

Chapter 16 Thermal Energy and Heat

Summary

16.1 Thermal Energy and Matter

➡ Heat flows spontaneously from hot objects to cold objects.

- **Heat** is the transfer of thermal energy from one object to another because of a temperature difference.

➡ Temperature is related to the average kinetic energy of the particles in an object due to their random motions through space.

- **Temperature** is a measure of how hot or cold an object is compared to a reference point.
- On the Celsius scale, the reference points are the freezing and boiling points of water. On the Kelvin scale, another reference point is **absolute zero**, which is defined as a temperature of 0 kelvins.

➡ Thermal energy depends on the mass, temperature, and phase (solid, liquid, or gas) of an object.

➡ Thermal expansion occurs when particles of matter move farther apart as temperature increases.

- **Thermal expansion** is an increase in the volume of a material due to a temperature increase.

➡ The lower a material's specific heat, the more its temperature rises when a given amount of energy is absorbed by a given mass.

- **Specific heat** is the amount of heat needed to raise the temperature of one gram of a material by one degree Celsius.
- The amount of heat absorbed by a material (Q) is the product of the mass of the material (m), the specific heat of the material (c), and the change in temperature (ΔT): $Q = m \times c \times \Delta T$.

➡ A calorimeter uses the principle that heat flows from a hotter object to a colder object until both reach the same temperature.

- A **calorimeter** is an instrument used to measure changes in thermal energy.

16.2 Heat and Thermodynamics

➡ **Conduction in gases is slower than in liquids and solids because the particles in a gas collide less often.**

- **Conduction** is the transfer of thermal energy with no overall transfer of matter. Conduction occurs within a material or between materials that are touching.
- A **thermal conductor** is a material that conducts thermal energy well.
- A material that conducts thermal energy poorly is a **thermal insulator**.

➡ **Convection currents are important in many natural cycles, such as ocean currents, weather systems, and movements of hot rock in Earth's interior.**

- **Convection** is the transfer of thermal energy when particles of a fluid move from one place to another. The moving particles transfer thermal energy from hot areas to cold areas.
- A **convection current** occurs when a fluid circulates in a loop as it alternately heats up and cools down. In a heated room, a convection current helps keep the temperature about the same throughout the room.

➡ **All objects radiate energy. As an object's temperature increases, the rate at which it radiates energy increases.**

- **Radiation** is the transfer of energy by waves moving through space.
- The study of conversions between thermal energy and other forms of energy is called **thermodynamics**.

➡ **The first law of thermodynamics states that energy is conserved.**

➡ **The second law of thermodynamics states that thermal energy can flow from colder objects to hotter objects only if work is done on the system.**

- A **heat engine** is any device that converts heat (thermal energy) into work.
- Thermal energy that is not converted into work is called **waste heat**.

➡ **The third law of thermodynamics states that absolute zero cannot be reached.**

16.3 Using Heat

➡ The two main types of heat engines are the **external combustion engine** and the **internal combustion engine**.

- An **external combustion engine** is an engine that burns fuel outside the engine.
- An **internal combustion engine** is a heat engine in which the fuel burns inside the engine.

➡ Most heating systems use **convection** to **distribute thermal energy**.

- A **central heating system** heats many rooms from one central location.
- There are several types of heating systems, including hot-water heating, steam heating, electric baseboard heating, and forced-air heating systems.

➡ Heat pumps must do work on a **refrigerant** in order to reverse the **normal flow of thermal energy**.

- A **heat pump** is a device that reverses the normal flow of thermal energy. A heat pump causes thermal energy to move from a cold area to a hot area.
- A **refrigerant** is a fluid that vaporizes and condenses inside the tubing of a heat pump.
- Refrigerators and air conditioners are cooling systems that use heat pumps.