Prefixes and Equalities

Using a retinal camera, an ophthalmologist photographs the retina of the eye.

Learning Goal Use the numerical values of prefixes to write a metric equality.

Prefixes

CORE CHEMISTRY SKILL
Using Prefixes

In the metric and SI systems of units, a **prefix** attached to any unit increases or decreases its size by some factor of 10.

1 **kilo**meter (1 km) = 1000 m

1 **milli**meter (1 mm) = 0.001 m

Prefixes and Equalities

- The relationship of a prefix to a unit can be expressed by replacing the prefix with its numerical value.

- For example, when the prefix *kilo* in kilometer is replaced with its value of 1000, we find that a kilometer is equal to 1000 meters.

1 **kilo**meter	=	1000 meters
1 **kilo**liter	=	1000 liters
1 **kilo**gram	=	1000 grams

Metric and SI Prefixes That Increase

TABLE 2.5 Metric and SI Prefixes

Prefix	Symbol	Numerical Value	Scientific Notation	Equality
Prefixes That Increase the Size of the Unit				
tera	T	1 000 000 000 000	10^{12}	$1\ \text{Ts} = 1 \times 10^{12}\ \text{s}$ $1\ \text{s} = 1 \times 10^{-12}\ \text{Ts}$
giga	G	1 000 000 000	10^{9}	$1\ \text{Gm} = 1 \times 10^{9}\ \text{m}$ $1\ \text{m} = 1 \times 10^{-9}\ \text{Gm}$
mega	M	1 000 000	10^{6}	$1\ \text{Mg} = 1 \times 10^{6}\ \text{g}$ $1\ \text{g} = 1 \times 10^{-6}\ \text{Mg}$
kilo	k	1 000	10^{3}	$1\ \text{km} = 1 \times 10^{3}\ \text{m}$ $1\ \text{m} = 1 \times 10^{-3}\ \text{km}$

Metric and SI Prefixes That Decrease

TABLE 2.5 Metric and SI Prefixes (continued)

Prefixes That Decrease the Size of the Unit				
deci	d	0.1	10^{-1}	$1\ \text{dL} = 1 \times 10^{-1}\ \text{L}$ $1\ \text{L} = 10\ \text{dL}$
centi	c	0.01	10^{-2}	$1\ \text{cm} = 1 \times 10^{-2}\ \text{m}$ $1\ \text{m} = 100\ \text{cm}$
milli	m	0.001	10^{-3}	$1\ \text{ms} = 1 \times 10^{-3}\ \text{s}$ $1\ \text{s} = 1 \times 10^{3}\ \text{ms}$
micro	μ*	0.000 001	10^{-6}	$1\ \mu\text{g} = 1 \times 10^{-6}\ \text{g}$ $1\ \text{g} = 1 \times 10^{6}\ \mu\text{g}$
nano	n	0.000 000 001	10^{-9}	$1\ \text{nm} = 1 \times 10^{-9}\ \text{m}$ $1\ \text{m} = 1 \times 10^{9}\ \text{nm}$
pico	p	0.000 000 000 001	10^{-12}	$1\ \text{ps} = 1 \times 10^{-12}\ \text{s}$ $1\ \text{s} = 1 \times 10^{12}\ \text{ps}$

*In medicine, the abbreviation *mc* for the prefix *micro* is used because the symbol μ may be misread, which could result in a medication error. Thus, 1 μg would be written as 1 mcg.

Daily Values for Selected Nutrients

The U.S. Food and Drug Administration uses metric prefixes to express amounts of daily nutrient requirements.

TABLE 2.4 Daily Values for Selected Nutrients

Nutrient	Amount Recommended
Calcium	1.0 g
Copper	2 mg
Iodine	150 μg (150 mcg)
Iron	18 mg
Magnesium	400 mg
Niacin	20 mg
Phosphorus	800 mg
Potassium	3.5 g
Selenium	70. μg (70. mcg)
Sodium	2.4 g
Zinc	15 mg

Learning Check

Fill in the blanks with the correct prefix.

A. 1000 m = 1 ___m

B. 1×10^{-6} g = 1 ___g

C. 0.1 L = 1 ___L

Measuring Length: Equalities

An **equality** shows the relationship between two units that measure the same quantity.

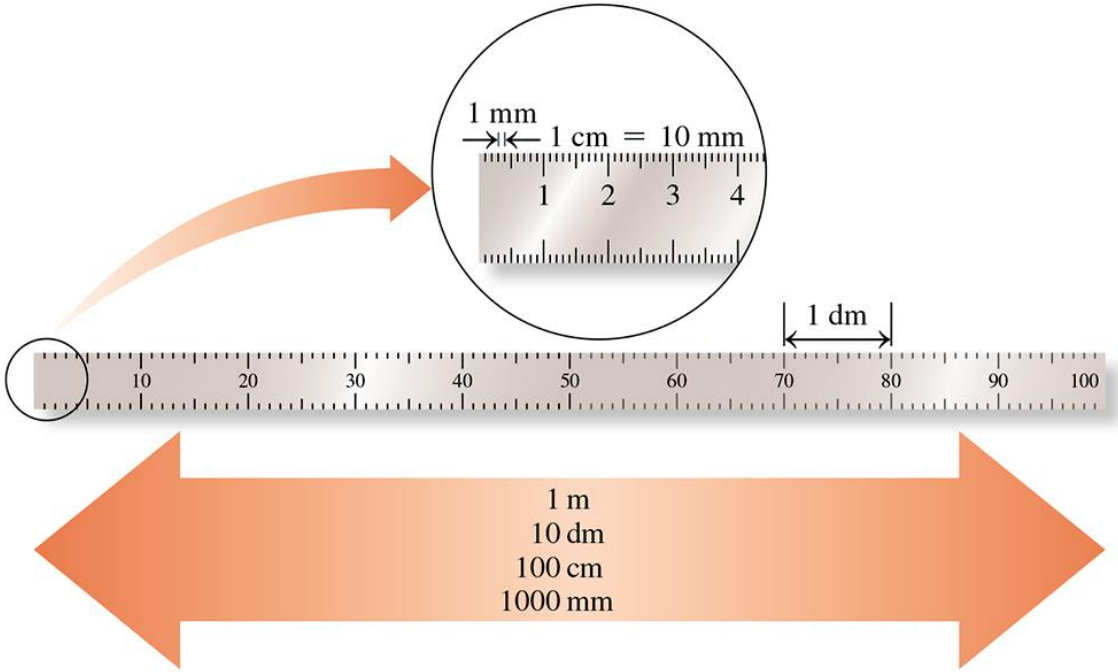
Each of the following equalities describes the same length in a different unit:

$$1\ \text{m} = 100\ \text{cm} = 1 \times 10^{2}\ \text{cm}$$

$$1\ \text{m} = 1000\ \text{mm} = 1 \times 10^{3}\ \text{mm}$$

$$1\ \text{cm} = 10\ \text{mm} = 1 \times 10^{1}\ \text{mm}$$

Measuring Length: Equalities



The metric length of 1 m is the same length as 10 dm, 100 cm, and 1000 mm.

Measuring Volume: Equalities

Volumes of 1 L or smaller are common in the health sciences. When a liter is divided into 10 equal portions, each portion is called a *deci*liter (dL).

The following are examples of some volume equalities:

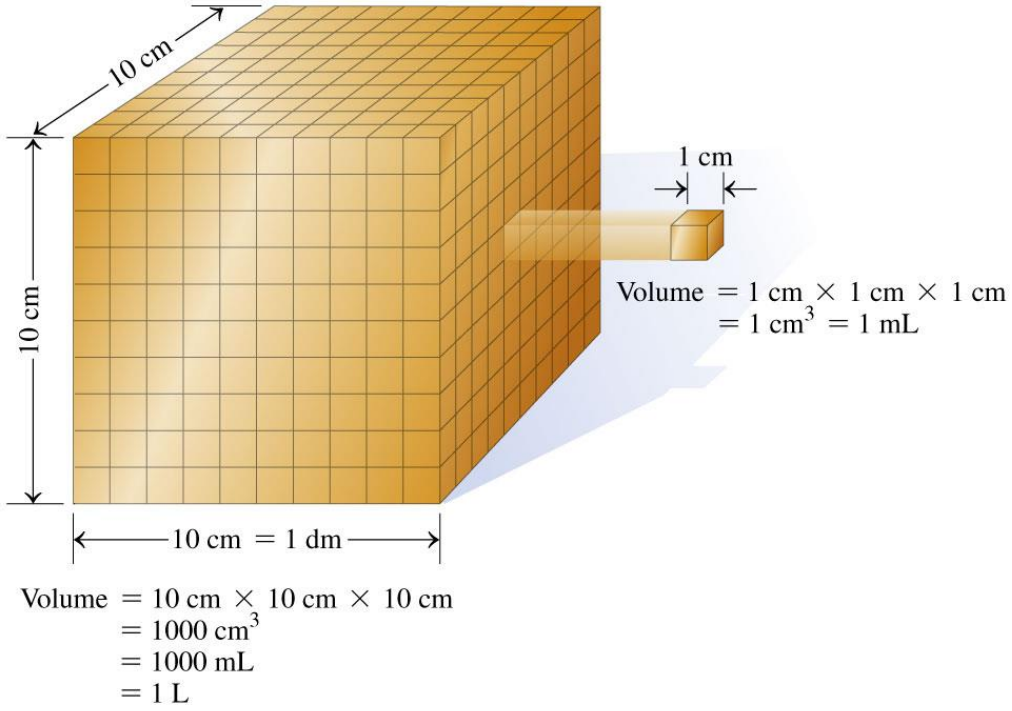
$1\ \text{L} = 10\ \text{dL} = 1 \times 10^{1}\ \text{dL}$

$1\ \text{L} = 1000\ \text{mL} = 1 \times 10^{3}\ \text{mL}$

$1\ \text{dL} = 100\ \text{mL} = 1 \times 10^{2}\ \text{mL}$

Measuring Volume

The **cubic centimeter** (**cm^3** or **cc**) is the volume of a cube with the dimensions 1 cm × 1 cm × 1 cm.

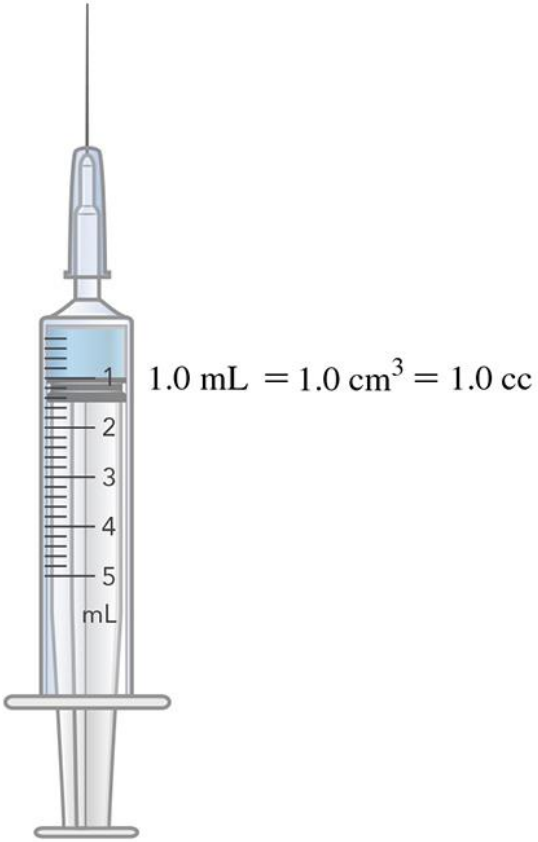


A cube measuring 10 cm on each side has a volume of 1000 cm^3, or 1 L; a cube measuring 1 cm on each side has a volume of 1 cm^3, 1 cc, or 1 mL.

Measuring Volume

A **cubic centimeter** (cc) has the same volume as a milliliter, and the units are often used interchangeably.

$1.0\ cm^3 = 1.0\ cc = 1.0\ mL$



Measuring Mass: Equalities

When you visit the doctor for a physical examination, he or she records your mass in kilograms (kg) and laboratory results in micrograms (μg or mcg).

The following are examples of equalities between different metric units of mass:

1 kg	= 1000 g	$= 1 \times 10^3$ g
1 g	= 1000 mg	$= 1 \times 10^3$ mg
1 g	= 100 cg	$= 1 \times 10^2$ cg
1 mg	= 1000 μg (mcg)	$= 1 \times 10^3$ μg (mcg)

Learning Check

Identify the larger unit in each of the following:

A. mm or cm

B. kilogram or centigram

C. dL or μL

D. mcg or mg

Learning Check

Indicate the unit that completes each of the following equalities:

A. 1000 m = _____

(1) 1 mm (2) 1 km (3) 1 dm

B. 0.01 m = _____

(1) 1 cm (2) 1 mm (3) 1 dm

Learning Check

Complete each of the following equalities:

A. 1 kg = _____

(1) 10 g (2) 100 g (3) 1000 g

B. 1 cL = _____

(1) 0.001 L (2) 0.01 L (3) 100 L

Writing Conversion Factors

In the United States, the contents of many packaged foods are listed in both U.S. and metric units.

Learning Goal Write a conversion factor for two units that describe the same quantity.

Equalities

Equalities

- use two different units to describe the same quantity
- can be between units of the metric system, or between U.S. units, or between metric and U.S. units

$$1\ \text{m} = 1000\ \text{mm}$$

$$1\ \text{lb} = 16\ \text{oz}$$

$$2.20\ \text{lb} = 1\ \text{kg}$$

Equalities on Food Labels

The contents of many packaged foods

- are listed in both metric and U.S. units.
- indicate the same amount of a substance in two different units.

In the United States, the contents of many packaged foods are listed in both U.S. and metric units.

Equalities and Significant Figures

The numbers in any equality between two metric units or between two U.S. system units are definitions.

Because numbers in a definition are exact, they are not used to determine significant figures (SFs).

$$1\ \text{g} = 1000\ \text{mg}$$

$$1\ \text{ft} = 12\ \text{in.}$$

$$1\ \text{min} = 60\ \text{s}$$

Equalities and Significant Figures

When an equality consists of a metric unit and a U.S. unit, one of the numbers in the equality is obtained by measurement and counts toward the significant figures (SFs) in the answer.

$$454\ \text{g} = 1\ \text{lb}$$

$$946\ \text{mL} = 1\ \text{qt}$$

$$39.4\ \text{in.} = 1\ \text{m}$$

Exception: The equality 1 in. = 2.54 cm has been defined as an exact relationship, and therefore 2.54 is an exact number.

Conversion Factors

CORE CHEMISTRY SKILL

Writing Conversion Factors from Equalities

Any equality can be written as fractions called **conversion factors**. Be sure to include units when you write conversion factors.

Conversion Factors for the Equality 1 h = 60 min

$$\frac{\text{Numerator}}{\text{Denominator}} \longrightarrow \frac{60\ \text{min}}{1\ \text{h}} \quad \text{and} \quad \frac{1\ \text{h}}{60\ \text{min}}$$

These conversion factors are read as "60 minutes per hour" and "1 hour per 60 minutes." The *per* means "divide."

Some Common Equalities

TABLE 2.7 Some Common Equalities

Quantity	Metric (SI)	U.S.	Metric–U.S.
Length	1 km = 1000 m	1 ft = 12 in.	2.54 cm = 1 in. (exact)
	1 m = 1000 mm	1 yd = 3 ft	1 m = 39.4 in.
	1 cm = 10 mm	1 mi = 5280 ft	1 km = 0.621 mi
Volume	1 L = 1000 mL	1 qt = 4 cups	946 mL = 1 qt
	1 dL = 100 mL	1 qt = 2 pt	1 L = 1.06 qt
	1 mL = 1 cm^3	1 gal = 4 qt	473 mL = 1 pt
	1 mL = 1 cc*		5 mL = 1 t (tsp)*
			15 mL = 1 T (tbsp)*
Mass	1 kg = 1000 g	1 lb = 16 oz	1 kg = 2.20 lb
	1 g = 1000 mg		454 g = 1 lb
	1 mg = 1000 mcg*		
Time	1 h = 60 min	1 h = 60 min	
	1 min = 60 s	1 min = 60 s	

*Used in medicine.

Writing Conversion Factors

We can write

- metric conversion factors:

$$1\text{ m} = 100\text{ cm} \qquad \frac{100\text{ cm}}{1\text{ m}} \text{ and } \frac{1\text{ m}}{100\text{ cm}}$$

- metric–U.S. system conversion factors:

$$1\text{ kg} = 2.20\text{ lb} \qquad \frac{2.20\text{ lb}}{1\text{ kg}} \text{ and } \frac{1\text{ kg}}{2.20\text{ lb}}$$

Learning Check

Write the equality and two conversion factors for each of the following pairs of units:

A. liters and milliliters

B. inches and meters

C. milligrams and micrograms

Conversion Factors Within a Problem

An equality may also be stated within a problem that only applies to that problem.

1. The car travels at 85 km/h.

Equality	Conversion Factors	Significant Figures or Exact
$85\ \text{km} = 1\ \text{h}$	$\frac{85\ \text{km}}{1\ \text{h}}$ and $\frac{1\ \text{h}}{85\ \text{km}}$	The 85 km is measured: It has two significant figures. The 1 h is exact.

Conversion Factors Within a Problem

2. The tablet contains 500 mg of vitamin C

Equality	Conversion Factors	Significant Figures or Exact
1 tablet = 500 mg of vitamin C	$\frac{500\text{ mg vitamin C}}{1\text{ tablet}}$ and $\frac{1\text{ tablet}}{500\text{ mg vitamin C}}$	The 500 mg is measured: It has one significant figure. The 1 tablet is exact.

Conversion Factors from a Percentage

A percent (%) is written as a conversion factor by choosing a unit and expressing the numerical relationship of the parts of this unit to 100 parts of the whole.

- For example, a person has 18% body fat by mass.

Equality	Conversion Factors	Significant Figures or Exact
18 kg of body fat = 100 kg of body mass	$\frac{18\text{ kg body fat}}{100\text{ kg body mass}}$ and $\frac{100\text{ kg body mass}}{18\text{ kg body fat}}$	The 18 kg is measured: It has two significant figures. The 100 kg is exact.

Conversion Factors from Dosage Problems

Equalities stated within dosage problems for medications can also be written as conversion factors.

Example: Keflex (cephalexin), an antibiotic used for respiratory and ear infections, is available in 250-mg capsules.

Equality	Conversion Factors	Significant Figures or Exact
1 capsule = 250 mg of Keflex	$\frac{250\text{ mg Keflex}}{1\text{ capsule}}$ and $\frac{1\text{ capsule}}{250\text{ mg Keflex}}$	The 250 mg is measured: It has two significant figures. The 1 capsule is exact.

Learning Check

Write the equality and two conversion factors for each of the following:

A. meters and decimeters

B. jewelry that contains 18% gold

C. One gallon of gas is $2.40.

2.6 Problem Solving Using Unit Conversions

Agricultural fertilizers applied to a field provide nitrogen for plant growth.

Learning Goal Use conversion factors to change from one unit to another.

Problem Solving Using Conversion Factors

CORE CHEMISTRY SKILL
Using Conversion Factors

The problem-solving process begins by analyzing the problem in order to

- identify the given unit and needed unit
- write a plan that converts the given unit to the needed unit
- identify one or more conversion factors that cancel units and provide the needed unit
- set up the calculation

Solving Problems Using Conversion Factors

Example: If a person weighs 178 lb, what is the body mass in kilograms?

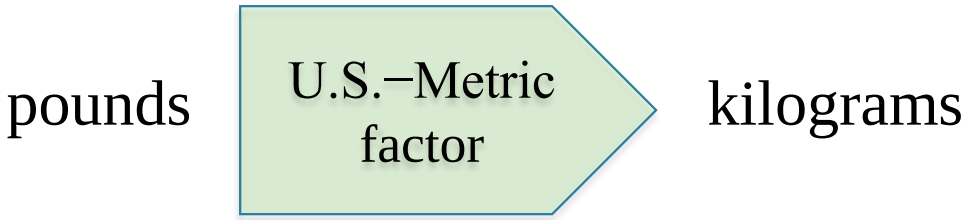
Solving Problems Using Conversion Factors

Example: If a person weighs 178 lb, what is the body mass in kilograms?

STEP 1 **State the given and needed quantities.**

ANALYZE THE PROBLEM	Given	Need	Connect
	178 lb	kilograms	conversion factor (kg/lb)

STEP 2 **Write a plan to convert the given unit to the needed unit.**



Solving Problems Using Conversion Factors

Example: If a person weighs 178 lb, what is the body mass in kilograms?

STEP 3 **State the equalities and conversion factors.**

$$1\text{ kg} = 2.20\text{ lb} \qquad \frac{2.20\text{ lb}}{1\text{ kg}} \text{ and } \frac{1\text{ kg}}{2.20\text{ lb}}$$

STEP 4 **Set up the problem to cancel units and calculate the answer.**

Exact

$$178\text{ lb} \times \frac{1\text{ kg}}{2.20\text{ lb}} = 80.9\text{ kg}$$

3 SFs 3 SFs 3 SFs

Learning Check

A rattlesnake is 2.44 m long. How many centimeters long is the snake?

Using Two or More Conversion Factors

In problem solving,

- two or more conversion factors are often needed to complete the change of units

  Unit 1 $\longrightarrow$ Unit 2 $\longrightarrow$ Unit 3

- to set up these problems, one factor follows the other
- each factor is arranged to cancel the preceding unit until the needed unit is obtained

  Given unit $\times$ Factor 1 $\times$ Factor 2 = Needed unit

Using Two or More Conversion Factors

Example: A doctor's order prescribed a dosage of 0.150 mg of Synthroid. If you only have 50.-mcg tablets in stock, how many tablets are required to provide the prescribed dosage?

STEP 1 **State the given and needed quantities.**

ANALYZE THE PROBLEM	Given	Need	Connect
	0.150 mg of Synthroid	number of tablets	1 tablet = 50. mcg of Synthroid

STEP 2 **Write a plan to convert the given unit to the needed unit.**

milligrams → (Metric factor) → micrograms → (Clinical factor) → number of tablets

Using Two or More Conversion Factors

Example: A doctor's order prescribed a dosage of 0.150 mg of Synthroid. If you only have 50.-mcg tablets in stock, how many tablets are required to provide the prescribed dosage?

STEP 3 **State the equalities and conversion factors.**

$$1\text{ mg} = 1000\text{ mcg} \qquad 1\text{ tablet} = 50.\text{ mcg of Synthroid}$$

$$\frac{1000\text{ mcg}}{1\text{ mg}} \text{ and } \frac{1\text{ mg}}{1000\text{ mcg}} \qquad \frac{50.\text{ mcg Synthroid}}{1\text{ tablet}} \text{ and } \frac{1\text{ tablet}}{50.\text{ mcg Synthroid}}$$

STEP 4 **Set up the problem to cancel units and calculate the answer.**

$$0.150\text{ mg Synthroid} \times \frac{1000\text{ mcg}}{1\text{ mg}} \times \frac{1\text{ tablet}}{50.\text{ mcg Synthroid}} = 3\text{ tablets}$$

Exact Exact

3 SFs Exact 2 SFs

Learning Check

How many minutes are in 1.6 days?

Learning Check

If your pace on a treadmill is 65 m/min, how many minutes will it take for you to walk a distance of 7.5 km?