Transformation of Energy

A transformation of energy is the changing of one type of energy into another type of energy. Some of these transformations are discussed in the following paragraphs.

Heat Production

Transformations of energy often occur when there is friction. For example, as a glacier flows, some of its kinetic energy is transformed into heat energy at the interface of the glacier and its valley walls. This transformation occurs because of friction between the moving glacier and the rock of the valley walls. Transformation of energy also occurs when wind blows over the ocean, creating waves and surface ocean currents. At the interface of the atmosphere and hydrosphere, heat is formed.

Transformations of Mechanical Energy

All the energy of an object or system not related to the individual motions of atoms and molecules is **mechanical energy**. It can also be defined as the total of the potential and kinetic energy of an object or system. An object in motion has a kind of energy called kinetic energy. The faster something moves and the more mass it has, the greater its kinetic energy. Objects or systems can also have a kind of energy called potential energy—energy related to position or phase. It may be thought of as "stored" energy. The higher an object is above the center of Earth, the greater its potential to fall—the greater its potential energy. The more mass that is involved, the more potential energy that is present.

Either kinetic or potential energy can be transformed into the other. For example, water at the top of a waterfall has potential energy because of its position relative to Earth's center. As the water falls to a lower level, some of its potential energy is transformed into kinetic energy, resulting in an increase in speed.

Transformation of Electromagnetic Wavelength

One example of wavelength transformation is when electromagnetic energy is absorbed by an object and reradiated at a longer wavelength. This occurs because energy moves from regions of greater to lower concentrations, and the region of greater concentration usually has a higher temperature and emits shorter wavelengths. This type of transformation is very common at Earth's surface. There the relatively short-wavelength ultraviolet and visible radiations from the sun are absorbed and reradiated as longer wavelength infrared radiations. Since Earth's surface is much lower in temperature than the sun, it emits longer wavelengths than the sun's surface.

Temperature and Heat

The temperature of an object or region is directly related to the amount of heat, or thermal energy, in the object or region.

Temperature

Temperature is a measure of the average kinetic energy of the particles of a body of matter—and is NOT a type of energy. According to the theory of matter, the particles of every material are in continuous, random motion, and therefore have kinetic energy. At any moment, some of the particles have more kinetic energy than others. The greater the average kinetic energy of the particles of matter, the higher the temperature.

Your senses respond to temperature by sensations of hot and cold. However, to accurately measure temperature you need to use a thermometer. A thermometer indicates temperature on a scale marked in degrees. Three different temperature scales are in use in the United States. Relationships among the three temperature scales—Fahrenheit, Celsius, and Kelvin—are given in the *Earth Science Reference Tables*. Figure 5-5 illustrates the method of converting among the three temperature scales.

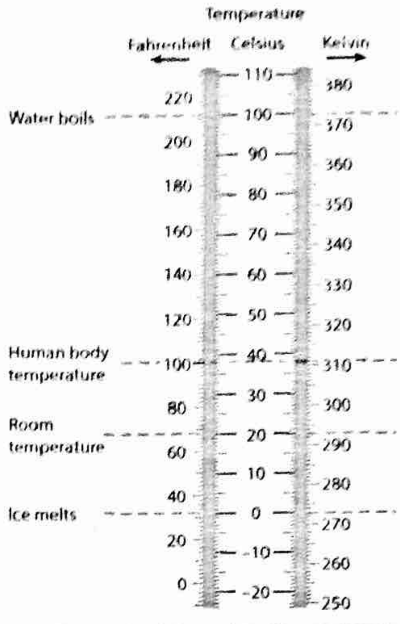


Figure 5-5. Converting among the three temperature scales: Note that each line on the thermometer scales is two degrees for Fahrenheit and one degree for Celsius and Kelvin. The lines are so close that a reading within one degree of Fahrenheit and 0.5 degree of Celsius or Kelvin is acceptable. To convert among the scales, hold a straight edge on the value you are converting from. Then read the value of the other temperature scale on the line. For example, room temperature is 68°F, which converts to 20°C and 293 K. Ice melts at 32°F, 0°C, and 273 K. Water boils at 212°F, 100°C, and 373 K.

Heat and Thermal Energy

As explained earlier, thermal energy is the energy of the motion of atoms and molecules. When the thermal energy of one object is greater—has a higher temperature—than another, some of the thermal energy will be transferred from the hotter body to the colder one. The type of energy that is transferred from hotter to colder objects is heat energy. It is measured in **joules**—a metric unit of energy or work.

Specific Heat

It takes 4.18 joules to raise the temperature of one gram of liquid water one degree Celsius. It takes only about 0.84 joules (one fifth as much) to raise the temperature of one gram of a typical rock (basalt) one degree Celsius. The quantity of heat needed to raise the temperature of one gram of any substance one degree Celsius is called the **specific heat** of that substance. In simpler terms, specific heat is the resistance a material presents to heating up or cooling off.

Liquid water has the highest specific heat of naturally occurring substances, which is why large bodies of water have a major moderating effect on weather and climate. All other naturally occurring substances have a specific heat less than that of liquid water. Therefore, gaining or losing the same amount of heat causes equal masses of these other substances to heat up or cool off, respectively, faster than water. See Specific Heats of Some Common Materials in the *Earth Science Reference Tables*.

Review Questions

25. How do the wavelengths of electromagnetic energy absorbed by materials on Earth compare to the wavelengths radiated by materials on Earth?

(1) The reradiated wavelengths are shorter.
(2) The reradiated wavelengths are longer.
(3) The absorbed and reradiated wavelengths are the same.

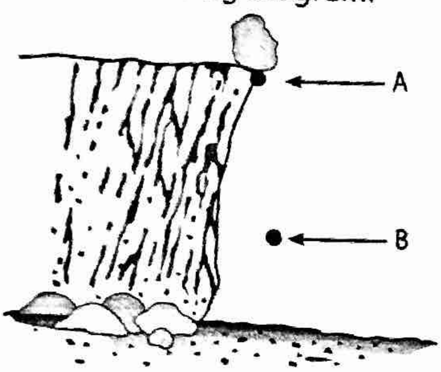
26. The temperature of an object is determined by the

(1) average kinetic energy of its molecules
(2) average potential energy of its molecules
(3) total kinetic energy of the object
(4) total potential energy of the object

27. The temperature of a stovetop is 65°C. What is the equivalent Fahrenheit temperature?

(1) 126°F (2) 132°F (3) 144°F (4) 149°F

28. A boulder falls freely from point A to point B, as shown in the following diagram.



Which statement best explains the relationship between the height of the boulder and its potential and kinetic energy as it falls?

(1) Its potential energy decreases, and its kinetic energy increases.
(2) Its potential energy increases, and its kinetic energy decreases.
(3) Its potential energy and kinetic energy both decrease.
(4) Its potential energy and kinetic energy both increase.

29. Equal masses of lead, granite, basalt, and water at 5°C are exposed to equal quantities of heat energy. Which would be the first to show a temperature rise of 10°C?

(1) lead
(2) granite
(3) basalt
(4) water

30. During some winters in the Finger Lakes region of New York State, the lake water remains unfrozen even though the land around the lakes is frozen and covered with snow. The primary cause of this difference is that water

(1) gains heat during evaporation
(2) is at a lower elevation
(3) has a higher specific heat
(4) reflects more radiation