Chapter 4: Critical Measurement Tools for the Competent Pharmacy Technician

2 Contact Hours

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Learning objectives
After the pharmacy technician has concluded this knowledge-based activity, he or she will be able to:

- Examine the historical significance of the apothecary and avoirdupois methods of measure, and critique the pros and cons of using these methods in contemporary pharmacy practice.
- Summarize the many advantages of using the metric system as the mainline approach to conducting pharmacy measurements.

- Recognize the simplicity with which metric units can be easily manipulated and interconverted, owing to their simple decimal notation.
- Express the importance of the International System, and how it works to consolidate a number of different concepts into a comprehensive, scientific measuring system.

Introduction
The metric system may be the most commonly observed system of measurement encountered by the pharmacy technician, and thus, should be thoroughly understood and appreciated. Even so, the apothecary, avoirdupois and household measurement systems also appear in contemporary practice. As a result, pharmacy technicians also must understand these approaches and be able to readily make conversions.

In addition to these systems of measurement, it is also critical that pharmacy technicians have a thorough understanding of SI units, milliequivalents, millimoles and temperature as each relates to pharmacy practice.

Each of the common measuring systems will be described as well as how they relate to the preferred pharmacy measurement approach: the metric system. To best understand the relatedness of the various measurement systems, a variety of examples will be provided to further illustrate the relationship between them and the metric system.

Weighing instruments
Before the development of mass-manufactured dosage forms, perhaps the most critical of instruments in an apothecary shop was an accurate instrument for measuring medicines. The historical problem, though, was that across the world, leaders could rarely agree on a universal standard of measurement.

However, in 1497, England resolved that the tory weight would be the official unit of mass to be used by both spice merchants and apothecaries. By the advent of the 18th century, traditional standard iron and lead weights were replaced with brass. Even when the avoirdupois system came into vogue in 1855, the majority of apothecaries stuck with their tory weights.

The earliest scales were made by suspending two pans on opposite ends of a beam. These devices were known as equal-arm scales. The medicinal substance would be poured into one pan, and it could be balanced by the placement of known counterweights in the other.

When the pans were filled with equal weight, they would be even, with the beam parallel to the ground. The sum of the counterweights would then be equal to the weight of the measured medicine. The beam would be suspended by its center, sometimes held by hand or at other times hung from a solid object above. One variation was a pillar scale that was similar in appearance but featured a freestanding pillar or support in the middle.1

Although the principles of weight measurement remain the same, the available technology has evolved over time. While modern pharmacies may use a variety of analytical balances, all pharmacies are required by law to have a Class A prescription balance in their facility. A Class A prescription balance is a double-pan, torsion-type balance that uses both internal weights for measurements up to 1 gram and external weights for measurements exceeding 1 gram.
The Class A balance is required to have a sensitivity of no less than 6 mg, with most balances having a maximum capacity of 120 grams. The Class A balance is required to be able to weigh 120 mg with an error of no greater than 5 percent. The National Bureau of Standards dictates that the Class A balance must have the following features:
- A metal identification plate indicating the serial number, model, sensitivity and capacity of the instrument.

**Liquid measurement**

When pharmacy technicians are measuring liquids, there are two main thoughts to keep in mind: First, they need to be mindful of their ability to accurately measure the components of a prescription preparation; and at the same time, should give serious consideration to how well the patient will be able to measure his or her own individual dose of medication.

With that said, while the techniques used to measure liquids are likely the simplest measurements made in the pharmacy, they are, at the same time, the most susceptible to error, sometimes caused by selecting the wrong instrument and sometimes by an unprofessional technique.

A few things should be kept in mind to ensure the highest-quality measurement of liquids:
- It is critical to use precision volumetric glassware to measure exact quantities of liquids. The capacity is always inscribed on the vessel, as well as the inscription TD (to deliver) or TC (to contain). This distinction is critical because it signifies whether the labeled volume is the amount contained in the vessel (TC), or the amount of liquid delivered upon emptying the vessel (TD).
- Typically, pipettes, burettes, syringes and droppers are TD vessels, while volumetric flasks and graduated cylinders are TC.
- One last key thought to keep in mind is that Erlenmeyer flasks, beakers and prescription bottles, regardless of markings, are not volumetric glassware, and should never be relied upon for accurate measuring.

**The apothecary system**

The apothecaries’ weight, evolved from an earlier Roman system, was used in Europe for measuring pharmaceutical ingredients as early as the year 1270. The measuring system was refined and modified based on direction from the British royal family.4

The apothecary system arrived in the United States from England during the colonial period as a method for measuring, weighing drugs, and solutions of medications. The main units used in the apothecary system include the grain, scruple, dram, ounce and troy pound. In cases where less than a full unit were used, fractions were employed to describe the partial measure. For example one-fourth of a grain would be written as gr. ¼, while the fraction “½” is written as “ss.”

One major drawback of the apothecary system is the ease with which at least two symbols can be easily confused, and thus they must always be written clearly: drams (ʒ) and ounces (℥). Lowercase Roman numerals are used after the symbols for these units of measure. For example, ʒiiss reads two and one-half drams while ℥iv reads four ounces.

The base unit of the apothecary weight system is the grain. The relationship between the different units is described below:
- 20 grains = one scruple.
- 3 scruples = one dram.
- 8 drams = one ounce.
- 12 ounces = one troy pound.

The conversion from apothecary weights to metric weight units is not so orderly:
- 1 grain = 64.8 milligrams.
- 1 scruple = 1.296 grams.
- 1 dram = 3.89 grams.
- 1 ounce = 31.1 grams.
- 1 pound = 373 grams.

While these units are used to measure weights, the measure of liquids are similar, using liquid pints, fluid ounces, fluid drams and fluid scruples, with the units breaking down as follows:
- 1 liquid pint = 16 fluid ounces = 473 milliliters.
- 1 fluid ounce = 8 fluid drams = 29.6 milliliters.
- 1 fluid dram = 3 fluid scruples = 3.7 milliliters.
- 1 fluid scruple = 20 minim = 1.23 milliliters.

Because in the apothecary system, ingredient quantities are usually written using Roman instead of the more commonly known and understood Arabic numerals, it is critical that pharmacy technicians familiarize themselves with the following notations and their meanings:
- ss = ½.
- \( \frac{1}{2} \) or \( \frac{1}{2} \) = 1.
- \( \frac{1}{2} \) or \( \frac{1}{2} \) = 5.
- \( \frac{1}{2} \) or \( \frac{1}{2} \) = 10.
- \( \frac{1}{2} \) or \( \frac{1}{2} \) = 50.
- \( \frac{1}{2} \) or \( \frac{1}{2} \) = 100.
- \( \frac{1}{2} \) or \( \frac{1}{2} \) = 500.
- \( \frac{1}{2} \) or \( \frac{1}{2} \) = 1,000.

**Interesting apothecary facts**

**The grain.** A grain weight found its origin as the weight of a dried grain of wheat (France); more specifically, in England, a dried grain of barleycorn.

**The Troy pound.** In medieval times, it was common for merchants to come to the people instead of the people coming to them. To accomplish this, merchants would travel the countryside, spending a day or more at regional fairs before returning home to restock their wares. Some cities were large enough to support “great fairs,” which drew merchants and traders from many countries.

One such city was a city in the Champagne region of France called Troye. It seems quite likely that the apothecary troy pound originated in this city, where a standard weight of coinage used for the measuring of metals, jewels and medicines was developed. In time, this approach was adopted throughout Europe and is still used in the jewelry trade.

**Scruples.** The apothecary term of scruples likely conjures up images of moral principles. Nonetheless, this connection is not obvious and likely has made many people wonder about its origin. According to history, in medieval times, the apothecary apprentices were supposed to use weights to carefully measure out the correct amount.
of medication for each prescription. But because the scruple was such a small amount (about the same as a one-quarter teaspoon of salt), an unwilling apprentice could instead just add a pinch of the ground substance in place of a measured scruple to a drug mixture instead going through the pain of carefully weighing out the required scruple of medicine. If the apothecary did not see the scruple weight laid out on the table, he might ask the apprentice, “Have you no scruples?”

As such, this phrase then became associated with carelessness or lack of concern for accuracy. Over time, it evolved to mean a lack of moral integrity or principles, so came the word “unscrupulous.”

Although the apothecary system has fallen from favor, pharmacy technicians must be intimately familiar with this ancient system of measurement and be able to make ready conversions to the metric system to properly dispense medications.

The avoirdupois system

The avoirdupois (which is pronounced ave-waar-do-puwah) is a system of weights used regularly, for most purposes, in the United States. Although not an official weighing system, it also is used to some extent by people in The United Kingdom and Canada. This odd-sounding word stems from old French and loosely translates to the “goods of weight.”

Like the apothecary system, the smallest weight is the grain, which also like in the apothecary system, is said to represent the weight of a grain of wheat. The next largest unit of weight is the dram, which is represented by 27.344 grains. Neither of these two units is frequently encountered when using the avoirdupois approach to measurement. The next units are commonly used and are the ounce, which is composed of 16 drams, and the pound, which is made up of 16 ounces.

When this is all combined, it can be calculated that in the avoirdupois system, a pound is equal to 7,000 grains. When this is contrasted to the apothecary system, where a pound is equal to 5,760 grains, it quickly becomes evident that a large medication error could occur if these two systems of weights were confused and somehow interchanged. This potential problem led to the abolishment of the apothecary system in the U.S. in the 1970s. Although not legally mandated, it is rare that units less than 1 ounce from the avoirdupois system are used in contemporary pharmacy practice. Further, when we think of pounds, we typically follow the avoirdupois approach and consider it to contain 16 ounces.

The avoirdupois system relates only to weights and does not contain units used for the measurement of liquids.

The conversions from avoirdupois to metric are:
- 1 pound = 453.592 grams.
- 1 ounce = 28.35 grams.

An interesting fact about the avoirdupois system of weights

It might be puzzling to some why the standard English measurement system has a French name. The reason for this is simple: At the time this approach was adopted, the language spoken by the English court was French, and because this was an official weighing system governing legal commerce, it followed that French was appropriate.

Household measurements

Household measurements, often a mixture of other measuring approaches, are often used in homes, particularly in kitchens. Some common household volume measurement units include the teaspoon, tablespoon, cup, pint, quart and gallon. Weights are typically counted as ounces and pounds.

As might be expected, these measuring approaches lack the precision and accuracy afforded by more standardized, scientific methods. Nonetheless, household measurements are common in pharmacy practice because patients lack familiarity with other approaches. In fact, prescription directions often use household measures, such as teaspoons. As such, pharmacy technicians must have a working knowledge of these methods and be able to interconvert.

Common household measurements and their equivalents are listed below:
- 3 teaspoons = 1 tablespoon.
- 2 tablespoons = 1 fluid ounce.
- 8 fluid ounces = 1 cup.
- 2 cups = 1 pint.
- 2 pints = 1 quart.
- 4 quarts = 1 gallon.
- 16 ounces = 1 pound.

Because of the inaccuracy of household measuring systems, it may make sense to convert household measurements to the metric system. This is especially important when entering information into a pharmacy computer system.

Household/metric conversions are described below:
- 1 teaspoon = 5 milliliters.
- 1 tablespoon = 15 milliliters.
- 1 fluid ounce = 30 milliliters.
- 1 cup = 240 milliliters.
- 1 pint = 480 milliliters.
- 1 quart = 960 milliliters.
- 1 gallon = 3,840 milliliters.
- 1 ounce = 30 grams.
- 1 pound = 454 grams.
- 2.2 pounds = 1 kilogram.

It is critical to note that the fluid ounce used in household measurement is the same fluid ounce used to measure volume in the apothecary system. Nonetheless, care should be taken when dealing with weights because there are 12 ounces in the apothecary pound and 16 ounces in a household pound. Typically, when people think of pounds, they are thinking of the 16-ounce household or avoirdupois pound.

The metric system

Multiple systems of measurement were common in traditional pharmacy practice. In 1799, a new system was adopted in France, designed to avoid many of the problems inherent to traditional systems. This new method of measurement was called the metric system.

The metric system quickly gained popularity and was adopted by a number of countries. Currently, only two countries in the world do not use the metric system as their official method of measurement. The United States is one of those two.

The metric system is composed of seven base units designed to describe various units of measurement. These base units and what they describe are:
- Meter (m) – length.
- Kilogram (kg) – mass (commonly used to describe weight).
- Kelvin (K) – temperature.
- Second (s) – Time.
- Ampere (A) – electrical current.
- Candela (cd) – luminous intensity.
- Mole (mol.) – amount of a substance.
A number of metric units can be easily defined in terms of the meter or kilogram, and these are the most common units of measurement that will be encountered by the pharmacy technician. Multiples of metric units are all related by the power of 10, which allows a conversion between units by simply shifting the decimal point. For example, while a kilogram is equal to 1,000 grams, a gram is equal to one-thousandth of a kilogram, or 0.001 kg.11 A series of prefixes are used to describe numbers larger or smaller than the base unit. These prefixes are:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tera</td>
<td>T</td>
<td>10^12</td>
<td>1 trillion</td>
</tr>
<tr>
<td>Giga</td>
<td>G</td>
<td>10^9</td>
<td>1 billion</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>10^6</td>
<td>1 million</td>
</tr>
<tr>
<td>Kilo</td>
<td>k</td>
<td>10^3</td>
<td>1,000</td>
</tr>
<tr>
<td>Hecto</td>
<td>h</td>
<td>10^2</td>
<td>100</td>
</tr>
<tr>
<td>Deci</td>
<td>d</td>
<td>10^-1</td>
<td>one-tenth</td>
</tr>
<tr>
<td>Centi</td>
<td>c</td>
<td>10^-2</td>
<td>one-hundredth</td>
</tr>
<tr>
<td>Milli</td>
<td>m</td>
<td>10^-3</td>
<td>one-thousandth</td>
</tr>
<tr>
<td>Micro</td>
<td>µ</td>
<td>10^-6</td>
<td>one-millionth</td>
</tr>
<tr>
<td>Nano</td>
<td>n</td>
<td>10^-9</td>
<td>one-billionth</td>
</tr>
<tr>
<td>Pico</td>
<td>p</td>
<td>10^-12</td>
<td>one-trillionth</td>
</tr>
</tbody>
</table>

The British Pharmacopeia has pushed for the pharmaceutical and medical professions to exclusively use the metric system since 1914. In 1944, a British physician publicly advocated a shift to the use of the metric system in medicine and pharmacy. This concept was well-embraced, and subsequent to this, all articles published in the British Medical Journal made use of metric equivalents for measurements.

International System of Units (abbreviated SI from the French Le Système International d'Unités)

At the time of the French Revolution, the decimal-based metric system was created. Subsequent to that, platinum standards representing the meter and the kilogram were deposited on June 22, 1799, in the Archives de la République in Paris. This was recognized as the initial step in the development of what is now known as the International System of Units (SI).

By 1832, Carl Friedrich Gauss, a German mathematician and physicist, began to strongly promote the application of SI units as a comprehensive and clear system of units and a set of prefixes to describe the physical sciences. Gauss was the first scientist to make absolute measurements of the earth’s magnetic force in a decimal system based on three basic units: millimeter, gram and second, representing the quantities of length, mass and time, respectively.

A kilogram had been defined as the mass of a cubic decimetre (one liter) of water. As described above, the international prototype of the kilogram was made of platinum and declared to be, from that time forward, the official unit of mass. It should be noted that although in common parlance, kilograms are used to refer to weight, in 1901, it was clarified that the kilogram is a unit of mass. (Mass measures the amount of a substance, while weight measures the gravitational pull of that substance.) It is critical to have a unit of measure that can be used to specify the amounts present of chemical elements or compounds. In 1971, the term “mole” was defined as the amount of any substance that contains the same number of particles as there are atoms of carbon in 0.012 kilograms (12 grams) of carbon. In the same declaration, it was determined that when the term mole is used, the particles being defined must be stated: atoms, molecules, ions, electrons or another sort of particle.

In a 1953 article, Nixon and Whittet suggested that the mixture of measurement systems then in place could lead to cases of confusion and serious errors. As a result of this, they concluded that there is little excuse for practicing pharmacies to use traditional units of measurement.13

When first steps were made to implement the use of the metric system, the main objection to its use was the fear of a misplaced decimal point, which could lead to a massive over- or under-dosage of medication. Proponents of the metric system countered that this could be avoided simply by using the proper prefixes, e.g., milli, kilo, and so on.13

Much of current pharmacy practice in the U.S. is guided by the United States Pharmacopeia (USP). USP 33-NF 28 states that “in general, weights and measures are expressed in the International System of Units” (SI: the metric system). USP also states that prescriptions shall be written to state the quantity and/or strength desired, using metric units, unless another approach is specified in the product monograph. Even in cases where a non-metric amount is prescribed, a metric-equivalent of that amount should be dispensed. Metric units are the only designations that should be used on product labels and labeling.14

From a practical perspective, there are a few guidelines to keep in mind when using the metric system for pharmacy measurements: In cases where less than a full unit is being described, it is critical to use a leading zero (0.5 milligrams, versus .5 milligrams). This helps to avoid overlooking the placement of the decimal point, which could lead to a ten-fold error (5 milligrams rather than the intended 0.5 milligrams). Conversely, trailing zeroes should also be avoided because 10.0 milliliters could easily be misinterpreted as 100 milliliters. Before any computations can be performed, all units must be converted to the same denomination. For example, to add 0.2 grams to 250 milligrams, the former quantity, 0.2 grams, should be converted to 200 milligrams.15

Photograph of an international kilogram prototype made of platinum 17

The SI unit for temperature was adopted in 1990, and is kelvin (K), which, by definition, is the point in degrees Celsius when all atomic motion ceases. To put this number into perspective, note that the freezing point of water, 0 degrees Celsius, is 273.15 K. The magnitude of degrees K and Celsius are identical.20
Milliequivalents and millimoles

**Millimoles:** While the SI unit for quantities of a substance is mole, this is a very large amount of material (remember, equivalent to the number of atoms in a 12-gram sample of carbon), and not really relevant to the quantities of substances used in the pharmacy. As a result, the term millimole, which is 1/1,000 of a mole (0.001 mole) is a more reasonable descriptor. To describe the concentration of a substance in solution, the term millimolar (mM) is often used. A 1 mM solution is, by definition, a solution containing 1 millimole of a substance dissolved in a liter of liquid.

**Milliequivalents:** While the millimole is used to describe the number of particles present in a sample, the situation can be complicated when electrolytes in solution require description. The actual chemical activity of an electrolyte solution is a feature of the type of electrolyte present. To make this determination, it is necessary to know the valence of the electrolyte.

### Temperature

The U.S. Food and Drug Administration has issued a number of regulations, and several professional organizations have developed guidelines designed to ensure that temperature-controlled prescription drug products are properly maintained from the manufacturer to the wholesaler, to the pharmacy, to the patients. This is an ideal opportunity for pharmacy technicians to help ensure that temperature-sensitive drug products are properly maintained from the manufacturer to the pharmacy, to the patients. It is critical that the practicing pharmacy technician is familiar with both measurement approaches and is easily able to convert back and forth, as warranted by the situation. Target temperature ranges may be stated in degrees Fahrenheit and also in degrees Celsius. As such, it is critical that the practicing pharmacy technician is familiar with both measurement approaches and is easily able to convert back and forth, as warranted by the situation.

While the details of temperature control may vary from jurisdiction to jurisdiction, all drug products have some guidelines for storage temperature, whether it is storage at ambient temperature, refrigerated or frozen.

In addition to describing drug product storage conditions, critical patient data could also include their body temperature. Depending on the practice setting, pharmacy technicians may find themselves in a position of needing to interpret this information.

Target temperature ranges may be stated in degrees Fahrenheit and also in degrees Celsius. As such, it is critical that the practicing pharmacy technician is familiar with both measurement approaches and is easily able to convert back and forth, as warranted by the situation.

The following formula can be used to convert from degrees Fahrenheit to degrees Celsius:

\[
\text{Degrees Celsius} = \frac{5}{9} (\text{Degrees Fahrenheit} - 32)
\]

To convert degrees Celsius to degrees Fahrenheit, the following formula can be used:

\[
\text{Degrees Fahrenheit} = \frac{9}{5} \times \text{Degrees Celsius} + 32
\]

To use SI terminology (degrees kelvin – K), simply add 273.15 to the temperature in degrees Celsius:

\[
\text{Degrees Kelvin} = \text{degrees Celsius} + 273.15
\]

**NOTE:** LOWERCASE kelvin. – cm

#### Practical examples

1. A prescription is written for 250 grams of morphine sulphate powder. As an astute pharmacy technician, you realize that while this is likely not the best way to describe a prescription, it can easily be converted to the metric system to be consistent with your pharmacy record-keeping system. To make this conversion, you know that 1 gram is one-half of a grain. A grain of morphine sulphate is the same as 64.8 milligrams, so ½ of a grain must be 32.4 milligrams of morphine sulphate:

\[
\frac{1}{2} \text{ grain} = \frac{1 \text{ grain}}{64.8 \text{ milligrams}} = 32.4 \text{ milligrams}
\]

2. You receive a prescription calling for the patient to receive 3/4 per dose, of a cough suppressant. Although it is likely best to express this dosage using the metric system for your pharmacy's database, you are a practical pharmacy technician, and realize that the patient will be measuring the dosage at home. As such, patient directions using the household measuring system may be most appropriate. This will require a series of multiple conversions:

\[
1 \text{ ounce} = \frac{about \ 30 \text{ milliliters}}{ounce} = \frac{1 \text{ teaspoon}}{5 \text{ milliliter}} = \frac{6 \text{ teaspoons}}{3 \text{ teaspoons}}
\]

3. One day while putting together the monthly order for compounding excipients, you come across a note from the pharmacist in charge requesting that you order a pound of magnesium sulphate for use in improving powder flow properties. Because the catalog you are using lists quantities using the metric system, you realize that you will need to convert the mass of magnesium sulphate to grams. You have just finished reviewing the apothecary as well as the avoirdupois systems of measurement though, and you are puzzled. Which system was the pharmacist thinking about when she made the order?

   - Apothecary: 1 troy pound = 373 grams.
   - Avoirdupois: 1 pound = 453.592 grams.

   You write a note to the pharmacist to clarify her intentions.

4. The pharmacist on duty has asked you to help put together a traditional herbal remedy for the treatment of cirrhosis of the liver that requires one scruple of *Bupleurum* species (a traditional Chinese herb used to treat inflammatory diseases). The only instrument that you have to weigh the powder substance is a metric, Class A prescription balance. Sadly, you are not up to date on all of your pharmacy technician colleagues has just finished studying for her pharmacy technician certification exam, and tells you what you need to know to make the conversion: 1 scruple = 1.296 grams.

5. A patient comes to the pharmacy counter and states that he has just returned from the doctor, who told him he should take a grain of aspirin per day to prevent cardiovascular incidents. Needless to say, the patient has no idea what a “grain of aspirin” is and does not know what to purchase. You know that a grain is almost 65 mg. Although you are not aware of a dosage form of aspirin that contains exactly that dose, you do know that an 81 mg dose of aspirin would be close to what the doctor ordered.

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**Some common electrolytes used in pharmacy practice and their valences are listed below:**

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Valence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (Na+)</td>
<td>1</td>
</tr>
<tr>
<td>Potassium (K+)</td>
<td>1</td>
</tr>
<tr>
<td>Calcium (Ca++)</td>
<td>2</td>
</tr>
<tr>
<td>Magnesium (Mg++)</td>
<td>2</td>
</tr>
</tbody>
</table>

The valence of the electrolyte determines the ionic charge, and thus the relative activity of the molecule. For example, a millimolar solution of sodium (valence/ionic charge of 1), would have one-half the activity of a millimolar solution of magnesium (valence/ionic charge of 2).
6. A patient presents a prescription for 100 milliliters of cough syrup. The product is stored in a 500 milliliter stock bottle, so you will need to procure an amber prescription bottle into which the prescribed amount of syrup can be measured. Looking through the supply cabinet, you encounter bottles labelled $\text{iv}$, $\text{iii}$ and $\text{ii}$. You are puzzled by these notations, and have no idea which bottle to select. These symbols look familiar, but you are confused with a similar symbol. After you go back and look at your notes describing apothecary measurement symbols (and the use of them with Roman numerals), you realize that these bottles have a capacity of 4, 3 and 2 ounces, respectively. A quick conversion to the metric system:

\[
1 \text{ fluid ounce} = 29.6 \text{ milliliters}
\]

tells you that if you use the $\text{iv}$ bottle, it will hold nearly 120 mL, ample to contain all of the medication called for in the prescription.

7. When working through a stack of prescriptions, you encounter an order calling for $\text{ii}$ of cholestyramine to be taken orally three times per day before meals. Although you have filled prescriptions for cholestyramine previously, you have never seen the dose described in this way. While the apothecary symbol looks familiar, you ask the pharmacist on duty for help confirming the prescription. She looks puzzled as well, but upon checking a reference book is able to determine the proper quantity. The symbol “$\text{ii}$” denotes drams using the apothecary method of measurement. The Roman numeral “$\text{ii}$” describes the fact that two drams should be dispensed. An apothecary/metric conversion table tells you that:

\[
1 \text{ dram} = 3.89 \text{ grams}
\]

With this knowledge, it is with confidence that you develop a prescription label directing the patient to take 8 grams of cholestyramine (2 scoops), three times daily, before meals (7.78 grams can be rounded to 8 grams for ease of measurement).

8. A mother has presented to you a prescription for amoxicillin suspension for her young child, who has an ear infection. The prescription is written to provide a two-teaspoon dose, twice daily for a total of 10 days. While you realize that it is likely good that the volume is stated in terms of teaspoons for the benefit of the mother measuring the dose, you will need to convert to the metric system for entering into the pharmacy computer system. Your keen knowledge of household measures makes this an easy task:

\[
1 \text{ teaspoon} = 5 \text{ milliliters}, \text{ so } 2 \text{ teaspoons} = 10 \text{ milliliters}.
\]

Since the medication will be taken twice daily, 20 milliliters per day will be required for 10 days, dictating a total quantity dispensed of 200 milliliters.

9. When reviewing a patient chart before dispensing a chemotherapeutic agent, you note that the patient has recorded an oral temperature of 99.0 degrees F. Pharmacy standard operating procedures require that before dispensing the medication, the pharmacy technician document the patient’s temperature and confirm that it is less than 38 degrees C. A quick conversion, using the formula:

\[
\text{Degrees Celsius} = \frac{5}{9} \times (\text{Degrees Fahrenheit} - 32)
\]

tells you that this patient has an oral temperature of 37.2 degrees C, which is an acceptable temperature for receiving his scheduled round of chemotherapy. You document this temperature and begin preparing the chemotherapy admixture.

10. An elderly patient comes to the pharmacy counter with a prescription for Colyte® to be used in preparation for a colonoscopy. The directions on the label say to dissolve the entire contents of the container in 3.84 liters of drinking water. The patient is confused because he never learned about the metric system in school. You quickly respond that he needs to dissolve the contents of the medication in a gallon of water. You know this because of the simple relationship:

\[
1 \text{ gallon} = 3,840 \text{ milliliters} = 3.84 \text{ liters}.
\]

11. One evening while working in the main hospital pharmacy, you receive a call from the pediatric unit stating that it needs a bag of unfractionated heparin prepared, designed to deliver 25 international units (IU)/kg/hour for an eight-hour period. The patient weighs 44 pounds. How many units of heparin should be injected into the IV bag?

This question has two parts:

a. 44 pounds must be converted to kilograms:

\[
44 \text{ pounds} = \frac{1 \text{ kilogram}}{2.2 \text{ pounds}} = 20 \text{ kilograms}
\]

b. The total IU to be injected = 25 IU x 20 kilograms x 8 hours = 4,000 IU

12. When reviewing clinical laboratory values in a liver disease patient, you note that the patient’s most recent ALT level was recorded as 110 international units (IU)/liter. Although this is the SI units for this laboratory value, your pharmacy standard operating procedure requires that you record the lab value using IU/deciliter. This conversion is easy for you to make because you are fully aware that a deciliter is equal to 100 milliliters, or 0.1 liter, making this value equal to 11 IU/deciliter.

13. When processing prescriptions, you run across an order for .5 milligrams of clonazepam, to be taken orally, as needed for anxiety. Based on your knowledge of the use of decimal notation in preparing prescriptions, a warning alarm goes off in your head, prompting you to contact the prescriber to verify the strength of the medication being filled. The problem here is the lack of a leading zero in the prescription strength. When written as .5, rather than 0.5, it is not totally clear, and could be confused with a 5 mg dose. You were correct to verify the dosage with the prescriber.

14. In a patient being treated for hypomagnesemia, you are required to review the patient’s serum magnesium levels before dispensing the medication. Upon observation, you see that the patient’s most recent magnesium level was 2 mEq/L. Out of curiosity, you decide that you would like to determine the milimolarity of magnesium in that patient. The first step is to determine that the valence of magnesium is 2. This means that for every millimole of magnesium, a total of 2 milliequivalents will be appreciated. Since the patient has a magnesium level of 2 mEq/L, it can be ascertained that their serum’s concentration of magnesium is 1 millimoles/liter, or 1 millimolar (mM).

15. Your pharmacy standard operating procedure states that the refrigerator must be constantly maintained in a temperature range of 5-10 degrees C. Here is the problem: The only properly calibrated thermometer in your pharmacy reads the temperature in degrees Fahrenheit. What can you do to remedy this problem? The easiest approach is to simply convert the acceptable temperature range to Fahrenheit using the formula:

\[
\text{Degrees Fahrenheit} = \text{Degrees Celsius} \times \frac{5}{9} + 32
\]

Using this formula, you can determine that the acceptable temperature range is 34.8 degrees F - 37.6 degrees F, which can easily be monitored using the available thermometer.
3. Which of the following statements about liquid measurements is FALSE?
   a. Erlenmeyer flasks are ideal for measuring liquid prescription volumes.
   b. They are the simplest measurements made in the pharmacy and are, at the same time, the most susceptible to error.
   c. The inscription TD means to “to document.”
   d. Measuring liquids is the most difficult measurement for pharmacy technicians.

4. Which of the following statements about household measurements is TRUE?
   a. Household measurements are the best way to document drug usage in most pharmacy computer systems.
   b. Household measuring systems are some of the most scientifically rigorous approaches available to pharmacy technicians.
   c. The most common household measurement unit is the kilogram.
   d. Household measurements are common in pharmacy practice because patients lack familiarity with other approaches.

5. When thinking about temperature and how it relates to pharmacy practice, which of the following is FALSE?
   a. Most drug products can be stored at whatever temperature is convenient.
   b. The U.S. Food and Drug Administration has issued a number of regulations designed to ensure that temperature-controlled prescription drug products are properly maintained.
   c. Target temperature ranges may be stated in degrees Fahrenheit and also in degrees Celsius.
   d. Temperature control standards may vary from jurisdiction to jurisdiction.