DIMENSIONAL ANALYSIS (FACTOR LABEL METHOD)

Using this method, it is possible to solve many problems by using the relationship of one unit to another. For example, 12 inches = one foot. Since these two numbers represent the same value, the fractions 12 in/1 ft and 1 ft/12 in are both equal to the number one. When you multiply another number by the number one, you do not change its value. However, you may change its unit.

Example 1: Convert 2 miles to inches

\[ 2 \text{ miles} \times \frac{5280 \text{ ft}}{1 \text{ mile}} \times \frac{12 \text{ inches}}{1 \text{ ft}} = 126,720 \text{ in} \] (Using significant figures, 2 miles = 100,000 in.)

Example 2: How many seconds are in 4.0 days?

\[ 4.0 \text{ days} \times \frac{24 \text{ hrs}}{1 \text{ day}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{60 \text{ sec}}{1 \text{ min}} = 345,600 \text{ sec} \] (Using sig figs, 4.0 days = 350,000 sec)

Solve the following problems. Write the answers in significant figures.

1. \( 3 \text{ hrs} = \frac{10,000}{1} \text{ sec} \) \[ 3 \text{ hrs} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{60 \text{ sec}}{1 \text{ min}} = 10,800 \text{ sec} = 10,000 \text{ sec} \]

2. \( 0.035 \text{ mg} = \frac{0.0035}{1} \text{ cg} \) \[ 0.035 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{100 \text{ cg}}{1 \text{ g}} = 0.0035 \text{ cg} \]

3. \( 5.5 \text{ kg} = \frac{12}{1} \text{ lbs} \) \[ 1 \text{ kg} = 2.2 \text{ lbs} \] \[ 5.5 \text{ kg} \times \frac{2.2 \text{ lbs}}{1 \text{ kg}} = 12.1 \text{ lbs} = 12 \text{ lbs} \]

4. \( 2.5 \text{ yds} = \frac{90}{1} \text{ in} \) \[ 1 \text{ yd} = 3 \text{ ft} \] \[ 2.5 \text{ yds} \times \frac{3 \text{ ft}}{1 \text{ yd}} \times \frac{12 \text{ in}}{1 \text{ ft}} = 90 \text{ in} \]

5. \( 1.3 \text{ yrs} = \frac{11,000}{1} \text{ hr} \) (1 yr \( \approx \) 365 days)

6. 3 moles = \( \frac{2 \times 10^{24}}{1} \) molecules (1 mole \( \approx \) 6.02 \( \times \) 10\(^{23}\) molecules)

7. \( 2.5 \times 10^{24} \) molecules = \( \frac{4.2}{3} \) moles

8. \( 5.1 \) moles = \( \frac{110}{1} \) liters (1 mole = 22.4 liters of gas at STP)

9. \( 100. \) liters of gas at STP = \( \frac{4.44}{1} \) moles

10. \( 50. \) liters of gas at STP = \( \frac{2.3 \times 10^4}{1} \) molecules

11. \( 5.0 \times 10^{24} \) molecules = \( \frac{190}{1} \) liters of gas at STP

12. \( 7.5 \times 10^3 \) mL = \( \frac{7.5}{1} \) liters

7.5 \( \times \) 10\(^3\) mL \( \times \) \( \frac{1 \text{ L}}{1000 \text{ mL}} = 7.5 \text{ L} = 18 \frac{1}{6} \text{ mL} \)
Solving Word Problems using Dimensional Analysis

Using Dimensional Analysis, make the following conversions. Show your work!

1. How many gallons of soft drink are there in a 2.0L bottle?
Fact: 1 gallon ≈ 3.785 L.

\[
2.0 \text{ L} \times \frac{1 \text{ gal}}{3.785 \text{ L}} = 0.5284 \text{ gal} = 0.53 \text{ gal}
\]

2. A diamond is made of pure carbon. The distance between any two neighboring carbon atoms in a diamond is 1.54 angstroms (Å). What is the distance in centimeters? Fact: 1 Å = 1 \times 10^{-8} \text{ cm}.

\[
1.54 \text{ Å} \times \frac{1 \times 10^{-8} \text{ cm}}{1 \text{ Å}} = 1.54 \times 10^{-8} \text{ cm}
\]

3. In 1975 the world record for the long jump was 29.21 ft. Convert this distance to meters.
Fact: 1 inch = 2.54 cm.

\[
29.21 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{25.4 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 8.903 \text{ m}
\]

4. The speed limit on many Australian highways is 100. km/hr. Convert this to mi/hr (round to the nearest whole number). Fact: 1 mi ≈ 1609 m.

\[
\frac{100 \text{ km}}{1 \text{ hr}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ mi}}{1609 \text{ m}} = 63.1504 \text{ mi/hr} \approx 63.2 \text{ mi/hr}
\]

5. The density of water at room temperature (25°C) is [0.9970 g/cm^3]. How many pounds does the water in a full 5.00 gallon pail weigh?
Facts: 1 cm^3 = 1 mL,
1 gal ≈ 3.785 L
0.453 kg ≈ 1.0 lb.

\[
5.00 \text{ gal} \times \frac{3.785 \text{ L}}{1 \text{ gal}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ cm}^3}{1 \text{ mL}} \times \frac{0.9970 \text{ g}}{1 \text{ cm}^3} \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \frac{1.6 \text{ lb}}{0.453 \text{ kg}} = 41.6517 \text{ lbs} = 41.7 \text{ lbs}
\]