Section 1 Temperature and Thermal Energy

A. **Kinetic theory**—explains how particles in matter behave
   1. All matter is composed of particles.
   2. Particles are in constant, random motion.
   3. Particles collide with each other and walls of their containers.

B. **Temperature**—related to the average kinetic energy of an object’s atoms or molecules
   1. The SI unit for temperature is Kelvin (K).
   2. Two other temperature scales are the Celsius scale and the Fahrenheit scale.

C. **Thermal energy**—the sum of the kinetic and potential energy of all the atoms in an object
   1. Thermal energy increases as temperature increases.
   2. At constant temperature, thermal energy increases if mass increases.

D. Thermal energy that flows from something at a higher temperature to something at a lower temperature is called **heat**.

E. **Specific heat**—amount of heat needed to raise the temperature of 1 kg of a material by one degree C or K.

F. Changes in thermal energy can be calculated as change in thermal energy equals mass times change in temperature times specific heat.
   1. When heat flows into an object and its temperature rises, the change in temperature is positive.
   2. When heat flows out of an object and its temperature decreases, the change in temperature is negative.
   3. A **calorimeter** is used to measure specific heat.

**DISCUSSION QUESTION:**
How do temperature and heat differ? Heat is thermal energy that flows from something warmer to something cooler; temperature is related to kinetic energy of atoms in a substance.
Section 2  States of Matter

A. States of matter—solid, liquid, gas, plasma

1. Solid state—particles are closely packed together in a specific type of geometric arrangement

2. Liquid state—a solid begins to liquefy at the melting point as the particles gain enough energy to overcome their ordered arrangement
   a. Energy required to reach the melting point is called the heat of fusion.
   b. Liquid particles have more space between them allowing them to flow and take the shape of their container.

3. Gaseous state—a liquid’s particles have enough energy to escape the attractive forces of the other particles in the liquid
   a. Heat of vaporization is the energy required for a liquid to change to a gas.
   b. At the boiling point, the pressure of the liquid’s vapor is equal to the pressure of the atmosphere, and that liquid becomes a gas.
   c. Gas particles spread evenly throughout their container in the process of diffusion.

4. Plasma—state of matter consisting of high-temperature gas with balanced positively and negatively charged particles.

B. Thermal expansion—increase in the size of a substance when the temperature increases

1. The size of a substance will then decrease when the temperature decreases.

2. Expansion and contraction occur in most solids, liquids, and gases.

3. Water is an exception because it expands as it becomes solid.

DISCUSSION QUESTION:
How are temperature and kinetic energy related? Temperature means the average kinetic energy of a substance, or how fast the particles are moving.

Section 3  Transferring Thermal Energy

A. Conduction—transfer of thermal energy through matter by direct contact of particles

1. Kinetic energy is transferred as particles collide.

2. Solids, particularly metals, are good heat conductors.

B. The transfer of energy by the motion of heated particles in a fluid is called convection.

1. Convection currents transfer heat from warmer to cooler parts of a fluid.
2. Convection currents create rain forests and deserts over different regions of Earth.

C. **Radiation**—energy transfer by electromagnetic waves.
   1. Some radiation is absorbed and some is reflected when it strikes a material.
   2. Heat transfer by radiation is faster in a gas than in a liquid or solid.

D. **Thermal insulator**—material that does not let heat flow through it easily.
   1. Gases such as air usually make better insulators than liquids or solids.
   2. A jacket with air pockets is a good insulator because the air slows the flow of body heat to the colder outside air.

**DISCUSSION QUESTION:**
What state of matter generally makes a good heat conductor? Heat insulator?
Solids generally conduct heat better than liquids or gases; gases usually make better insulators than liquids or solids.

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**Section 4 Using Thermal Energy**

A. **Heating systems**—warm homes and buildings
   1. **Forced-air** system—fuel heats air, which is blown through ducts and vents; cool air is returned to the furnace to be reheated.
   2. **Radiator** system—hot water or steam in a radiator transfers thermal energy to the air
   3. **Electric** heating system—electrically heated coils in ceilings or floors heat air by conduction

B. **Thermodynamics**—the study of the relationships among thermal energy, heat, and work
   1. **First law of thermodynamics**—the increase in energy of a system equals the energy added to the system
   2. **Second law of thermodynamics**—the increase in thermal energy of the cool object equals the decrease in thermal energy of the warm object.

C. **Heat engine**—an engine that converts thermal energy into mechanical energy
   1. An internal combustion engine burns fuel inside the engine in chambers or cylinders.
   2. Internal combustion engines convert only about 26 percent of the fuel’s chemical energy to mechanical energy.

D. **Entropy** is a measure of how dispersed energy is.

**DISCUSSION QUESTION:**
What are three types of heating systems? Forced-air systems, radiator systems, and electric systems.
Chapter Review
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Part A. Vocabulary Review
1. radiation (7/3)
2. conduction (7/3)
3. liquid (5/2)
4. decrease (6/2) (5/2)
5. insulators (5/3)
6. convection (8/3)
7. particles (4/2)
8. calorimeter (3/1)
9. kinetic energy (5/2)

Part B. Concept Review
1. does (7/3)
2. true (7/3)
3. conductor (8/3)
4. convection (7/3)
5. convection (7/3)
6. true (8/3)
7. true (7/3)
8. less (7/3)
9. true (8/3)
10. radiation (7/3)
11. true (1/1) (2/1)
12. An internal combustion engine burns its fuel inside itself. Fuel for an external combustion engine is burned outside the engine.

Celsius & Kelvin Conversions

1. Would you describe these temperatures as warm, hot or cold? Label the temperatures with W for warm, H for hot, and C for cold.
   a. 100 K (cold)
   b. 60°C (warm)
   c. 250 K (cold)
   d. 25°C (cold)
   e. 400 K (hot)
   f. -100°C (cold)

2. What is the equation that converts degrees Celsius to Kelvins?

   °C + 273 = K

3. Convert each of the Kelvin temperatures to degrees Celsius, and all the degrees Celsius temperatures to Kelvins.
   a. 100 K = -173 °C
   b. 60°C = 337 K
   c. 250 K = -37 °C
   d. 25°C = 297 K
   e. 400 K = 127 °C
   f. -100°C = 173 K

Section 4 Reinforcement ANSWERS

1. a steam-heating system
2. furnace heats water to a boil
3. internal combustion engine
4. conduction
5. to prevent the heat from escaping
6. conduction
7. Radiation
8. It cools and condenses to water.
9. convection