Measurement and Temperature Conversions

YOU WILL SOON UNLOCK THE KEY to converting from English to metric quantities and from Fahrenheit to Celsius temperatures. Pharmacy uses the terms avoirdupois (AV) and apothecary (AP) instead of English, or customary, and metric systems. In your pharmacy studies, you will learn to convert quantities in volume, weight, length, and temperature. By using conversions, you will measure, mix, and label prescription medications.

Objectives:

1. Convert between metric and customary measurements.
2. Convert between Fahrenheit and Celsius (Centigrade) temperatures.

Key Terms:

apothecary
avoirdupois
Celsius
Fahrenheit
household conversions
mass
metric system
volume

Metric and Customary Pharmacy Conversions

You will need to solve common pharmacy-related problems. As a result, you will learn to convert between metric and customary (English) measurements as you employ ratio, proportion, and dimensional analysis to calculate conversions, under the supervision of a pharmacist.

The **metric system** is a method based on the decimal system in which everything is measured in multiples or fractions of 10. The standard measure for length is meter (m); weight is gram (g); and volume is the liter (L).

Commonly used prefixes are:

kilo	1,000
milli	0.001 = $^{1}/_{1000}$
micro	0.000001 = $^{1}/_{1,000,000}$

- **Volume** is the amount of space occupied by a three-dimensional substance or object. Volume is measured in cubic units as ml or L.
- **Mass** is the amount of matter in an object. Matter is a general term for the substance within physical objects. Mass is measured in kg, g, mg, and mcg.

FIGURE 1. This is a measuring cup for liquids that measures metric amounts.

AVOIRDUPOIS SYSTEM

The **avoirdupois** (AV) weight system is used mainly by English-speaking countries and is based on the pound, which is equal to 16 ounces or 7,000 grains (gr). The avoirdupois weight system is used to measure and compound bulk medications.

437.5 gr = 1 oz = 28.35 g

7,000 gr = 1 lb =16 oz = 454 g

1 kg = 2.2 lb

1 gr = 64.8 mg

DIGGING DEEPER...

UNCOVERING ADDITIONAL FACTS: The Grain as a Unit of Measure

During the Bronze Age, barley and wheat grains were a legal definition of units of mass. Back through history, the fundamental unit of apothecary, avoirdupois, and Troy systems was a single grain, usually based on the weight of a grain of barley. Since 1958, the grain or Troy grain has been designated as 64.8 milligrams, which is equal to one gram = 15.43 grains. There are exactly 7,000 grains per avoirdupois pound and 5,760 grains in the Troy pound.

The grain is the only unit of mass common to all three mass and weight systems. The Troy weight is now used exclusively to measure the mass of precious gold, silver, and gemstones. Apothecary and avoirdupois systems are both common pharmacy measurements.

APOTHECARY SYSTEM

The **apothecary** (AP) units of measure were developed to accommodate the measurement of smaller portions of medications. The apothecary's system of measurement is based on volume and weight and can be used to convert units for compounding and for dilution mixtures. The apothecary system was brought to the United States from England during the colonial period and has now largely been replaced by the metric system. Its units are grain, scruple, dram, ounce, and pound.

Apothecary (AP) Unit of Measure	Abbreviation and/or Metric Symbol
pound	lb
ounce	oz (℥)
dram	ʒ
scruple	℈
grain	gr
gallon	gal
pint	pt
fluid ounce	fl oz (f℥)
fluid dram	fʒ
minim	♏

BROADENING AWARENESS...

AMAZING ASPECTS: Dram, Scruple, and Minim

The dram, scruple, and minim are old forms of measurement used in avoirdupois and apothecary systems. In England, the 1963 Weights and Measures Act provided for the abolition of the fluid dram, fluid scruple, and the minim. On Feb. 1, 1971, these measurements were declared illegal as official units of measure.

In the U.S. avoirdupois system, the dram (dr or ʒ) equals the mass of $^1/_{296}$ pound or $^1/_{16}$ ounce, 27.34 grains, or 1.77 grams. In the English apothecary system, a dram equals $^1/_8$ ounce, 60 grains, or 3.89 grams. One scruple (℈) equals 1.3 grams, 20 grains, or $^1/_{24}$ of an ounce.

Minim (♏, M, or min.) is the smallest unit of liquid measure. The minim was introduced as an alternative to the drop, previously the smallest unit of apothecary measure. Since the size of a drop varies depending on the viscosity and gravity of a liquid, it was replaced by the minim, measured by a graduated tube invented in 1791. The minim is standardized to equal 0.06 ml, and 60 minims equal 1 fluid dram or $^1/_{480}$ ounce. The metric system has eliminated the use of the minim in most parts of the world.

Volume		Approximate Metric Equivalent
1 fluid dram	60 minims	3.7 milliliters
1 fluid ounce	8 fluid drams	30 milliliters
1 pint	16 fluid ounces	473 milliliters
1 quart	2 pints	946 milliliters
1 gallon	4 quarts	3.78 liters
Weight		
1 grain		64.8 milligrams
1 scruple	20 grains	1.3 grams
1 dram	3 scruples	3.9 grams
1 ounce	8 drams	30 grams
1 pound	12 ounces	373 grams

Household conversions are units used to measure liquids with home utensils:

teaspoons	tsp
tablespoons	TBS
cups	c
pints	pt
quarts	qt
gallons	gal

Common Pharmacy Conversions

(AP = Apothecary; AV = Avoirdupois)

Measurement	Equivalent
Volume	
1 L	1,000 ml
1 lb (AV)	16 oz
1 cup	8 oz
1 fl oz	5 ml

(Continued)

1 TBS	15 ml
1 TBS	0.5 fl oz
1 pt	480 ml
1 pt	16 oz
2 pt	1 qt
4 qt	1 gal
1 cup	8 fl oz = 240 ml
1 gal	3,840 ml
Weight	
1 kg	1,000 g
1 mg	1,000 mcg
1 g	1,000 mg
1 oz	30 g
16 oz	1 lb (AV)
1 lb	454 g
1 kg	2.2 lb
1 gr	64.8 mg
1 oz	480 gr

Use the conversion information in this lesson to solve problems:

1. 1 L = _____ ml

$$\cancel{1\text{ L}} \times \frac{1000\text{ ml}}{\cancel{1\text{ L}}} = 1000\text{ ml}$$

2. 2500 g = _____ kg

$$2500\ \cancel{\text{g}} \times \frac{1\text{ kg}}{1000\ \cancel{\text{g}}} = 2.5\text{ kg}$$

3. 1.2 g = _____ mg

$$1.2\ \cancel{\text{g}} \times \frac{1000\text{ mg}}{1\ \cancel{\text{g}}} = 1200\text{ mg}$$

4. 1000 mcg = _____ mg

$$\cancel{1000\text{ mcg}} \times \frac{1\text{ mg}}{\cancel{1000\text{ mcg}}} = 1\text{ mg}$$

5. 3 TBS = _____ tsp

$$3\ \cancel{\text{TBS}} \times \frac{3\ \text{tsp}}{1\ \cancel{\text{TBS}}} = 9\ \text{tsp}$$

6. 2 TBS = _____ ml

$$2\ \cancel{\text{TBS}} \times \frac{15\ \text{ml}}{1\ \cancel{\text{TBS}}} = 30\ \text{ml}$$

7. 8 fl oz = _____ ml

$$8\ \cancel{\text{fl oz}} \times \frac{30\ \text{ml}}{1\ \cancel{\text{fl oz}}} = 240\ \text{ml}$$

8. 45.5 kg = _____ lb

$$45.5\ \cancel{\text{kg}} \times \frac{2.2\ \text{lb}}{1\ \cancel{\text{kg}}} = 100.1\ \text{lb}$$

Fahrenheit and Celsius Temperature Conversions

The **Fahrenheit** temperature scale was established in 1724 and was named after German scientist Daniel Gabriel Fahrenheit. He determined that water froze at 32°F and boiled at 212°F. Noting the difference between the two points is 180°, each degree on the Fahrenheit scale is $^1/_{180}$ of the interval between the freezing and boiling points.

The Fahrenheit scale was widely used for weather forecasting and in the medical field until the 1970s when the Celsius scale replaced it in many parts of the world. In many countries, the Celsius scale was adopted, along with the metric system. Fahrenheit remains the official weather reporting scale in the United States, but the scientific world uses the Celsius scale.

The Celsius scale (called centigrade until 1948) was named after Swedish astronomer Anders Celsius. On the **Celsius** scale, the freezing point is 0°, and the boiling point is 100°. Most countries use the Celsius scale in science, climate forecasting, and industry.

In pharmacy, temperature is reported in Fahrenheit and Cel-

FIGURE 2. A thermometer on a hot beach shows the difference in Fahrenheit and Celsius readings.

sius, so you will need to know how to convert from one to the other. The formulas for conversion are:

Fahrenheit to Celsius: °F = $^{9}/_{5}$ °C + 32

Celsius to Fahrenheit: °C = $^{5}/_{9}$ × (°F – 32)

Convert 25°C to degrees Fahrenheit:

1. °F = $^{9}/_{5}$°C + 32
2. °F = $^{9}/_{5}$ × 25
3. °F = 9 × 25 = 225
3. °F = 255 ÷ 5 = 45
4. °F = 45 + 32
5. °F = 77°F

Convert 100.5°F to degrees Celsius:

1. °C = $^{5}/_{9}$ × (°F – 32)
2. °C = $^{5}/_{9}$ × (100.5 – 32)
3. °C = $^{5}/_{9}$ × 68.5
4. °C = 68.5 × 5 = 342.5
5. °C = 342.5 ÷ 9 = 38
6. °C = 38°

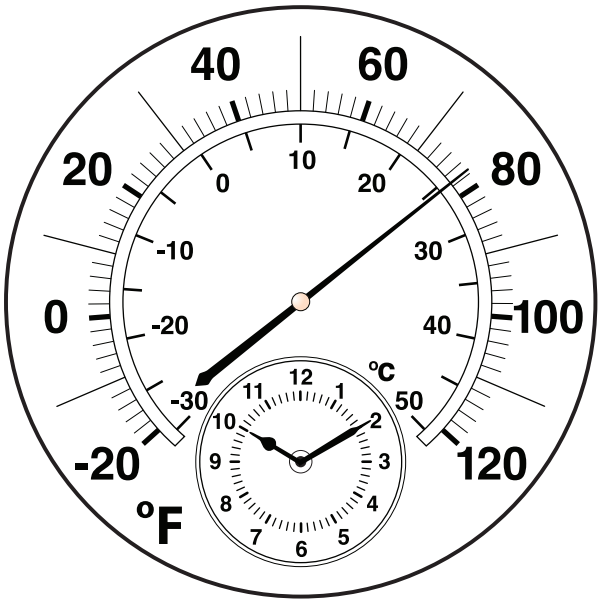

FIGURE 3. This instrument measures Fahrenheit and Celsius temperatures.

Summary:

Pharmacists convert quantities in volume, weight, length, and temperature. The metric and customary English systems can be interchangeable in configuring prescriptions. The metric system is based on multiples of 10. The standard measure for length is meter (m); weight is gram (g); and volume is the liter (L).

The avoirdupois (AV) weight system is used mainly by English-speaking countries and is based on the pound, which is equal to 16 ounces or 7,000 grains (gr). The avoirdupois weight system is used to measure and compound bulk medications. The apothecary (AP) units of measure were developed to accommodate the measurement of smaller portions of medications. The apothecary's system of measurement is based on volume and weight and can be used to convert units for compounding and for dilution mixtures.

In pharmacy, temperature is reported in Fahrenheit and Celsius. In many countries, the Celsius scale was adopted along with the metric system. Fahrenheit remains the official weather reporting scale in the United States, but the scientific world uses the Celsius scale.

Checking Your Knowledge:

1. What is the basis of the metric system, and what are standard metric measures?
2. Name the weight system that is based on the pound and measures compound bulk medications.
3. Which measurement system is used to measure smaller portions of medications, and what are its units of measure?
4. Name the two major temperature systems. What is the difference in freezing and boiling points in the two systems?
5. In what fields are Fahrenheit temperatures used?

Expanding Your Knowledge:

Visit the *Sciencebug Z* website and solve metric problems at http://www.sciencebugz.com/chemistry/chprbmetric.htm.

Web Links:

Measurement Conversion Tables
http://www.tostepharmd.net/pharm/clinical/measurement.html

Pharmacy Conversion Terms
http://www.pharmacytechnician.net/resources/a-pharmacy-technicians-measurement-conversions

Calculations Overview
http://www.passassured.com/nonflashcalc.htm

Celsius to Fahrenheit
http://www.ncdc.noaa.gov/oa/climate/conversion/tempconvert.html