1.3 Principles of Weighing and Measuring

GOAL *To present calculations needed to ensure precision when quantities of drugs are measured and discuss the theory underlying these calculations.*

OBJECTIVES

This chapter equips students to:

- Define the sensitivity requirement and least weighable quantity (LWQ) of a Class A prescription balance
- Explain the percentage of error allowed when quantities of drugs are measured
- Calculate the actual percentage of error resulting given the sensitivity requirement of a balance and the quantity to be weighed
- Calculate the percentage of error when a more sensitive device is used to measure the same product given a weight or volume needed
- Calculate the least weighable quantity for a balance when given the instrument's sensitivity requirement and percentage of error
- Determine the smallest measurable quantity for a graduated cylinder based on its capacity
- Define an aliquot
- Demonstrate the aliquot method for measuring solid–solid, solid–liquid, and liquid–liquid preparations

KEYWORDS

Accuracy
Aliquot
Least weighable quantity (minimum measurable quantity)
Percentage of error
Precision
Prescription balance
Sensitivity requirement (SR)

Importance for Medical Math and Clinical Practice

It is easiest to explain the concepts of weighing and measuring using examples of drug product preparation. This chapter is heavily weighted with these examples. There are also important applications—especially the method of aliquots—in dosing drugs to patients in a clinical setting. This will become clearer in later chapters where not only preparing a dose but also administering the dose to patients will be the subject of medical math calculations. Note that these principles become most important when small doses of possibly very toxic drugs must be precisely measured and administered frequently or continuously to very ill patients. Please see the Summary to begin the transition from the preparation of drug doses to the administration of drug doses.

Weighing and measuring is all about precision and accuracy. The pharmacist must always calculate the most exact arithmetic answer possible for a problem. However, if the problem requires the preparation of a drug product, the most exact arithmetic answer does not translate into a finished product with the correct composition unless the equipment used introduces little error during the weighing or measurement of each ingredient. This means scales (balances) and graduated cylinders must be accurate and capable of being used in a way to ensure precision with repeated measurement. *Accuracy* means the amount of material indicated by the particular device used is exactly that amount required by national standards. *Precision* means that repeated samples weighed or measured by a device would all be exactly the same amount. This is often illustrated by a bullseye target. A group of shots scattered all over the target would represent neither accuracy nor precision. A group of shots very close together but not on the exact center of the target would represent good precision but poor accuracy. A group of shots very close together and on the exact center of the target would represent both good accuracy and precision. Of course, humans make errors using measuring devices, but the device must be constructed to minimize error when used by an individual with good measurement skills.

Even the finest weighing and measuring devices have some error. There are two types of balances used to weigh drugs. The *class A torsion balance* is one used less often by most practicing pharmacists. The *electronic balance* is the one used most often in current pharmacy practice. However, the principles discussed below are the same regardless of whether the twisting of a metal ribbon (class A torsion) or the current change through a load cell (electronic) is the actual response to the stress of weight placed on the balance. For measuring volumes of liquids, a graduated cylinder is used. A cone-shaped (conical) graduate should be avoided because it is more difficult to read a volume accurately with this type of graduate. The size of a graduated cylinder should be selected so that the volume to be measured is more than 20% of its capacity. The logic behind this 20% rule is similar to that discussed below for balances except, that instead of viewing a pointer on a balance, the accuracy of the user's eye in measuring the first milliliters of volume filling the graduate are the issue. Error greater than 5% in the measured volume is avoided by following the rule.

KEY CONCEPT

Common sizes of graduated cylinders are 10, 30, 50, 100, and 250 mL.

The torsion balance responds to weight placed on it by moving a small pointer across a series of equally-spaced lines on an indicator plate. It's known, based on the engineering standard to which the balance is built, that a 6-mg weight placed on the balance will move the pointer exactly the distance between two index lines (see Figure I.3-1).

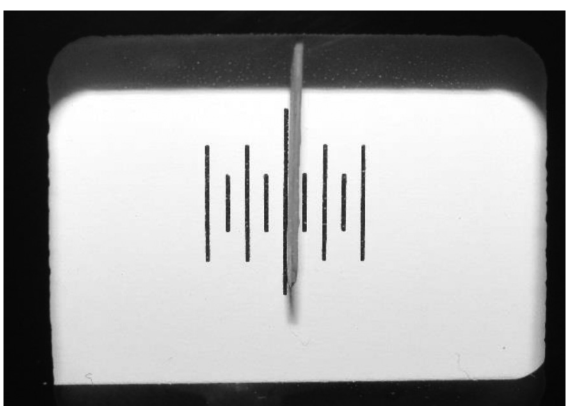

Figure I.3-1 Torsion balance.