Example 1 – Medicine The label on a stock drug container gives the concentration of a solution as 1200mg/ mL. Determine the volume of the medication that must be given to fill a physician's order of 1600 mg of the drug (figure 17.8).

- Unknown An analysis of the problem shows that the unknown (the volume of solution to be given) must have units of volume (mL medicine).
- Knowns: We know that the solution has a concentration of 1200 mg drug/mL medicine and that we must obtain 1600 mg of the drug. Figure 17.8 illustrates what must be done.
- Conversion factors and formulas: None necessary.
- Equation: You must divide by concentration and multiply by mass of the drug in order to get the desired units (mg medicine).
- Calculation: After the units are canceled, the equation yields 1.333 mL of medicine.

Example 2 – Space Science

On June 19, 1976, the United States successfully landed *Viking1* on the surface of the planet Mars. Twenty years later, on July 4, 1997, NASA landed another robotic probe named the *Mars Pathfinder* at a distance of 520 miles from the *Viking 1* landing site. Unlike the *Viking* mission, the Pathfinder mission included a surface rover known as *Sojourner*, a six-wheeled vehicle that was controlled by an Earth-based operator. Knowing that the distance between the landing site of the *Mars Pathfinder* and the *Viking 1* craft is 520 miles, what would be the minimum number of hours required to drive *Sojourner* to the Viking site assuming a top speed of 0.70 centimeters per second, and no obstacles (figure 17.9).

- Unknown: The number of hours to reach the *Viking 1* site.
- Knowns: The distance is 520 miles, and the speed is 0.7 centimeters per second.
- Conversion factors and formulas: The distance is measured in customary units (miles) while the speed of *Sojourner* is measured in metric units (centimeters/second). We will therefore need to use the following conversion ratios to obtain units with the correct dimensions: 2.54 centimeters/inch, 12 inches/foot, 5280 feet/mile.
- Equation: The answer must have units of time. The only known factor that includes units of time is the speed of the rover (distance/time). It is therefore evident that we must divide by speed to get units of time in the numerator where they are needed. To arrive at the desired units of time, it is necessary to cancel the units of distance by multiplying by the distance that must be traveled. It is now necessary to multiply or divide by the appropriate conversion ratios to insure that all units of distance are canceled.
- Calculation: After the units are canceled, the equation yields the answer in hours, as desired. The number is changed to two significant figures since one of the factors has only two significant figures, and you can have no greater accuracy than your least accurate factor.

Example 3 - Physics

A 2.00-L tank of helium gas contains 1.785 g at a pressure of 202 kPa. What is the temperature of the gas in the tank in kelvin given that the molecular weight of helium is 4.002 g/mol and the universal gas constant is 8.29 x 10^3 L·Pa/mol·K (figure 17.10)?

- Unknown : The unknown is the temperature of the gas, expressed in kelvin.
- Knowns: Volume of helium container (2.00 L), mass of helium (1.785 g), molecular weight (*MW*) of helium (He; 4.002 g/mol), pressure of helium (202 kPa), universal gas constant (8.29 x 10^3 L·Pa/mol·K). In addition, we know the number of moles (n = 0.446 mol) of helium since $n = m/MW$.
- Conversion factors and formulas: This problem requires the use of the ideal gas law equation ($PV=nRT$) which must be expressed in terms of temperature: $T=PV/nR$.
- Equation: The equation must be set up so all units cancel except the desired units, kelvin (K).
- Calculation: Once the equation is set up so that the units cancel to leave only the target units of K, then calculations can be performed.

Example 4 - Chemistry

Calculate the mass of silver metal that can be deposited if a 5.12 ampere current is passed through a silver nitrate solution for 2.00 hours. Note: there are 96,500 C per mole of electrons, and the gram atomic weight of silver is 107.9g/mol (figure 17.11).

- Unknown An analysis of the problem shows that the unknown (the mass of silver metal deposited) must have units of grams silver.
- Knowns: We know that the current is 5.12 amps for a period of 2.00 hours. We also know that 1 mole of silver is deposited per mole of electrons from the fact that silver is a plus one cation ($Ag^+ + e^- \rightarrow Ag$). From the problem description we know the experimental setup and can therefore draw a diagram. We also can acquire the gram-atomic weight of silver from the periodic table.
- Conversion factors and formulas: This problem will require a number of conversion factors in order to get the appropriate units. One coulomb is one amp second. One mole of electrons is 96,500 coulombs. One hour is 60 minutes. One minute is 60 seconds. Because these are equalities, they can be represented as conversion factors, each of which is equal to one.
- Equation: The units of the unknown become the "target units" and are set up on the right side of the equation. The left side of the equation is assembled so that units will cancel and leave only the target units.
- Calculation: Once the equation is set up so that the units cancel to leave only the target units, calculations can be performed.

Example 5 – Earth Science

The island of Greenland is approximately 840,000 mi^2, 85 percent of which is covered by ice with an average thickness of 1500 meters. Estimate the mass of the ice in Greenland in kg (assume two significant figures). The density of ice is 0.917 g/mL, and 1 cm^3 = 1 mL (figure 17.12).

- Unknown An analysis of the problem shows that the unknown must have units of mass. Since the specific units of mass are not specified, we will use the MKS unit of kilograms.
- Knowns: Since we know that the area of Greenland is 840,000 $miles^2$, and 85% of it is covered by ice, then 714,000 $miles^2$ must be covered by ice. We also know that the density of ice = 0.917 g/mL and the ice has an average depth (height) of 1500 m.
- Conversion factors and formulas: Some measurements are in customary units, while others are in metric. We should always convert all units to metric unless otherwise specified. To do so, we will need to convert miles to meters using the following conversion factors: 5280 ft/mile, and 0.3048 m/ft. We also need to use conversion factors to obtain consistent metric units for mass and volume. Knowing that 1 cm = 0.01 m, then 1 cm^3 = 0.000001 m^3. We also know that 1 kg= 1000 g.
- Equation: The units of the unknown become the "target units" and are set up on the right side of the equation (kg ice). The equation *mass = (height x area) density* is the basic equation, and the conversion factors are inserted to make certain all units are consistent.
- Calculation: Once the equation is set up so units cancel to leave only the target units of kilograms of ice, calculations can be performed.

Example 6 - Biology

The rate of photosynthesis is often measured in the number of micromoles of CO_2 fixed per square meter of leaf tissue, per second (μmol CO_2/m^2s). What is the rate of photosynthesis in a leaf with an area of 10 cm^2 if it assimilates 0.00005 grams of carbon dioxide each minute (MW of CO_2= 48 g/mol)? (figure 17.13).

- Unknown We are trying to determine the rate of photosynthesis in units of μmol CO_2/m^2s.
- Knowns: The rate of carbon dioxide assimilation by the leaf is 0.00005 grams of carbon dioxide per minute. We also know that the leaf area responsible for this is 10 cm^2.
- Conversion factors and formulas: The gram molecular weight of CO_2= 48 g/mol. This will be essential in determining the number of micromoles of carbon dioxide. We also know that there are 10^6 micromoles/mole, 100cm/m, and 60s/min. We may multiply or divide by these unit factors because each one is an identity (equal to 1).
- Equation: Since the rate of photosynthesis is defined as the number of moles of carbon dioxide absorbed per square meter of tissue per second, the equation becomes: *Rate=quantity of CO_2 per square area of tissue, per second.*
- Calculation: Once the equation is set up so that the units cancel to leave only the target units of μmol CO_2/m^2s, then calculations can be performed.