example of heat insulation is the "thermos bottle" or **Dewar flask**. This bottle is made of double-walled glass. Air is removed from between the two glass walls to create a vacuum. When a hot liquid is placed inside the bottle, it heats the inner glass wall. The bottle has no molecules at all touching the outer glass wall. The outer glass wall cannot be heated. The radiant heat is trapped also by painting the inside of the glass silver. The silver reflects the radiation, causing it to be trapped in the substance. The outer wall of the bottle never becomes warm. The heat is trapped within the bottle, keeping the liquid warm for many hours.

Match these terms.

2.14 _____ silver paint
2.15 _____ vacuum
2.16 _____ air
2.17 _____ Dewar flask

a. radiation
b. reflects radiation
c. "Thermos" bottle
d. between the glass walls of the Dewar flask
e. a good insulator

Answer these questions.

2.18 Explain in complete sentences how a convection current is set up.

_____

_____

_____

2.19 Explain why air is not a good conductor of heat. _____

_____

2.20 Explain why solar radiation can travel through a vacuum. _____

_____

_____

Teacher check _____
Initial Date

CHEMICAL ENERGY

Most substances have the ability to react to the presence of some other substance. These reactions can be very powerful or hardly noticeable. The reason substances react to each other is because of their makeup. Every substance consists of atoms bound together. Most atoms are either attracted to or repelled by other atoms. When two or more substances are brought together, their atoms may attract or repel one another. Atoms in the substances may be separated and joined in a different way to make new substances. This activity releases or absorbs energy in the form of heat and/or light. This process is referred to as a chemical reaction.

One type of chemical reaction that is particularly valuable in producing heat is