Section 1: Temperature

Preview

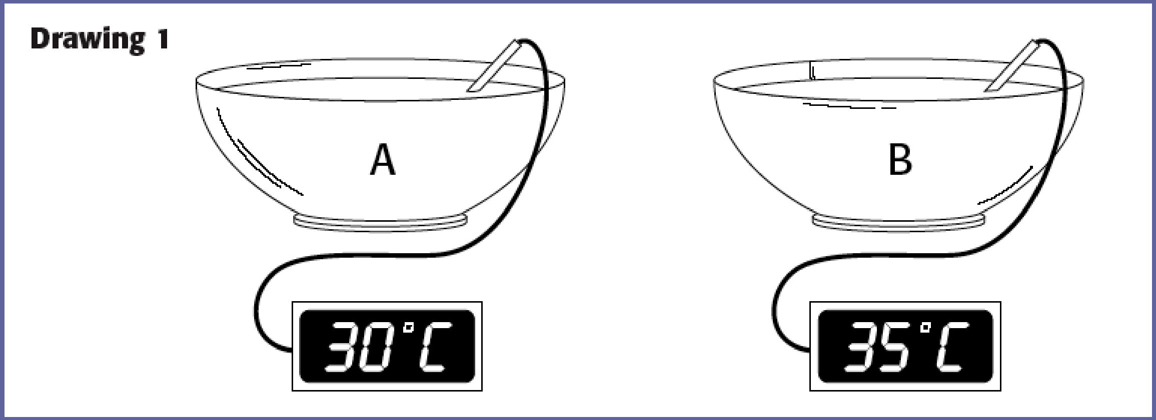
- Key Ideas
- Bellringer
- Temperature and Energy
- Temperature Scales
- Math Skills
- Relating Temperature to Energy Transfer
- Temperature and Heat

Key Ideas

- What does temperature have to do with energy?
- What three temperature scales are commonly used?
- What makes things feel hot or cold?

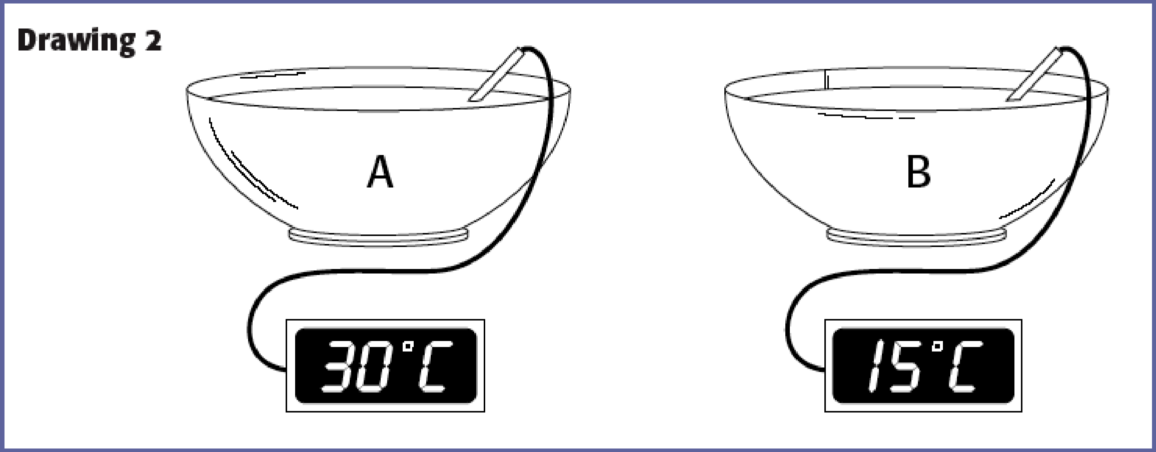
Bellringer

We use words like *hot* and *cold, long* and *short,* and *heavy* and *light* every day to describe the differences between things. In science, however, this is often not accurate enough and leads to confusion.



1. In drawing 1, which bowl would feel warm to your hands? Which bowl would feel cooler?

Bellringer, *continued*



2. In drawing 2, which bowl would feel warm to your hands? Which would feel cooler?

3. A person from Seattle tells his friend from Florida that the weather in Seattle is somewhat warm. When the friend arrives for a visit, he finds that he is uncomfortably cool wearing the shorts he packed. What would be a more effective way for the person from Seattle to explain the weather?

Temperature and Energy

- What does temperature have to do with energy?

- The temperature of a substance is proportional to the average kinetic energy of the substance's particles.

- **temperature:** a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particles in an object

Temperature and Energy, *continued*

- All particles have kinetic energy.
  - All particles in a substance are constantly moving.
  - As the average kinetic energy of the particles in an object increases, the object's temperature increases.
- Common thermometers rely on expansion.
  - Most substances expand when their temperatures increase.
  - **thermometer:** an instrument that measures and indicates temperature
- Thermostats rely on the expansion of different metals.

Temperature Scales

- What three temperature scales are commonly used?

- The Fahrenheit, Celsius, and Kelvin temperature scales are commonly used for different applications in different parts of the world.

Temperature Scales, *continued*

- The units on the Fahrenheit scale are called *degrees Fahrenheit* (°F).
- On the Fahrenheit scale, water freezes at 32 °F and boils at 212 °F.
- The Celsius scale gives a value of 0 °C to the freezing point of water and a value of 100 °C to the boiling point of water at standard atmospheric pressure.

Temperature Scales, *continued*

- One degree Celsius is equal to 1.8 degrees Fahrenheit.
- The temperature at which water freezes differs for the two scales by 32 degrees.

Fahrenheit-Celsius Conversion Equations

$$T_F = 1.8T_C + 32.0$$

$$T_C = \frac{T_F - 32.0}{1.8}$$

T_F = Fahrenheit temperature, T_C = Celsius temperature

Temperature Scales, *continued*

- The Kelvin scale is based on absolute zero.
- **absolute zero:** the temperature at which molecular energy is at a minimum
  - 0 K on the Kelvin scale or –273.16 ºC on the Celsius scale)

Celsius-Kelvin Conversion Equation

$$T_K = T_C + 237$$

T_k = Kelvin temperature, T_C = Celsius temperature

Math Skills

Temperature Scale Conversion

The highest temperature ever recorded in Earth's atmosphere was 57.8 °C at Al-Aziziyah, Libya, in 1922. Express this temperature in degrees Fahrenheit and in kelvins.

1. List the given and the unknown values.

Given: T_C = 57.8 ºC

Unknown: T_F = ? ºF

T_K = ? K

Math Skills, *continued*

2. Write down the equations for temperature conversions.

$$T_F = 1.8T_C + 32.0$$

$$T_K = T_C + 273$$

3. Insert the known values into the equations, and solve.

$$T_F = (1.8 \times 57.8) + 32.0 = 104 + 32.0 = 136\ ^{\circ}\mathrm{F}$$

$$T_K = 57.8 + 273 = 331\ \mathrm{K}$$

Relating Temperature to Energy Transfer

〉 What makes things feel hot or cold?

〉 The feeling associated with temperature difference results from energy transfer.

- When two objects that are at different temperatures are touching, energy will be transferred from one to the other.

Relating Temperature to Energy Transfer, *continued*

- Temperature changes indicate an energy transfer.
- **heat:** the energy transferred between objects that are at different temperatures
- The transfer of energy as heat always takes place from something at a higher temperature to something at a lower temperature.
- The greater the difference in the temperatures of the two objects, the faster the energy will be transferred as heat.

Section 2: Energy Transfer

Preview

- Key Ideas
- Bellringer
- Methods of Energy Transfer
- Conductors and Insulators
- Specific Heat
- Math Skills

Key Ideas

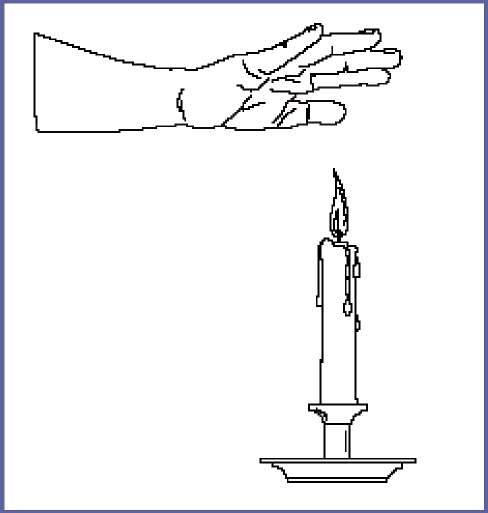
- How does energy transfer happen?
- What do conductors and insulators do?
- What makes something a good conductor of heat?

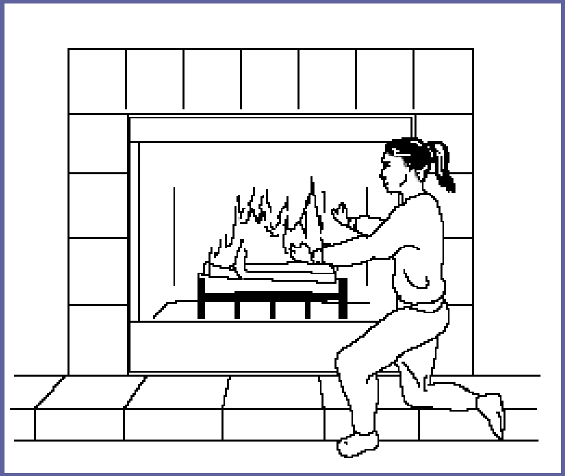
Bellringer

The three pictures all show examples of energy transfer. Answer the questions about what happens in each picture, and identify how the heat goes from one object to another in each case.

1. Why is it a bad idea to drink hot cocoa out of a tin cup? Explain the energy transfer on the atomic level.

Bellringer, *continued*





2. What happens to your hand when you place it above a lighted candle? (Assume you are not touching the flame. Explain the energy transfers on the atomic level. **Hint:** Remember that warm air rises.)

3. When you sit near a fire, you can feel its warmth on your skin, even if the air is cool. Does this sensation depend upon the fact that warm air rises?

Methods of Energy Transfer

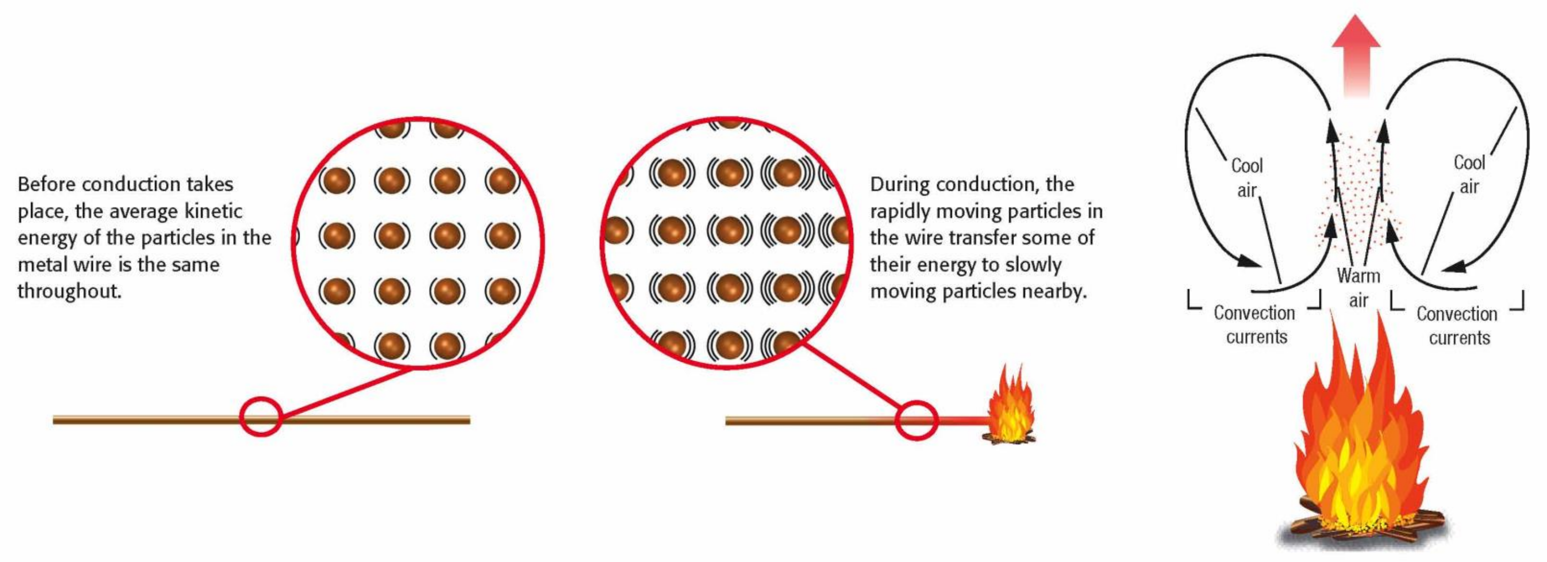
- How does energy transfer happen?

- Heat energy can be transferred in three ways: conduction, convection, and radiation.

Methods of Energy Transfer, *continued*

- Conduction occurs between objects in direct contact.
  - **thermal conduction:** the transfer of energy as heat through a material
- Convection results from the movement of warm fluids.
  - **convection:** the movement of matter due to differences in density that are caused by temperature variations
  - **convection current:** any movement of matter that result from differences in density; may be vertical, circular, or cyclical
  - The heating and cooling of a room involve convection currents.

Conduction and Convection



Methods of Energy Transfer, *continued*

- Radiation does not require physical contact between objects.
  - **radiation:** the energy that is transferred as electromagnetic waves, such as visible light and infrared waves
- All hot objects give off infrared radiation.
- Unlike conduction and convection, radiation does not involve the movement of matter across space.
- Radiation is the only way that energy can be transferred through a vacuum
- Much of the energy we receive from the sun is transferred by radiation.

Conductors and Insulators

- What do conductors and insulators do?

- A *conductor* is a material through which energy can be easily transferred as heat.

- An *insulator* is a material that transfers energy poorly.

Conductors and Insulators, *continued*

- Heat energy is transferred through particle collisions.
  - Gases are very poor heat conductors because their particles are so far apart.
  - Denser materials usually conduct energy better than less dense materials do.
  - Metals tend to conduct energy very well.
  - Plastics conduct energy poorly.

Specific Heat

- What makes something a good conductor of heat?
- What makes a substance a good or poor conductor depends in part on how much energy is required to change the temperature of the substance by a certain amount.

- **specific heat:** the quantity of heat required to raise a unit mass of homogenous material 1 K or 1 °C in a specified way given constant pressure and volume

Specific Heat, *continued*

- Specific heat describes how much energy is required to raise an object’s temperature.
- Specific heat is a characteristic physical property.
  - It is represented by *c*.
- Specific heat can be used to figure out how much energy it takes to raise an object’s temperature.

Specific Heat Equation

energy = specific heat × mass × temperature change

$$\text{energy} = cm\Delta T$$

Values of Specific Heat at 25 °C

Substance	*c* (J/kg•K)	Substance	*c* (J/kg•K)
Water (liquid)	4,186	Copper	385
Ethanol (liquid)	2,440	Iron	449
Ammonia (gas)	2,060	Silver	234
Steam	1,870	Mercury	140
Aluminum	897	Gold	129
Carbon (graphite)	709	Lead	129

Math Skills

Specific Heat

How much energy must be transferred as heat to 200 kg of water in a bathtub to raise the water's temperature from 25 °C to 37 °C?

1. List the given and the unknown values.

Given: ΔT = 37 °C – 25 °C = 12 °C = 12 K

ΔT = 12 K

m = 200 kg

c = 4,186 J/kg•K

Unknown: *energy* = ? J

Math Skills, *continued*

2. Write down the specific heat equation.

energy = $cm\Delta T$

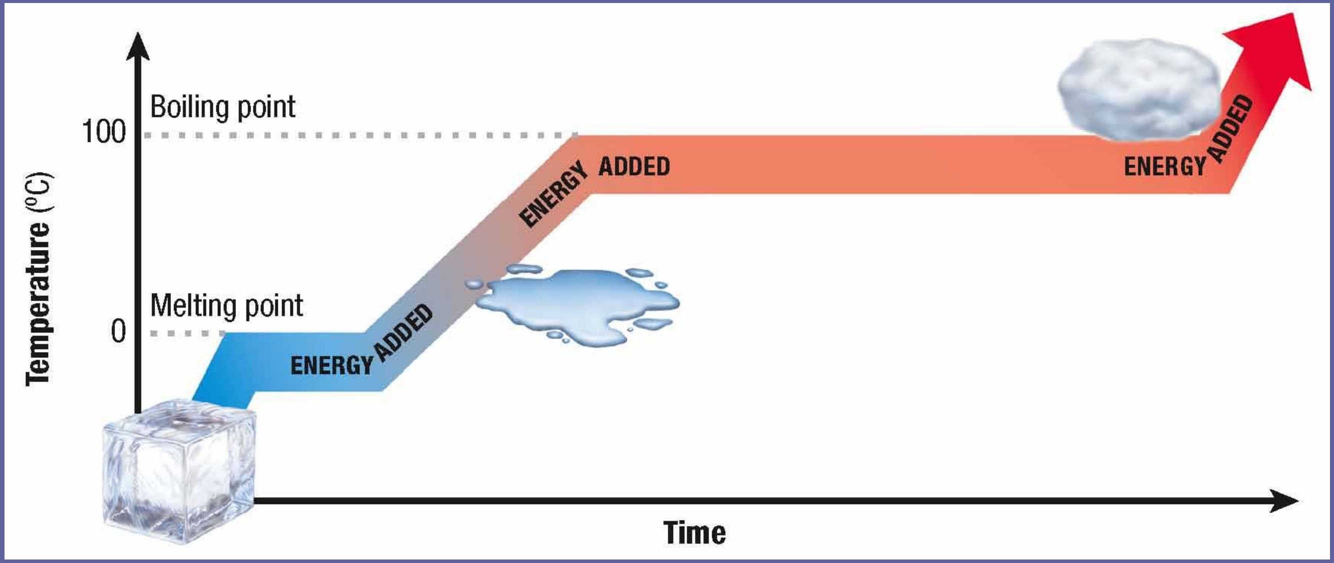
3. Substitute the specific heat, mass, and temperature change values, and solve.

$$\text{energy} = \left(\frac{4{,}186\ \text{J}}{\text{kg} \bullet \text{K}}\right) \times (200\ \text{kg}) \times (12\ \text{K})$$

$$\text{energy} = 10{,}000{,}000\ \text{J} = 1.0 \times 10^4\ \text{kJ}$$

Specific Heat, *continued*

- Heat raises an object's temperature or changes the object's state.
  - While a substance is melting or boiling, the temperature does not change.



Section 3: Using Heat

Preview

- Key Ideas
- Bellringer
- Laws of Thermodynamics
- Heat Engines
- Internal Combustion Engine

Key Ideas

- What happens to heat energy when it is transferred?
- What do heat engines do?

Bellringer

According to the law of conservation of energy, energy is never created or destroyed. But energy does change forms and can be transferred. Use these ideas to answer the following questions about how a car works.

1. As an automobile's air conditioner cools the interior of the car, what happens to the energy from the warm air inside the car?
2. In terms of chemical and mechanical energy, explain why a running car engine gives off heat.
3. How is heat given off by a running car engine related to the usable energy inside the engine?

Laws of Thermodynamics

- What happens to heat energy when it is transferred?
- The *first law of thermodynamics* states that the total energy used in any process is conserved, whether that energy is transferred as a result of work, heat, or both.
- The *second law of thermodynamics* states that the energy transferred as heat always moves from an object at a higher temperature to an object at a lower temperature.

Laws of Thermodynamics

- Work can increase average kinetic energy.
  - *mechanical processes:* processes in which energy is transferred by work
- The disorder of a system tends to increase.
  - Over time, in any given system left to itself, the entropy of that system will tend to increase.
  - **entropy:** a measure of the randomness or disorder of a system
- Usable energy decreases in all energy transfers.
  - If entropy increases, less energy is in a usable form.
  - Conduction and radiation may cause energy to be transferred to the surrounding.

Heat Engines

- What do heat engines do?
- In a heat engine, potential chemical energy and internal kinetic energy are converted to mechanical energy by the process of combustion.

- **heat engine:** a machine that transforms heat into mechanical energy, or work
- Internal-combustion engines and external-combustion engines are the two main types of heat engines.

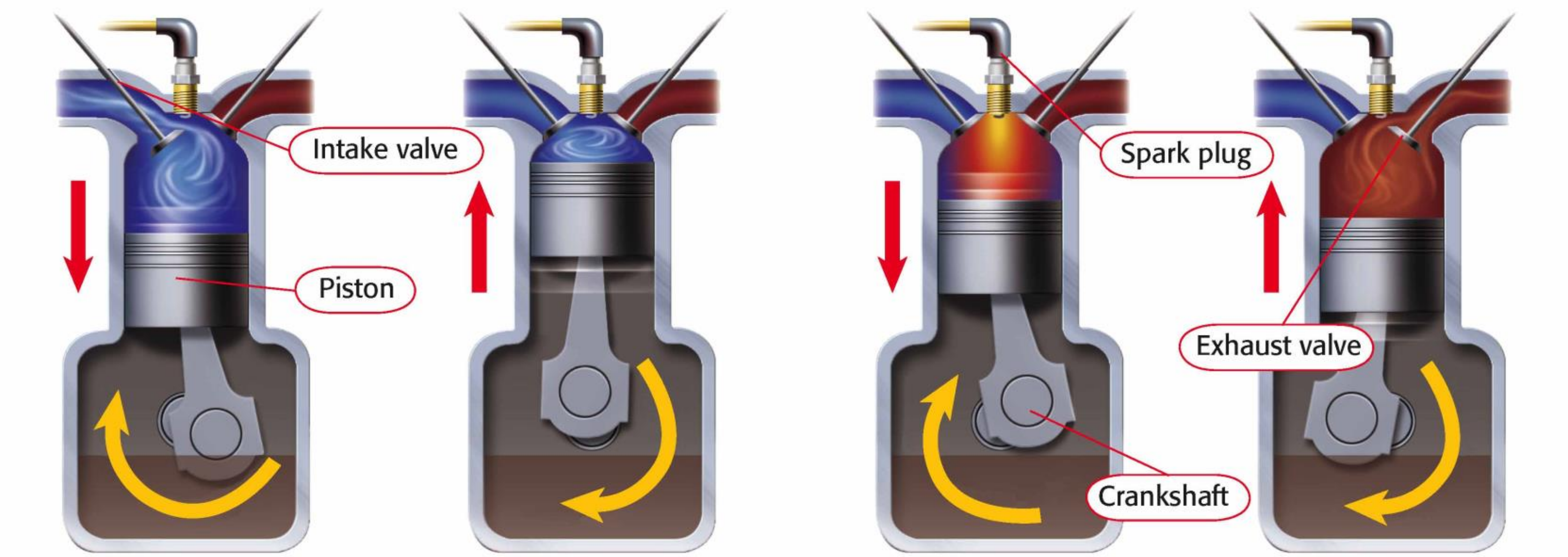
Heat Engines, *continued*

- Internal-combustion engines burn fuel inside the engine.
  - An automobile engine is a four-stroke engine, because four strokes take place for each cycle of the piston.
  - The four strokes are:
    - *intake*
    - *compression*
    - *power*
    - *exhaust*
  - Internal-combustion engines always generate heat.
    - Friction and other forces cause much of the energy to be lost to the atmosphere as heat.

Heat Engines, *continued*

- Automobile engines use carburetors or fuel injectors.
  - A *carburetor* is the part of the engine in which liquid gasoline becomes vaporized.
  - Some engines have fuel injectors instead of carburetors.

Internal Combustion Engine



In the *intake* stroke, a mixture of fuel vapor and air is brought into the cylinder from the carburetor as the piston moves downward.

In the *compression* stroke, the piston moves up and compresses the fuel-air mixture.

In the *power* stroke, the spark plug ignites the mixture, which expands quickly and moves the piston down to turn the crankshaft.

The *exhaust* stroke takes place when the piston moves up again and forces the waste products to move out of the exhaust valve.