

To solve the multiplication problem, first multiply the factors: $2 \times 4 = 8$. Then add the exponents: $14 + 12 = 26$. Combine the factors: 8×10^{26} . Finally, multiply the units and write your answer in scientific notation: $8 \times 10^{26} \text{ cm}^2$.

Practice Problems

15. Solve the following multiplication and division problems. Write your answers in scientific notation.
- $(12 \times 10^4 \text{ m}) \times (5 \times 10^{-2} \text{ m})$
 - $(3 \times 10^7 \text{ km}) \times (3 \times 10^7 \text{ km})$
 - $(2 \times 10^{-4} \text{ mm}) \times (2 \times 10^{-4} \text{ mm})$
 - $(90 \times 10^{14} \text{ kg}) \div (9 \times 10^{12} \text{ L})$
 - $(12 \times 10^{-4} \text{ m}) \div (3 \times 10^{-4} \text{ s})$
 - $(20 \times 10^{15} \text{ km}) \div (5 \times 10^{11} \text{ s})$

► **Dimensional analysis** Dimensional analysis is a method of problem solving that focuses on the units that are used to describe matter. Dimensional analysis often uses conversion factors. A **conversion factor** is a ratio of equivalent values used to express the same quantity in different units. A conversion factor is always equal to 1. Multiplying a quantity by a conversion factor does not change its value—because it is the same as multiplying by 1—but the units of the quantity can change.

Example Problem 2-7

Converting From One Unit to Another Unit

How many centigrams are in 5 kilograms?

Two conversion factors are needed to solve this problem. Remember that there are 1000 grams in a kilogram and 100 centigrams in a gram. To determine the number of centigrams in 1 kilogram, set up the first conversion factor so that kilograms cancel out. Set up the second conversion factor so that grams cancel out.

$$5 \text{ kg} \times \frac{1 \text{ g}}{1000 \text{ kg}} \times \frac{100 \text{ cg}}{1 \text{ g}} = 0.5 \text{ cg}$$

Practice Problems

- Mount Everest is 8847 m high. How many centimeters high is the mountain?
- Your friend is 1.56 m tall. How many millimeters tall is your friend?
- A family consumes 2.5 gallons of milk per week. How many liters of milk do they need to buy for one week? (Hint: 1 L = 0.908 quart; 1 gallon = 4 quarts.)
- How many hours are there in one week? How many minutes are there in one week?

2.3 How reliable are measurements?

When scientists look at measurements, they want to know how accurate as well as how precise the measurements are. **Accuracy** refers to how close a measured value is to an accepted value. **Precision** refers to how close a series of measurements are to one another. Precise measurements might not be accurate, and accurate measurements might not be precise. When you make measurements, you want to aim for both precision and accuracy.

► **Percent error** Quantities measured during an experiment are called experimental values. The difference between an accepted value and an experimental value is called an error. The ratio of an error to an accepted value is called **percent error**. The equation for percent error is as follows.

$$\text{Percent error} = \frac{\text{error}}{\text{accepted value}} \times 100$$

When you calculate percent error, ignore any plus or minus signs because only the size of the error counts.

Example Problem 2-8

Calculating Percent Error

Juan calculated the density of aluminum three times.

- Trial 1: 2.74 g/cm^3
 Trial 2: 2.68 g/cm^3
 Trial 3: 2.84 g/cm^3

Aluminum has a density of 2.70 g/cm^3 . Calculate the percent error for each trial.

First, calculate the error for each trial by subtracting Juan's measurement from the accepted value (2.70 g/cm^3).

- Trial 1: error = $2.70 \text{ g/cm}^3 - 2.74 \text{ g/cm}^3 = -0.04 \text{ g/cm}^3$
 Trial 2: error = $2.70 \text{ g/cm}^3 - 2.68 \text{ g/cm}^3 = 0.02 \text{ g/cm}^3$
 Trial 3: error = $2.70 \text{ g/cm}^3 - 2.84 \text{ g/cm}^3 = -0.14 \text{ g/cm}^3$

Then, substitute each error and the accepted value into the percent error equation. Ignore the plus and minus signs.

$$\text{Trial 1: percent error} = \frac{0.04 \text{ g/cm}^3}{2.70 \text{ g/cm}^3} \times 100 = 1.48\%$$

$$\text{Trial 2: percent error} = \frac{0.02 \text{ g/cm}^3}{2.70 \text{ g/cm}^3} \times 100 = 0.741\%$$

$$\text{Trial 3: percent error} = \frac{0.14 \text{ g/cm}^3}{2.70 \text{ g/cm}^3} \times 100 = 5.19\%$$

Practice Problems

- Suppose you calculate your semester grade in chemistry as 90.1, but you receive a grade of 89.4. What is your percent error?
- On a bathroom scale, a person always weighs 2.5 pounds less than on the scale at the doctor's office. What is the percent error of the bathroom scale if the person's actual weight is 125 pounds?
- A length of wood has a labeled length value of 2.50 meters. You measure its length three times. Each time you get the same value: 2.35 meters.
 - What is the percent error of your measurements?
 - Are your measurements precise? Are they accurate?

► **Significant figures** The number of digits reported in a measurement indicates how precise the measurement is. The more digits reported, the more precise the measurement. The digits reported in a measurement are called **significant figures**. **Significant figures** include all known digits plus one estimated digit.

These rules will help you recognize significant figures.

- Nonzero numbers are always significant.
45.893421 min has eight significant figures
- Zeros between nonzero numbers are always significant.
2001.5 km has five significant figures
- All final zeros to the right of the decimal place are significant.
6.00 g has three significant figures
- Zeros that act as placeholders are not significant. You can convert quantities to scientific notation to remove placeholder zeros.
0.0089 g and 290 g each have two significant figures
- Counting numbers and defined constants have an infinite number of significant figures.

Example Problem 2-9

Counting Significant Figures

How many significant figures are in the following measurements?

- 0.002 849 kg
- 40 030 kg

Apply rules 1–4 from above. Check your answers by writing the quantities in scientific notation.

- 0.002 849 kg has four significant figures; 2.849×10^{-3}
- 40 030 kg has four significant figures; 4.003×10^4

Practice Problems

- Determine the number of significant figures in each measurement.

a. 0.000 010 L	c. $2.4050 \times 10^{-4} \text{ kg}$
b. 907.0 km	d. 300 100 000 g