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Skills Worksheet

Problem Solving

Conversions

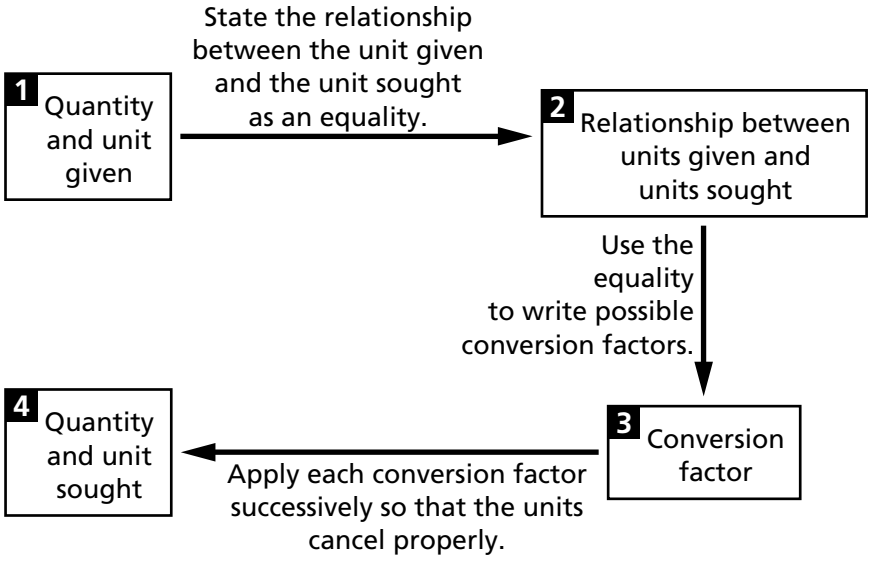
One of the aims of chemistry is to describe changes—to tell what changed, how it changed, and what it changed into. Another aim of chemistry is to look at matter and its changes and to ask questions such as how much, how big, how hot, how many, how hard, and how long did it take.

For example, chemistry asks the following:

- How much energy is needed to start a reaction?
- How much will the volume of a gas increase if you heat it?
- How long will a reaction take?
- How much can a reaction produce?
- How much of the reactant is needed to produce a required amount of product?
- How much energy does a reaction release?
- How high will the temperature of the solution get as a reaction occurs?

To answer these questions, chemists must make measurements. Measurements in science can never be treated as just numbers; they must always involve both a number and a *unit*. When you use measurements to calculate any quantity, the unit must always accompany the number in the calculation. Sometimes the unit given is not the most appropriate unit for the situation or calculation. In this case, a conversion can change the impractical unit into a more useful one. For instance, you would not want to measure the distance from New York City to San Francisco in inches. A simple conversion can transform the number of inches between the two cities to the much more practical number of miles.

General Plan for Converting Measurements



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CONVERTING SIMPLE SI UNITS

Sample Problem 1

A small bottle contains 45.5 g of calcium chloride. What is the mass of calcium chloride in milligrams?

Solution

ANALYZE

What is given in the problem? **the mass of calcium chloride in grams**

What are you asked to find? **the mass of calcium chloride in milligrams**

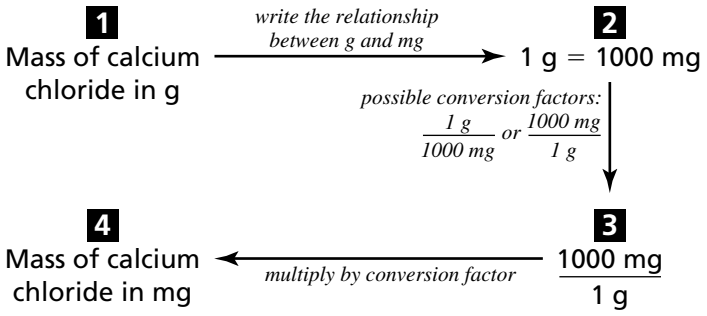
A table showing what you know and what you do not know can help you organize the data. Being organized is a key to developing good problem solving skills.

Items	Data
Quantity given	45.5 g calcium chloride
Units of quantity given	grams
Units of quantity sought	milligrams
Relationship between units	1 g = 1000 mg
Conversion factor	?
Quantity sought	? mg calcium chloride

PLAN

What steps are needed to convert grams to milligrams?

Determine a conversion factor that relates grams and milligrams. Multiply the number of grams by that factor. Arrange the factor so that units cancel to give the units sought.



Relationship between units: 1 g = 1000 mg

Possible conversion factors: $\cancel{\frac{1\text{ g}}{1000\text{ mg}}}$ or $\frac{1000\text{ mg}}{1\text{ g}}$

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The correct conversion factor is the one that when multiplied by the given quantity causes the units to cancel.

$$\overset{\textit{given}}{\text{g calcium chloride}} \times \overset{\substack{\textit{conversion factor} \\ g \rightarrow mg}}{\frac{1000\text{ mg}}{1\text{ g}}} = \overset{\textit{quantity sought}}{\text{mg calcium chloride}}$$

COMPUTE

$$45.5\ \cancel{\text{g}}\text{ calcium chloride} \times \frac{1000\text{mg}}{1\ \cancel{\text{g}}} = 45\ 500\text{ mg calcium chloride}$$

EVALUATE

Are the units correct?

Yes; milligrams are the desired units. Grams cancel to give milligrams.

Is the answer reasonable?

Yes; the number of milligrams is 1000 times the number of grams.

Practice

1. State the following measured quantities in the units indicated:

a. 5.2 cm of magnesium ribbon in millimeters **ans: 52 mm**

b. 0.049 kg of sulfur in grams **ans: 49 g**

c. 1.60 mL of ethanol in microliters **ans: 1600 μL**

d. 0.0025 g of vitamin A in micrograms **ans: 2500 μg**

e. 0.020 kg of tin in milligrams **ans: 20 000 mg**

f. 3 kL of saline solution in liters **ans: 3000 L**

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Problem Solving *continued*

2. State the following measured quantities in the units indicated:

a. 150 mg of aspirin in grams **ans: 0.15 g**

b. 2500 mL of hydrochloric acid in liters **ans: 2.5 L**

c. 0.5 g of sodium in kilograms **ans: 0.0005 kg**

d. 55 L of carbon dioxide gas in kiloliters **ans: 0.055 kL**

e. 35 mm in centimeters **ans: 3.5 cm**

h. 8740 m in kilometers **ans: 8.74 km**

i. 209 nm in millimeters **ans: 0.000 209 mm**

j. 500 000 μg in kilograms **ans: 0.0005 khhtg**

3. The greatest distance between Earth and the sun during Earth's revolution is 152 million kilometers. What is this distance in megameters? **ans: 152 000 Mm**

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Sample Problem 2

A metallurgist is going to make an experimental alloy that requires adding 325 g of bismuth to 2.500 kg of molten lead. What is the total mass of the mixture in kilograms?

Solution

ANALYZE

What is given in the problem? **the mass of bismuth in grams, the mass of lead in kg**

What are you asked to find? **the total mass of the mixture**

Items	Data
Quantity given	325 g of bismuth
Units of quantity given	grams
Units of quantity sought	kilograms
Relationship between units	1000 g = 1 kg
Conversion factor	?
Quantity sought	? kg of bismuth
Mass of lead	2.500 kg
Total mass	? kg of mixture

PLAN

To be added, the quantities must be expressed in the same units—in this case, kilograms. Therefore, 325 g of bismuth must be converted to kilograms of bismuth.

What steps are needed to convert grams to kilograms?
Determine a conversion factor that relates grams to kilograms. Apply that conversion factor to obtain the quantity sought.

What steps are needed to find the total mass of the mixture in kilograms?
Add the mass of the lead in kilograms to the mass of the bismuth in kilograms.

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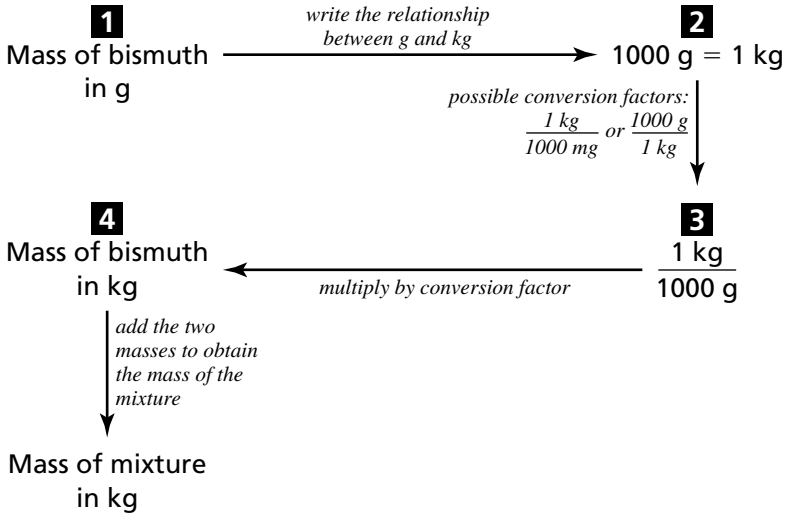
Problem Solving *continued*



Relationship between units: 1000 g = 1 kg

Possible conversion factors: $\frac{1000\ \text{g}}{1\ \text{kg}}$ or $\frac{1\ \text{kg}}{1000\ \text{g}}$

$$\overset{\text{given}}{\text{g bismuth}} \times \overset{\text{conversion factor } g \rightarrow kg}{\frac{1\ \text{kg}}{1000\ \text{g}}} = \overset{\text{quantity sought}}{\text{kg bismuth}}$$

$$\overset{\text{calculated above}}{\text{kg bismuth}} + \overset{\text{given}}{\text{kg lead}} = \text{kg mixture}$$

COMPUTE

$$325\ \text{g bismuth} \times \frac{1\ \text{kg}}{1000\ \text{g}} = 0.325\ \text{kg bismuth}$$

$$0.325\ \text{kg bismuth} + 2.500\ \text{kg lead} = 2.825\ \text{kg mixture}$$

EVALUATE

Are the units correct?

Yes; kilograms are the units sought.

Is the answer reasonable?

Yes; the value, 0.325, is one-thousandth the given value, 325.

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Practice

1. How many milliliters of water will it take to fill a 2 L bottle that already contains 1.87 L of water? **ans: 130 mL**

2. A piece of copper wire is 150 cm long. How long is the wire in millimeters? How many 50 mm segments of wire can be cut from the length? **ans: 1500 mm; 30 pieces**

3. The ladle at an iron foundry can hold 8500 kg of molten iron. 646 metric tons of iron are needed to make rails. How many ladlefuls of iron will it take to make 646 metric tons of iron? (1 metric ton = 1000 kg) **ans: 76 ladlefuls**

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CONVERTING DERIVED SI UNITS

Sample Problem 3

A balloon contains 0.5 m^3 of neon gas. What is the volume of gas in cubic centimeters?

Solution

ANALYZE

What is given in the problem? **the volume of neon in cubic meters**

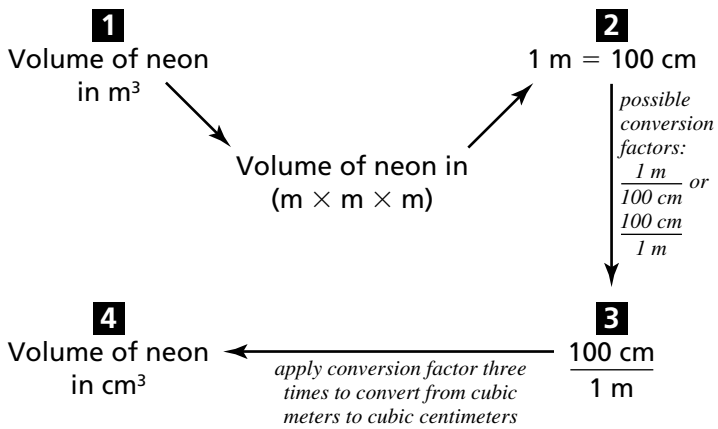
What are you asked to find? **volume of neon in cubic centimeters**

Items	Data
Quantity given	0.5 m^3 of neon
Units of quantity given	cubic meters
Units of quantity sought	cubic centimeters
Relationship between units	1 m = 100 cm
Conversion factor	?
Quantity sought	? cm^3 neon

PLAN

What steps are needed to convert cubic meters to cubic centimeters?

Rewrite the quantity in simple SI units. Determine the relationship between meters and centimeters. Write a conversion factor for each of the units in the given quantity. Multiply that quantity by the conversion factors. Arrange the factors so that units will cancel to give the units of the quantity sought.



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Problem Solving *continued*

Rewrite the given quantity in simple units as follows.

$$m^3 = m \times m \times m$$

Relationship between units: 1 m = 100 cm

Possible conversion factors: $\cancel{\frac{1\ m}{100\ cm}}$ or $\frac{100\ cm}{1\ m}$

$$\overset{\text{given}}{m^3\ \text{neon}} \times \underbrace{\frac{100\ cm}{1\ m} \times \frac{100\ cm}{1\ m} \times \frac{100\ cm}{1\ m}}_{\text{conversion factors cm} \rightarrow \text{m, applied three times}} = \overset{\text{quantity sought}}{cm^3\ \text{neon}}$$

COMPUTE

$$0.50\ m^3\ \text{neon} = 0.50\ (\cancel{m} \times \cancel{m} \times \cancel{m}) \times \frac{100\ cm}{1\ \cancel{m}} \times \frac{100\ cm}{1\ \cancel{m}} \times \frac{100\ cm}{1\ \cancel{m}} = 500\ 000\ cm^3\ \text{neon}$$

EVALUATE

Are the units correct?

Yes; cubic centimeters were the units sought.

Is the answer reasonable?

Yes; 500 000 cm^3 is half the number of cm^3 in 1 m^3.

Practice

1. State the following measured quantities in the units indicated.

a. 310 000 cm^3 of concrete in cubic meters **ans: 0.31 m^3**

b. 6.5 m^2 of steel sheet in square centimeters **ans: 65 000 cm^2**

c. 0.035 m^3 of chlorine gas in cubic centimeters **ans: 35 000 cm^3**

d. 0.49 cm^2 of copper in square millimeters **ans: 49 mm^2**

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Problem Solving *continued*

e. 1200 dm^3 of acetic acid solution in cubic meters **ans: 1.2 m^3**

f. 87.5 mm^3 of actinium in cubic centimeters **ans: 0.0875 cm^3**

g. 250 000 cm^2 of polyethylene sheet in square meters **ans: 25 m^2**

2. How many palisade cells from plant leaves would fit in a volume of 1.0 cm^3 of cells if the average volume of a palisade cell is 0.0147 mm^3? **ans: 68 027 cells**