### Example Problem 2-2
*Calculating Density*

A 1.1-g ice cube raises the level of water in a 10-mL graduated cylinder 1.2 mL. What is the density of the ice cube?

To find the ice cube's density, divide its mass by the volume of water it displaced and solve.

density = mass/volume

$$\text{density} = \frac{1.1 \text{ g}}{1.2 \text{ mL}} = 0.92 \text{ g/mL}$$

### Example Problem 2-3
*Using Density and Volume to Find Mass*

Suppose you drop a solid gold cube into a 10-mL graduated cylinder containing 8.50 mL of water. The level of the water rises to 10.70 mL. You know that gold has a density of 19.3 g/cm$^3$, or 19.3 g/mL. What is the mass of the gold cube?

To find the mass of the gold cube, rearrange the equation for density to solve for mass.

density = mass/volume

mass = volume × density

Substitute the values for volume and density into the equation and solve for mass.

$$\text{mass} = 2.20\ \cancel{\text{mL}} \times 19.3\ \text{g}/\cancel{\text{mL}} = 42.5 \text{ g}$$

### Practice Problems

5. Calculate the density of a piece of bone with a mass of 3.8 g and a volume of 2.0 cm$^3$.
6. A spoonful of sugar with a mass of 8.8 grams is poured into a 10-mL graduated cylinder. The volume reading is 5.5 mL. What is the density of the sugar?
7. A 10.0-gram pat of butter raises the water level in a 50-mL graduated cylinder by 11.6 mL. What is the density of the butter?
8. A sample of metal has a mass of 34.65 g. When placed in a graduated cylinder containing water, the water level rises 3.3 mL. Which of the following metals is the sample made from: silver, which has a density of 10.5 g/cm$^3$; tin, which has a density of 7.28 g/cm$^3$; or titanium, which has a density of 4.5 g/cm$^3$?
9. Rock salt has a density of 2.18 g/cm$^3$. What would the volume be of a 4.8-g sample of rock salt?
10. A piece of lead displaces 1.5 mL of water in a graduated cylinder. Lead has a density of 11.34 g/cm$^3$. What is the mass of the piece of lead?

▸ **Temperature** The temperature of an object describes how hot or cold the object is relative to other objects. Scientists use two temperature scales—the Celsius scale and the Kelvin scale—to measure temperature. You will be using the Celsius scale in most of your experiments. On the Celsius scale, the freezing point of water is defined as 0 degrees and the boiling point of water is defined as 100 degrees.

A **kelvin** is the SI base unit of temperature. On the Kelvin scale, water freezes at about 273 K and boils at about 373 K. One kelvin is equal in size to one degree on the Celsius scale. To convert from degrees Celsius to kelvins, add 273 to the Celsius measurement. To convert from kelvins to degrees Celsius, subtract 273 from the measurement in kelvins.

### Practice Problems

11. Convert each temperature reported in degrees Celsius to kelvins.
    - **a.** 54°C
    - **b.** −54°C
    - **c.** 15°C
12. Convert each temperature reported in kelvins to degrees Celsius.
    - **a.** 32 K
    - **b.** 0 K
    - **c.** 281 K

## 2.2 Scientific Notation and Dimensional Analysis

Extremely small and extremely large numbers can be compared more easily when they are converted into a form called scientific notation. **Scientific notation** expresses numbers as a multiple of two factors: a number between 1 and 10; and ten raised to a power, or exponent. The exponent tells you how many times the first factor must be multiplied by ten. When numbers larger than 1 are expressed in scientific notation, the power of ten is positive. When numbers smaller than 1 are expressed in scientific notation, the power of ten is negative. For example, 2000 is written as $2 \times 10^3$ in scientific notation, and 0.002 is written as $2 \times 10^{-3}$.

### Example Problem 2-4
*Expressing Quantities in Scientific Notation*

The surface area of the Pacific Ocean is 166 000 000 000 000 m$^2$. Write this quantity in scientific notation.

To write the quantity in scientific notation, move the decimal point to after the first digit to produce a factor that is between 1 and 10. Then count the number of places you moved the decimal point; this number is the exponent ($n$). Delete the extra zeros at the end of the first factor, and multiply the result by $10^n$. When the decimal point moves to the left, $n$ is positive. When the decimal point moves to the right, $n$ is negative. In this problem, the decimal point moves 14 places to the left; thus, the quantity is written as $1.66 \times 10^{14}$ in scientific notation.

### Practice Problems

13. Express the following quantities in scientific notation.
    - **a.** 50 000 m/s$^2$
    - **b.** 0.000 000 000 62 kg
    - **c.** 0.000 023 s
    - **d.** 21 300 000 mL
    - **e.** 990 900 000 m/s
    - **f.** 0.000 000 004 L

▸ **Adding and subtracting using scientific notation** To add or subtract quantities written in scientific notation, the quantities must have the same exponent. For example, $4.5 \times 10^{14}$ m + $2.1 \times 10^{14}$ m = $6.6 \times 10^{14}$ m. If two quantities are expressed to different powers of ten, you must change one of the quantities so that they are both expressed to the same power of ten before you add or subtract them.

### Example Problem 2-5
*Adding Quantities Written in Scientific Notation*

Solve the following problem.

$2.45 \times 10^{14}$ kg + $4.00 \times 10^{12}$ kg

First express both quantities to the same power of ten. Either quantity can be changed. For example, you might change $2.45 \times 10^{14}$ to $245 \times 10^{12}$. Then add the quantities: $245 \times 10^{12}$ kg + $4.00 \times 10^{12}$ kg = $249 \times 10^{12}$ kg. Write the final answer in scientific notation: $2.49 \times 10^{14}$ kg.

### Practice Problems

14. Solve the following addition and subtraction problems. Write your answers in scientific notation.
    - **a.** $5.10 \times 10^{20} + 4.11 \times 10^{21}$
    - **b.** $6.20 \times 10^{8} - 3.0 \times 10^{6}$
    - **c.** $2.303 \times 10^{5} - 2.30 \times 10^{3}$
    - **d.** $1.20 \times 10^{-4} + 4.7 \times 10^{-5}$
    - **e.** $6.20 \times 10^{-6} + 5.30 \times 10^{-5}$
    - **f.** $8.200 \times 10^{2} - 2.0 \times 10^{-1}$

▸ **Multiplying and dividing using scientific notation** When multiplying or dividing quantities written in scientific notation, the quantities do not have to have the same exponent. For multiplication, multiply the first factors, then add the exponents. For division, divide the first factors, then subtract the exponents.

### Example Problem 2-6
*Multiplying Quantities Written in Scientific Notation*

Solve the following problem.

$(2 \times 10^{14}$ cm$) \times (4 \times 10^{12}$ cm$)$