21.1 Temperature

The quantity that tells how hot or cold something is compared with a standard is **temperature.** We express temperature by a number that corresponds to a degree mark on some chosen scale.

Nearly all matter expands when its temperature increases and contracts when its temperature decreases. A common thermometer measures temperature by showing the expansion and contraction of a liquid—usually mercury or colored alcohol—in a glass tube using a scale. Temperature is generally measured on one of three different scales.

Celsius Scale On the most widely used temperature scale, the **Celsius scale,** the number 0 is assigned to the temperature at which water freezes, and the number 100 to the temperature at which water boils (at standard atmospheric pressure).[21.1] The gap between freezing and boiling is divided into 100 equal parts, called *degrees.*

Fahrenheit Scale On the temperature scale used commonly in the United States, the **Fahrenheit scale,** the number 32 designates the temperature at which water freezes, and the number 212 is assigned to the temperature at which water boils (at 1 atm). The Fahrenheit scale will become obsolete if and when the United States goes metric.

Kelvin Scale The scale used in scientific research is the SI scale—the *Kelvin scale.* Its degrees are the same size as the Celsius degree and are called "kelvins." On the **Kelvin scale,** the number 0 is assigned to the lowest possible temperature—*absolute zero.* At **absolute zero,** a substance has no kinetic energy to give up. Zero on the Kelvin scale, or absolute zero, corresponds to –273°C on the Celsius scale. We will learn more about the Kelvin scale in Chapter 24.

Scale Conversion Arithmetic formulas can be used for converting from one temperature scale to another and are often popular in classroom exams. Such arithmetic exercises are not really physics, so we will not be concerned with them here. Besides, a conversion from Celsius to Fahrenheit, or vice versa, can be very closely approximated by simply reading the corresponding temperature from the side-by-side scales in Figure 21.1.

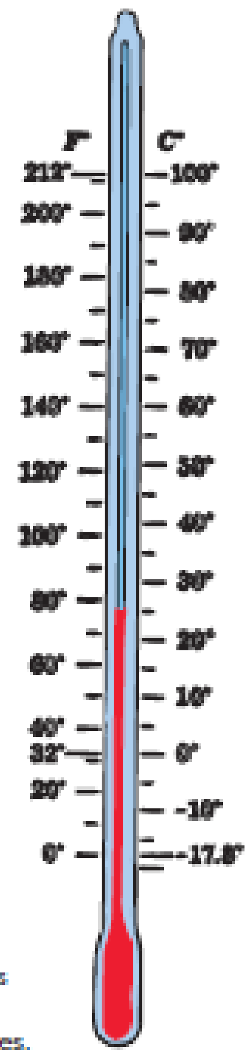
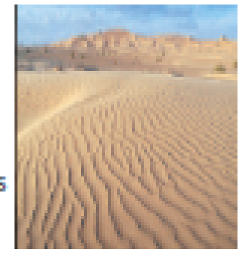


FIGURE 21.1 ▶
This thermometer measures temperature on both Fahrenheit and Celsius scales.

Link to ENTOMOLOGY

Desert Ants



The surface temperatures of some deserts in Africa and central Asia reach 60°C (140°F). This is hot, but not too hot for a species of ant (*Cataglyphis*) that thrives at this searing temperature. These desert ants can forage for food at temperatures too high for lizards who eat them. Resistant to heat, these ants can withstand higher temperatures than any other creatures in the desert. They scavenge the desert surface for corpses of those who did not find cover in time, touching the hot sand as little as possible while often sprinting on four legs with two high in the air. Although their foraging paths zigzag over the desert floor, their return paths are almost straight lines to their nest holes. They attain speeds of 100 body lengths per second. During an average six-day life, most of these ants retrieve 15 to 20 times their weight in food.

Temperature and Kinetic Energy Temperature is related to the random motions of the molecules in a substance. In the simplest case of an ideal gas, temperature is proportional to the *average* kinetic energy of molecular translational motion (that is, motion along a straight or curved path). In solids and liquids, where molecules are more constrained and have potential energy, temperature is more complicated. But it is still true that temperature is closely related to the average kinetic energy of translational motion of molecules. **The higher the temperature of a substance, the faster is the motion of its molecules.** So the warmth you feel when you touch a hot surface is the kinetic energy transferred by molecules in the surface to molecules in your fingers.

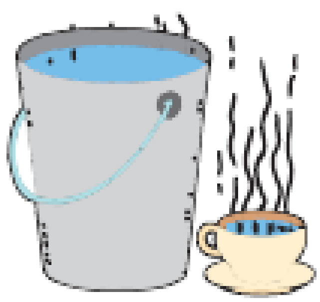


FIGURE 21.2 ▲
There is more molecular kinetic energy in the bucketful of warm water than in the small cupful of higher-temperature water.

Note that temperature is *not* a measure of the *total* kinetic energy of all the molecules in a substance. There is twice as much kinetic energy in 2 liters of boiling water as in 1 liter. But the temperatures of both liters of water are the same because the average kinetic energy of molecules in each is the same. Figure 21.2 shows that a bucket of warm water can contain more molecular kinetic energy than a cup of hot water.

CONCEPT CHECK What is the relationship between the temperature of a substance and the speed of its molecules?

A Guide To Creating Chapter Outlines

List the Chapter Title

I. Section 1 Heading (Red Font)
   1. Summarization of paragraph 1
      a. Vocabulary Term – Definition
   A. Main Point (Blue Font)
      1. Summarization of paragraph 1
         a. Vocabulary Term – Definition
   B. Main Point (Blue Font)
      1. Summarization of paragraph 1
         a. Vocabulary Term – Definition
   C. Main Point (Blue Font)
      1. Summarization of paragraph 1
         a. Vocabulary Term – Definition
         b. Vocabulary Term – Definition
   D. Main Point (Blue Font)
      1. Summarization of paragraph 1
   E. Main Point (Blue Font)
      1. Summarization of paragraph 1
      2. Summarization of paragraph 2
      3. Summarization of paragraph 3

Summarizing/Using Examples : Summarizing the paragraph will help you reword the information into information you understand. Examples described in the textbook are important information and should be mentioned in your summaries. Tests are never simply definitions. The examples used on exams may or may not be the same ones in the book, but familiarity with one example will always help you apply the information to *new* examples.

Defining Vocabulary Terms: There are many new vocabulary terms to use in this semester of chemistry. Unless you make the effort to learn and use the vocabulary words, you will not do well in the course. The glossary is not the best way to obtain a vocabulary definition. The glossary does not give any examples or connect the term to the information you are learning. The best way to define a word is to look at the definition given in the chapter of your textbook.