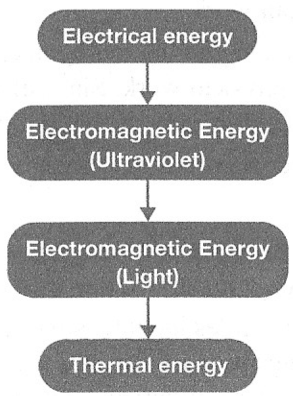
Chapter 8 Answer Key

8.1 Section Review

1. The law of conservation of energy states that energy cannot be created or destroyed. Energy can only be converted from one form to another. The "lost" energy is work done against friction which converts other forms of energy into heat and wear.

2.



8.2 Section Review

1. A typical adult consumes about 2000 Calories a day. When you convert that to watts, you get about 100 watts of power which is the same as a light bulb.

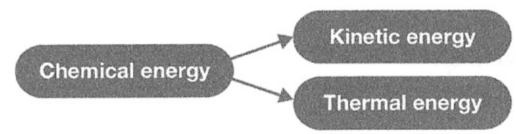
$$\frac{2{,}000 \text{ Calories}}{1 \text{ day}} \times \frac{4{,}187 \text{ Joules}}{\text{Calorie}} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ hour}}{60 \text{ minutes}} \times \frac{1 \text{ minute}}{60 \text{ seconds}} = 97 \text{ Watts}$$

2. Thermodynamics is the physics of heat. Most energy sources used to generate electric power convert chemical energy to heat, and then use the heat to drive machines such as cars and generators in power plants.

3. Efficiency = input work / output work
Efficiency = $(1 \times 10^3 \text{ J}) / (1 \times 10^6 \text{ J}) = 0.1\%$

8.3 Section Review

1.



2. Answers will vary. Some example of natural energy systems are the water cycle, a food chain, radiant energy on Earth, and weather systems.

Connection Answers

1. Diagrams will show potential energy of water transformed into mechanical energy of the spinning turbine and then transformed into electrical energy of the generator. At each stage, some energy is "lost" when it is transformed to friction or heat energy.
2. Some energy will be "lost" to friction and heat when the float/weight device slides up and down on the tether. When the falling weight spins the generator shaft, more energy will be "lost" as friction and heat. The heat would be transferred to the water surrounding the device.
3. Engineers must build very rugged machines to harness tidal power, because the machines must be able to withstand violent weather and the corrosive effects of salt water. Engineers face the additional challenge of building machines with parts that are as simple as possible to repair or replace in the water.

Understanding Vocabulary

1. radiant energy
2. chemical energy
3. mechanical energy
4. second law of thermodynamics
5. steady state
6. food chain

Reviewing Concepts

Section 8.1

1. Because it is spent and saved in a number of ways and also because you have to have some to start with, and what you spend decreases what you have left.
2. Potential energy is stored energy and chemical energy is energy "stored" in the bonds that join atoms.
3. The pressure in a fluid is a form of energy because pressure causes fluid to gain kinetic energy as it flows from higher to lower pressure regions.
4. Potential energy because the position of the rubber band is allowing it to store energy.
5. This energy is not really lost, it is just changed into a form that is not easily accounted for, like heat and wear (grinding away of molecules).

Section 8.2

6. Power is the rate of converting energy or doing work. It is calculated by dividing the amount of energy changed (or work done) by the time it takes to make the change.
7. Answers will vary. Examples include: watts are used to measure radiant energy put out by light bulbs; horsepower is used to measure the output of car engines.
8. The rate at which work is done, or the rate at which energy flows (is converted from one form to another).
9. Efficiency describes how well energy is converted from one form to another. It is calculated by dividing output energy (or power) by input energy (or power).
10. A car engine produces output work (moving the car) from the flow of heat. Gasoline burns very hot and the air outside is cold. Heat from the gasoline does work as it moves from hot to cold. The second law says that when work is done by heat flowing, the output work is always less than the amount of heat that flows - this is true for a car's engine combusting gasoline as almost 2/3 of the energy in gasoline flows out of the car's tailpipe and radiator as heat with only 1/3 actually becoming useful output work.
11. Because most of the energy in the food you eat becomes heat, very little becomes useful physical work. Since efficiency is calculated using output work, the efficiency of living things is quite low.
12. Lower since more energy would be converted to heat and wear.

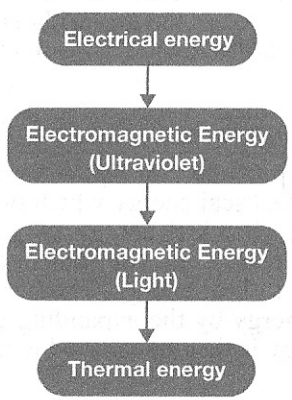
Section 8.3

13. The energy mostly flows back and forth between potential and kinetic energy with some energy lost to friction on each swing.
14. Answers will vary. Examples include: small cars and lawn mowers have high power ratings because they are used to do a lot of work in a small amount of time. A small fan and a desk lamp have low power ratings because we are concerned with the work that they do, but the rate at which the work is done is not very important.
15. Radiant energy from the sun; much is absorbed by oceans and lakes and used to drive the water cycle.
16. It takes many herbivores to support one carnivore. As you proceed up through the levels of the food chain, a significant amount of energy is lost at each level. This means that the nutritional value available to carnivores is less than the energy available to herbivores.
17. Decomposers break down waste and bodies of other animals into simple molecules that can be used by plants. Decomposers recycle raw materials such as carbon and nitrogen so they can be used by producers again.

Solving Problems

Section 8.1

1. Someone must have pushed the bal. If it had started from rest, then it would have only had 9.8 J of energy, the potential energy due to its position at the top of the hill.
   $PE = mgh = (1\text{ kg})(9.8\text{ m/s}^2)(1\text{ m}) = 9.8\text{ J}$
   Based on energy conservation, the ball could therefore only have 9.8 J of kinetic energy at the bottom of the hill and a maximum speed of 4.4 m/s.
   $KE = {}^1\!/_2 mv^2 = {}^1\!/_2(1\text{ kg})v^2 = 9.8\text{ J};\ v = 4.4\text{ m/s}$
   Since the ball is moving at 20 m/s at the bottom of the hill, it must have started with more than just its initial potential energy at the top of the hill.
2. 0.9 J were "lost" which means that 0.9 J of energy were converted to work done against friction like heat and wear.
3. Answers are:
   a. the potential energy of the blue ball
   b. potential energy, kinetic energy, electrical energy
   c.



   d. No. When the ball turns the paddle wheel, the generator will turn, turning the motor on. But the switch will turn the motor off, so the hammer will not swing.

Section 8.2

4. Answers are:
   a. $W = E_p = mgh$
      $W = (75\text{ kg})(9.8\text{ m/s}^2)(3\text{ m}) = 2{,}205\text{ J}$
   b. $P = W \div t$
      $P = (2{,}205\text{ J}) \div (3\text{ s}) = 735\text{ W}$
   c. 0.99 horsepower
   d. 5.3%
5. Answers are:
   a. Work $= Fd = (35\text{ N})(350\text{ m}) = 12{,}250\text{ J}$
   b. $P = E \div t = 12{,}250 \div (6\text{ s}) = 2042\text{ W}$
   c. 2.74 horsepower
6. $P = E \div t = (55\text{ J}) \div (55\text{ s}) = 1$ watt
7. Efficiency $= W_{out} \div W_{in}$
   $0.86 = W_{out} \div 70\text{ J}$
   $W_{out} = 60.2\text{ J}$
8. Answers are:
   a. Efficiency $= E_{out} \div E_{in}$
      $0.85 = E_{out} \div 800\text{ J}$
      $E_{out} = 680\text{ J}$
   b. Work $= Fd$
      $680\text{ J} = (13{,}600\text{ N})d$
      $d = 0.05\text{ m}$
9. Answers are:
   a. $P = Fd \div t = Fv = (200\text{ N})(2\text{ m/s}) = 400\text{ W}$
   b. $P = Fd \div t = Fv = (200\text{ N})(1\text{ m/s}) = 200\text{ W}$

Section 8.3

10. Answers are:
    a. $E_p = mgh = (20\text{ people} \times 70\text{ kg/person})(9.8\text{ m/s}^2)(5\text{ m})$
       $E_p = 68{,}600$
    b. Power Rating = Energy ÷ time = 68,600 ÷ 5 s = 13,720 W
       Power Rating = 18.4 horsepower

11. electrical energy = 1.0 J; mechanical energy (motor) = 0.60 J; mechanical energy (gears) = 0.57 J
    output work = 0.51 J; friction and heat = 9.49 J; overall efficiency = 5.1%

Test Practice

Section 8.1

1. b
2. a
3. c
4. a
   $PE = mgh$
   $PE = (20\text{ kg})(9.8\text{ m/s}^2)(10\text{m}) = 1{,}960\text{ J}$
   $KE = \frac{1}{2} mv^2$
   $KE = \frac{1}{2}(20\text{ kg})(12\text{ m/s})^2 = 1{,}440\text{ J}$
   1960 J – 1440 J = 520 J lost to friction

Section 8.2

5. d
   $P = W/t$
   $P = (60\text{ kg})(9.8\text{ m/s}^2)(3\text{ m}) / (4\text{ s})$
   $P = 441\text{ W}$
6. b
7. c
8. c
   30 Calories = 30 (4,187 J) = 125,610 J
   efficiency = output work / input work = 9,800 / 125,610 = 8%

Section 8.3

9. b
10. c
   $P = W/t$
   $P = (500\text{ kg})(9.8\text{ m/s}^2)(20\text{ m}) / (40\text{ s})$
   $P = 2{,}450\text{ W}$
   2,450 J/s = 3.3 hp
11. d
12. a

Applying Your Knowledge

Section 8.1

1. Answers are:
   a. Solar cells require sunlight to operate. This is available continuously in outer space without obstruction from sources such as clouds.
   b. Answers will vary. They may include the following:
   Advantages: The energy is clean, limitless, and free to collect; extra energy can be sold to the power company.
   Disadvantages: Cost of initial installation is high; storage system batteries and materials can be dangerous, the supply is not necessarily steady because the sun is not always shining; not all homes are properly oriented to the sun.
   c. Less than 1%; there is legislation in several states located in the southwest that is encouraging the production of energy by solar cells to rise to 10% by the year 2012.
   d. Currently Arizona would be considered the leader although California is a close second. The climate in these two states is most conducive to the use of solar cells. Also, California faces a huge energy deficit. Production of energy by solar cells, a clean source, would help to fill the gap without producing more smog, a prevalent problem for many California locales.

Section 8.2

2. Answers may vary. Answers typical of student response:
   a. The chemical potential energy stored in the battery is transformed to electrical energy which provides a spark and heat to transform the chemical energy of gasoline. Ignition of the gasoline vapor results in the transformation of the stored chemical energy to heat energy. The heat energy is transformed to mechanical energy by the expanding gas in the cylinder. The mechanical energy is then transferred to the drive train and to the wheels.

Chapter 9 Answer Key

9.1 Section Review

1. The hot tea has a higher temperature and therefore a higher kinetic energy.
2. In a gas, the kinetic energy from temperature is greater than the intermolecular forces. The kinetic energy from temperature tends to push the molecules apaart.
3. At sea level, you are under a column of air subject to Earth's gravitational field. The air pressure is similar to pressure exerted on a surface immersed in fluid.

9.2 Section Review

1. Temperature measures the average random kinetic energy of particles of matter. Thermal energy is the sum of all the kinetic energies of all of the particles in a sample.
2. $E = mC_p(T_2 - T_1)$
   $E = (20\text{ kg}) \times 4{,}184\text{ J/kg°C}\ (35°\text{C} - 0°\text{C}) = 2{,}928{,}800\text{ J}$

9.3 Section Review

1. Answers will vary. Some examples are: putting a cold pan on a hot electric stove unit, or putting cold food into a hot pan.
2. convection
3. The lamp would emit more thermal radiation as it heats up. Objects with higher temperatures emit more thermal radiation
4. The heat will flow from the room to the ice cube. Heat always flows from hot to cold.

Connection Answers

1. Earth's atmosphere keeps global temperatures within a narrow range to which humans can adapt. It provides the oxygen needed for body systems to function properly. It shields human bodies from harmful radiation that cannot be blocked by skin cells and provides the air pressure needed to keep the circulatory system functioning properly.
2. The EMU has a two-piece outer garment with a pressure bladder and restraint layer cover with a nylon liner. These layers keep the astronaut's body from swelling while in the vacuum of space. The EMU also provides an oxygen source and carbon dioxide ventilating system to keep the astronaut's respiratory system functioning properly.
3. Astronauts can experience extremely hot or extremely cold temperatures while outside the spacecraft. The EMU contains a water circulation system that helps the astronaut's body maintain a steady temperature. Astronauts also need protection from space debris. The EMU helmet and anti-abrasion outer layer garment provide a barrier which protects the astronauts from tissue damage.

Understanding Vocabulary

1. compound
2. intermolecular
3. Celsius
4. plasma
5. thermal
6. convection, conduction or conduction, convection

Reviewing Concepts

Section 9.1

1. Brownian movement is the irregular motion of small particles of matter such as pollen grains suspended in water as observed under a microscope. It provides strong evidence that matter is made of atoms.
2. Macroscopic: table salt appears as a white, granular substance. Atomic: table salt is a compound made of sodium and chlorine atoms bonded together.
3. An element is a pure substance that cannot be broken down into simpler substances by physical or chemical means. Examples include: hydrogen, carbon, oxygen, and aluminum.

A compound is a pure substance that contains two or more elements chemically joined. Examples include: water, salt, and carbon dioxide.

4. A compound contains two or more substances chemically joined together that has the same consistency throughout; a mixture contains more than one kind of atom, molecule or compound, but the contents are not chemically joined together.
5. The KE associated with temperature is the energy due to the random back and forth motion on the atomic or molecular level. This motion is directly proportional to the temperature. The KE associated with the gross motion of an object is not affected by temperature and is proportional to the velocity of the object.
6. The strength of intermolecular forces and the temperature determine whether a substance is a solid, liquid or gas.
7. A solid holds its shape and does not flow. The particles in a solid vibrate in place but cannot move around. A liquid has a definite volume but no definite shape – it flows. The particles in a liquid can move around but remain close together. A gas flows like a liquid but can expand or contract to fill a container so it has no definite shape. The particles in a gas move faster, on average, than those in a liquid. In the plasma phase, matter becomes ionized as electrons are broken loose from atoms. Because the electrons are free to move independently, plasma can conduct electricity.
8. solid-solid mixture: soil, liquid-solid mixture: ocean water, liquid-liquid mixture: radiator coolant, liquid-gas mixture: air in water, gas-gas mixture: air
9. Melting and freezing for a substance occur at the same temperature, the melting/freezing point. When enough energy is added the intermolecular forces are overcome allowing molecules to separate and move as a liquid. The temperature remains at the melting point until all solid is changed to liquid form. When energy is removed, the intermolecular forces overcome the random motion provided by the translational KE and movement is restricted to the vibration of a solid.
10. At the macroscopic level, boiling takes place within a liquid as bubbles of gas form and rise to the surface. At the atomic level, the intermolecular forces between water molecules are completely overcome and the liquid becomes a gas
11. Evaporation occurs when molecules go from liquid to gas at temperatures below the boiling point. This happens because molecules within the liquid have different kinetic energies and the molecules with higher energies sometimes have enough energy to break the bonds of their neighbors causing them to become a gas. This is different from boiling where the energy source is external and the changes occur only at the boiling point.
12. The difference between the freezing point of water and the boiling point of water on the Fahrenheit scale is 180 degrees, from 32°F to 212°F. On the Celsius scale the difference is 100 degrees, from 0°C to 100 °C. A Fahrenheit degree measures a smaller change in temperature than a Celsius degree. One Fahrenheit degree represents the same as 5/9 of a Celsius degree.
13. There is no apparent upper limit to temperature but there is a lower limit, identified as absolute zero, the point at which molecules have the lowest energy they can have and the temperature can go no lower.
14. The molecules of fluids are held together weakly by intermolecular forces. Consequently, gases and liquids move around and collide with each other and with the walls of their containers. The trillions of collisions per second made with the walls create the pressure.
15. The Kelvin scale is important to scientists because it starts at absolute zero. The Kelvin scale measures the actual energy of the atoms while the other scales measure the relative energy, relative to their zero points.
16. In the U.S., the Fahrenheit scale is commonly used to measure temperature. Europe and most other countries of the world use the Celsius scale. On the Fahrenheit scale "the 20s" is cold. On the Celsius scale, "the 20s" is warm; it's in the 70s on the Fahrenheit scale. The Italian student dressed for Celsius temperatures to which he was accustomed

Section 9.2

17. Temperature is the average kinetic energy of the particles of a system. Thermal energy is the total kinetic energy of the particles of a system.
18. Heat is the flow of thermal energy. Heat only occurs when there is a difference in temperature.
19. The swimming pool has a much larger amount of water and therefore has much more thermal energy. Thermal energy measures the total kinetic energy and depends upon the amount of material Temperature measure the average kinetic energy and does not depend on the amount of material. Higher thermal energy does not mean higher temperature since mass is a factor as well.
20. joule: the metric unit most often used in physics and engineering. Btu; used to describe heating and air conditioning systems. calorie: the metric unit most often used in chemistry. Calorie: actually the kilocalorie, sometimes called the Great Calorie, used to describe the energy in food.
21. The specific heat of a substance is the amount heat needed to raise a unit mass of the substance one degree of temperature. Frequently stated in units of J/kg°C, it indicates how quickly the temperature of a substance will change with the addition or loss of heat. Generally the specific heat is lower for more dense materials and higher for materials of lower density. This is due to the fact that the more dense materials contain fewer molecules of the substance per kilogram allowing more energy to flow to or from each molecule thus causing a greater temperature change for the amount heat added or lost.
22. Water has a high specific heat. Land, because it has a low specific heat, experiences large changes in temperature when it absorbs heat from the sun. Water tends to have smaller changes in temperature when it absorbs the same amount of heat. During the daytime, oceans help keep Earth cool, while at night, after the land has quickly cooled, help keep Earth warm by slowing the rate at which heat is emitted back into space.

Section 9.3

23. Heat conduction is the transfer of heat by direct contact of particles of matter. Convection is the transfer of heat by the motion of a fluid in the form of currents. Thermal radiation is the transfer of heat in the form of electromagnetic waves including light.
24. Heat conduction is occurring as the heat from your hand is transferred to the cold soda.
25. Metals are better conductors of heat. A pan made of metal efficiently conducts heat from the stove's heat source to the food in the pan.
26. Gases, having particles that are spread far apart, are good thermal insulators. Materials with air pockets within them tend to be good thermal insulators. Examples include foam cups, down jackets, and fiberglass insulation.
27. Solids are generally the best conductors because the particles are packed closely together. Gases are generally the poorest because the particles are spread so far apart. Liquids are intermediate in their ability because their molecules are closer together than gases but farther apart than solids.
28. Hot air rises because it is less dense than cold air creating a convection current.
29. Convection depends upon the ability of molecules to move about freely. Therefore, convection does NOT occur in solids because the molecules are locked in a structure.
30. The color of an object affects its ability to absorb thermal radiation. Black objects absorb heat best.
31. Heat transfer occurs from higher temperatures to lower temperatures. If the air temperature is 100°F this is higher than the average body temperature of 98.6°F. Heat will be transferred to the body rather than away from it by radiation, convection and conduction.

Solving Problems

Section 9.1

1. a. mixture b. element c. compound d. mixture
2. $T_c = (T_f - 32) \times 5/9 = (98.6°F - 32) \times 5/9 = 37°C$
3. $T_f = (9/5)T_c + 32 = (9/5)(5{,}500°C) + 32 = 9{,}932°F$
4. $T_f = (9/5)T_c + 32 = (9/5)(250°C) + 32 = 482°F$
5. $T_c = (T_f - 32) \times 5/9 = (451°F - 32) \times 5/9 = 233°C$

6. Answers are:
   a. a. solid (ans. temperature below 0°C, ice)
   b. b. liquid (ans. temperatures between 0°C and 100°C, water)
   c. c. gas (ans. temperatures 100°C and above, steam)
7. The substance is a gas. It expanded to completely fill the container.
8. $F = P \times A$
   surface area of can= A_T= [area of walls of can] + [2 × area of can end].
   A_T= (Height × π × diameter) + $2\pi r^2$ = (12.0 cm × π × 6.50 cm) + $2\pi(6.50\text{ cm})^2$;
   A_T= 245.0 cm^2 + 265.5 cm^2 = 510.5 cm^2 = 0.05105 m^2;
   F = 1,030 N/m^2 × 0.05105 m^2 = 52.6 N

Section 9.2

9. $Q = mc\Delta T$
   Q = (10 kg)(2,500 J/kg°C)(25°C-20°C) = 125,000 joules
10. $\Delta T = Q \div mc$ = (5,000 J) ÷ (0.5 kg)(4,184 J/kg°C) = 2.4°C
11. $\Delta T = Q \div mc$ = (47,000 J) ÷ (1 kg)(470 J/kg°C) = 100°C
12. $Q = mc\Delta T$
    Q = (10 kg)(900 J/kg°C)(40°C -10°C) = 270,000 joules
13. It takes one calorie to raise 1 gram of water by 1°C, so it takes 20 calories to raise 1 gram of water by 20°C.

Section 9.3

14. Air is a good insulator, so the chickadee fluffs its feathers on a cold days to trap pockets of air that act as insulation and prevent it from losing heat.
15. The thermal energy of the hot water is transferred via conduction to the metal cup and then to its handle, because metal is such a good thermal conductor. By using a cup material that is a good insulator, such as plastic, the transfer of heat to the cup is reduced and the transfer of heat from the cup to its handle is reduced.
16. Answers are:
    a. a. convection
    b. b. conduction
    c. c. radiation
    d. d. conduction
    e. e. convection
    f. f. radiation

Test Practice

Section 9.1

1. d
2. a
3. c
4. b
5. d
6. a

Section 9.2

7. d
8. b

Section 9.3

9. d
10. d

Applying Your Knowledge

Section 9.1

1. Matter is subdivided into mixtures and substances. Mixtures include homogeneous and heterogeneous mixtures. Substances include elements and compounds. Students should be encouraged to come up with a unique way to display the classification of matter. If they use poster board, have them fill up the entire available space. Additionally, have your students provide examples for each step in the classification.
2. Encourage your students to use their creativity. For example, they could design a charade or a play using their classmates to act out the role of molecules buffeting about a larger piece of material. For more information on Brownian motion, the web site www.aip.org/history/einstein/brownian.html