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HOLT ChemFile TEACHING RESOURCES

5. SI CONVERSIONS

Sometimes the unit in which a quantity was measured must be converted to a different unit so it can be used in mathematical operations. Suppose you have half a pizza and you want to know how many slices you have. Pizza and slices cannot be compared because they are different units. To compare them, you need a **conversion factor.** If a pizza has 8 slices, then 1 pizza = 8 slices. This can be rewritten in the following ways.

$$\frac{1 \text{ pizza}}{8 \text{ slices}} = 1 \qquad \text{and} \qquad \frac{8 \text{ slices}}{1 \text{ pizza}} = 1$$

These are conversion factors. Notice that both fractions are equal to 1. This means that if you multiply them by another value, the value will not change. You can use a conversion factor to convert the amount of pizza into the number of slices.

$$\frac{1}{2} \cancel{\text{pizza}} \times \frac{8 \text{ slices}}{1 \cancel{\text{pizza}}} = 4 \text{ slices}$$

There are four slices in half a pizza. Notice that the conversion factor was chosen so that the new unit, slices, appears in the answer and the original unit, pizza, cancels.

EXAMPLE 1

Simple Conversions

How many meters are in 54 cm?

Determine the possible conversion factors. The two units in this problem are m and cm. We know that 1 m = 100 cm. So,

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

Decide which conversion factor will give the desired unit for the answer. The answer needs to be in m. To get m we need to use the conversion factor that has m in the numerator and divides by cm (to cancel cm in the original value).

$$\frac{1 \text{ m}}{100 \text{ cm}}$$

Multiply the original value by the conversion factor.

$$54 \cancel{\text{cm}} \times \frac{1 \text{ m}}{100 \cancel{\text{cm}}} = 0.54 \text{ m}$$

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EXAMPLE 2

Using Multiple Conversion Factors

How many milligrams are in 153 kg?

Determine the possible conversion factors. The original value is in kg, and the answer needs to be in mg. Using the relationships between grams and kilograms, and grams and milligrams, four conversion factors can be written. We know that 1 kg = 1000 g. So,

$$\frac{1\text{ kg}}{1000\text{ g}} = 1 \qquad \text{and} \qquad \frac{1000\text{ g}}{1\text{ kg}} = 1$$

We also know that 1 g = 1000 mg. So,

$$\frac{1\text{ g}}{1000\text{ mg}} = 1 \qquad \text{and} \qquad \frac{1000\text{ mg}}{1\text{ g}} = 1$$

Decide which conversion factors will give the correct unit for the answer. First, we need a conversion factor that has g in the numerator and divides by kg (to cancel kg in the original value).

$$\frac{1000\text{ g}}{1\text{ kg}}$$

Since the answer needs to be in mg, next we need a conversion factor that has mg in the numerator and divides by g (to cancel g).

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

Multiply the original value by the two conversion factors.

$$153\ \cancel{\text{kg}} \times \frac{1000\ \cancel{\text{g}}}{1\ \cancel{\text{kg}}} \times \frac{1000\text{ mg}}{1\ \cancel{\text{g}}} = 153\,000\,000\text{ mg}$$

PRACTICE

1. Work through the following problem.
How many kiloliters are in 5400 L?

a. Determine the possible conversion factors.
What are the two units used in this problem? _____

What quantities of these two units are equal? _____
Rewrite this equality as conversion factors.

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b. Decide which conversion factor will give the desired unit for the answer.

_____

c. Multiply the original value by the conversion factor.

Answer _____

2. Convert each of the following.

a. How many milligrams are in 1 g?

Answer _____

b. How many nanometers are in 1 m?

Answer _____

3. Work through the following problem.
How many kilometers are in 987 cm?

a. Determine the possible equalities between the units in the problem and meters.

_____

b. Rewrite these equalities as conversion factors.

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c. Decide which conversion factors will give the correct unit for the answer.

d. Multiply the original value by the two conversion factors.

Answer _____

4. Convert each of the following.

a. How many millimeters are in 89.3 km?

Answer _____

b. How many milligrams are in 1 Mg?

Answer _____

c. How many micrograms are in 15 cg?

Answer _____

d. How many micrometers are in 25 000 nm?

Answer _____

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5. Convert each of the following.

a. How many grams are in 5.67 ng?

Answer _____

b. How many millimeters are in 54 km?

Answer _____

c. How many centimeters are in 0.62 mm?

Answer _____

d. How many milliliters are in 22.4 L?

Answer _____

6. For a party, you bought a 2 L bottle of cola and glasses that hold 200 mL each.

a. How many mL of cola do you have?

Answer _____

b. How many glasses can you fill?

Answer _____

7. For an experiment, you need 1.20 kg of sodium bicarbonate. You have three jars of sodium bicarbonate. One jar is labeled 0.250 kg, one is labeled 454 g, and the third is labeled 350 g. Do you have enough sodium bicarbonate for the experiment?

Answer _____

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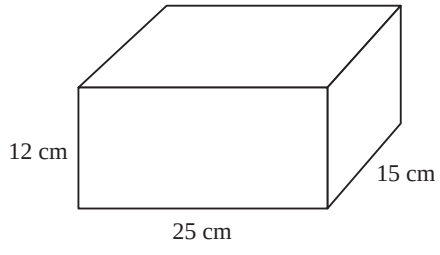
VOLUME IN SI UNITS

Volume is a measure of the three dimensions of an object. The volume of an object is found by multiplying length (l) times width (w) times height (h). Each of these three measures is a linear distance. If each of these is measured in centimeters, the unit is cubic centimeters (cm^3) which comes from multiplying $l \times w \times h$. One cubic centimeter is equivalent to 1 mL.

EXAMPLE 3

Converting Units of Volume

A box has a length of 25 cm, a width of 15 cm, and a height of 12 cm. What is the volume of the box in liters?



Calculate the volume in cm^3. Because the formula for calculating volume uses units of length, we cannot calculate liters directly. We first have to calculate the volume in cm^3 so that we can use the relationship 1 cm^3 = 1 mL.

$$l \times w \times h = 25 \text{ cm} \times 15 \text{ cm} \times 12 \text{ cm} = 4500 \text{ cm}^3$$

Determine the conversion factor to convert from cm^3 to mL. We know that 1 cm^3 = 1 mL. The conversion factor $\frac{1 \text{ mL}}{1 \text{ cm}^3}$ will put mL in the numerator and will cancel cm^3.

Determine the conversion factor to convert from mL to the units required in the answer. The answer must be in L. We know that 1000 mL = 1 L. To put L in the numerator and to cancel mL, use the conversion factor $\frac{1 \text{ L}}{1000 \text{ mL}}$.

Multiply the volume in cm^3 by the conversion factors.

$$4500 \text{ } \cancel{\text{cm}^3} \times \frac{1 \text{ } \cancel{\text{mL}}}{1 \text{ } \cancel{\text{cm}^3}} \times \frac{1 \text{ L}}{1000 \text{ } \cancel{\text{mL}}} = 4.5 \text{ L}$$

Determine the number of significant figures. 4.5 mL has the correct number of significant figures.

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PRACTICE

8. Work through the following problem.
What is the volume in liters of a box that measures 1 m × 2 m × 5 m?

a. Calculate the volume in cm^3.
(Hint: First convert the lengths given in meters to centimeters. Then calculate the volume.)

b. Determine the conversion factor to convert from cm^3 to mL.

c. Determine the conversion factor to convert from mL to the units required in the answer.

d. Multiply the volume in cm^3 by the conversion factors.

e. Determine the number of significant figures.

9. Convert each of the following.

a. What is 7640 cm^3 in liters?

Answer _____

b. What is 3.68 L in cubic centimeters?

Answer _____

c. 2859 cm^3 = ____ mL

Answer _____

d. 8370 cm^3 = ____ L

Answer _____

10. A cube has sides that are 0.030 m. What is the volume of the cube in liters?

Answer _____

11. A swimming pool is 10 m long, 5 m wide, and 2 m deep.

a. What is the volume of the swimming pool in milliliters?

Answer _____

b. What is the volume in liters of the same swimming pool?

Answer _____

12. A chemist wants to fill a cylindrical tank with helium gas. The tank has a radius (r) of 35.0 cm and a length (l) of 1.50 m. How many liters of helium are required? (The equation for the volume of a cylinder is $3.14r^2 \times l$.)

Answer _____

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TEMPERATURE IN SI UNITS

In science experiments, temperature is often measured in degrees Celsius (°C). However, the SI unit for temperature is the kelvin (K). The difference in the two scales is their zero point. The zero point in Celsius is the freezing point of water, while the zero point on the kelvin scale is absolute zero. Absolute zero, 0 K, is the coldest temperature theoretically possible. In degrees Celsius, absolute zero is −237.16°C. Because the kelvin and Celsius scales have the same size units, you can convert between kelvin and Celsius by using either of the following equations.

$$°C + 273 = K \quad \text{or} \quad K - 273 = °C$$

EXAMPLE 4

Converting Temperature Units

Express 25°C in kelvins.

$$K = °C + 273$$
$$= 25 + 273 = 298\ K$$

PRACTICE

13. Convert each of the following.

a. What is 489 K in degrees Celsius?

Answer _____

b. 100°C = ____ K

Answer _____

c. −39°C = ____ K

Answer _____

d. 61 K = ____ °C

Answer _____

e. What is 37°C equal to on the kelvin scale?

Answer _____