

**Basic Skills for Chemistry**  
**CHEM-1020**  
**Experiment No. 1**  
**Introduction to Measurements and Basic Laboratory Techniques**

**Introduction:** In chemistry, as in all the sciences, quantitative measurements are of extreme importance. You must be able to use measuring instruments properly to get reliable experimental information. In this experiment, you will learn how to use several common laboratory instruments and then learn how to interpret the data they provide.

**Data and Measurements:** All data taken in this course must be recorded in black ink, exactly as read, directly onto a data sheet. Never record data on scraps of paper for copying onto a data sheet later. If you wish to disregard a measurement or repeat it, never erase or obliterate it. Simply draw a line through the written measurement and take the reading again. For full credit, data sheets for all experiments must be stapled to the back of each report.

All measurements consist of a number and the measurement units. You may not say that something is 3.75 long without specifying whether you mean m, cm, mm, etc. Stating 35 degrees is meaningless unless you specify °F, °C or degrees of a circle. Get into the habit immediately of writing units for every measurement.

Every measurement made, whether analog or digital, no matter how precise it may be, is always an approximation. For the purposes of this course, we assume that any measurement is uncertain to plus or minus one in its last digit. Because the last digit is uncertain, one can never know the exact value of any measured quantity. For instance, a measurement of 2.34 cm means that the length of the object measured is somewhere between 2.33 cm and 2.35 cm. How precisely a measurement can be made depends on the quality of the instrument and the size of its smallest divisions. You will learn in this experiment that the last digit of any analog measurement is an approximation, determined by estimating between the smallest divisions on an instrument scale.

**Measurement of Length:** The principles explained here for measuring length also apply to most of the other measured quantities you will encounter in chemistry such as volume, mass and temperature.

Your instructor will demonstrate the use of a centimeter ruler and review the following measuring guidelines. The typical centimeter ruler has *numbered* intervals 1 cm apart (the width of your little fingernail). Between each numbered 1 cm mark are ten smaller unmarked intervals, 0.1 cm apart. Imagine that the 0.1 cm intervals are then divided into ten additional intervals 0.10 cm apart. The centimeter ruler is properly read to 0.01 cm by estimating between the smallest divisions. It is important to recognize that the last significant digit in any measurement is gotten by this estimation process. Even though it is determined by estimation, the last digit is counted as a significant digit.

**Determination of Solid Volumes:** Volumes can be measured in several ways depending on the physical state of the substance being measured and the purpose of the measurement. The volume of a regular solid can be determined by measuring the dimensions of the solid and inserting the measurements into the appropriate formula. For instance, the volume of a rectangular solid having length 8.03 cm, width 9.51 cm and height 7.00 cm is calculated from the rectangular solid volume formula as follows:

$$V = L \cdot W \cdot H = 8.03 \text{ cm} \cdot 9.51 \text{ cm} \cdot 7.00 \text{ cm} = 535 \text{ cm}^3$$

Volumes of irregular solids are often measured by water displacement, using Archimedes' principle, which states that a solid object displaces a liquid volume equal to that of the object's volume.

**Measurement of Liquid Volumes:** Liquid volumes are usually measured directly by pouring the liquid into a graduated cylinder. Graduated cylinders range in size from 10 mL to 2000 mL. For the highest precision, it is best to use the smallest graduate that holds the amount of liquid to be measured. After liquid is poured into a graduated cylinder, it is set on a flat surface at eye level. The volume is correctly read at the *bottom* of the meniscus (the curved air-liquid interface). Your instructor will demonstrate this technique and show you how to highlight or backlight the meniscus for better visibility. The precision to which a graduate is read is determined the same way as for metric rulers and most other instruments. The first step is to determine what units the instrument is designed to read, in this case, mL. Next, the smallest division is identified and then the instrument is usually read to one-tenth of that amount. For example, a graduate whose smallest division is 0.1 mL is read to 0.01 mL. If the smallest division is 10 mL, the graduate is read to the nearest 1 mL. A graduate with markings 0.2 mL apart is best read to the nearest 0.02 mL. (Some graduates have 0.5 mL or 5 mL as their smallest divisions. Those graduates are best read to one-fifth of the smallest division, or to 0.1 mL and 1 mL, respectively.)

**Measurement of Mass:** Masses can be measured on several types of laboratory balances. Electronic balances are easy to learn and will be utilized later in this course. First you will learn the principles of weighing on two types of mechanical balances, referred to here as the high form balance or hanging pan balance and the platform or low form balance. The operating principle of a mechanical balances is easy to understand. A mass to be determined is placed on a pan or platform and balanced against a set of known masses on the other side of the balance beam fulcrum. Masses determined by a balance are not affected by variations in gravity because gravity acts the same on both sides of the balance beam.

A single, clean object may be placed directly on a balance pan and weighed as long as the balance has first been zeroed in. Zeroing in means the balance is adjusted so it registers zero mass with nothing in the pan. Chemical, whether solid or liquid, must *never* be placed in a balance pan. There are two methods discussed here for weighing chemicals in a container and making allowances for the container mass. In both methods, there is no need to zero in the balance because any error in the zero setting will be cancelled out by the subtraction of one mass from another.

In the first method, known as direct weighing, the container receiving the chemical is weighed first. Then the balance beam masses are advanced by the desired amount, which is written down, and the chemical is added to the container until the instrument is in balance again. The amount added is the difference between the two measurements.

In the weighing by difference method a container supplying the chemical is weighed first. Then the desired amount of chemical is removed from the supply container, placed in a receiving container and the container is weighed again. The amount removed is the difference between the two supply container weighings.

## **EXPERIMENTAL:**

**Measurement of Length:** Examine a wooden or metal centimeter ruler.

- a) On the data sheet, record the units, the smallest division on the ruler and the precision to which the ruler must be read.
- b) After you have determined how the ruler is to be used, obtain a wood or metal block and measure its height, length and width. Make sure your measurement precisions agree with the way you decided the ruler is to be read. For your report, calculate the volume of the solid.

**Measurement of Liquid Volumes:**

- a) Examine a 10 mL, a 25 (or 50 mL), a 100 mL, a 500 mL and a 1000 mL graduated cylinder. Record the smallest division and the precision to which each should be read.
- b) Use the information from part a) to measure the volume of water contained by a small (10 cm) test tube, a large (25 cm) test tube, a 400 mL beaker, and a Florence flask.

**Measurement of Mass:**

- a) Record the smallest scale division on the low form (platform) balance and on the high form (hanging pan) balance and determine how each balance is to be read.
- b) Obtain an unknown mass, a numbered metal slug. Record the number of the slug, remove the slug from its envelope, zero in a hanging pan balance and determine the mass of the slug. If you are unsure of your weighing technique, weigh some other object such as a small beaker and have your instructor check your result.
- c) Weigh a medium (15 cm) test tube on the low-form balance. Advance the balance beam rider exactly 1.00 g and add some common table salt until the balance beam balances again. Cork the test tube and attach an adhesive label with your name, course and section number and the letter c. Turn the test tube in to your instructor for grading.
- d) Fill a 50 mL beaker no more than one-quarter full of salt and weigh it on the high-form balance. Transfer about one gram (anywhere between 0.8 g and 1.2 g will do) of the salt to another test tube and reweigh the beaker. Cork the test tube, attach a label with your name, course and section number and the letter d. Turn in this test tube for grading.

Note that for parts b) and c) it is not necessary, and in fact is a waste of time, to zero in the balances.

You will be graded on how well you follow directions and on the accuracy of your weighings.

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**Measurement of Length**

a) Smallest division on the centimeter ruler\_\_\_\_\_

Precision to which the ruler must be read\_\_\_\_\_

b) Rectangular Solid

Rectangular solid height\_\_\_\_\_

Rectangular solid width\_\_\_\_\_

Rectangular solid length\_\_\_\_\_

**Preparing to Measure Liquid Volumes:**

a) **Graduated Cylinder Measurement Precision**

Size of Graduated Cylinder	Size of smallest division	Precision of Reading
10 mL		
25 or 50 mL		
100 mL		
500 mL		
1000 mL		

b) **Measuring Specific Liquid Volumes**

Type of Glassware Used	Size of Graduated Cylinder Used	Measured Liquid Volume
Small Test tube		
Large Test tube		
400 mL Beaker		
Florence Flask		

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**Measurement of Mass:**

**a) How to Read the Balances:**

Smallest scale division on the low form (platform) balance: \_\_\_\_\_

The low form balance is read to: \_\_\_\_\_

Smallest scale division on the high form (hanging pan) balance: \_\_\_\_\_

The high form balance is read to: \_\_\_\_\_

**b) Mass of Unknown Metal Slug**

Unknown Mass Number: \_\_\_\_\_

Measured Mass of Metal Slug on the High Form Balance: \_\_\_\_\_

**c) Salt Sample Weighed on the Low-Form Balance**

Mass of test tube with added salt sample: \_\_\_\_\_

Mass of empty test tube: \_\_\_\_\_

Mass of salt handed in: \_\_\_\_\_

**d) Salt Sample Weighed on the High-form Balance**

Mass of beaker and salt: \_\_\_\_\_

Mass of beaker and salt after sample removal: \_\_\_\_\_

Mass of salt handed in: \_\_\_\_\_

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**Report for Introduction to Measurements and Basic Laboratory Techniques**

- 1) Calculate the volume of your wooden block. Show the formula and setup and express your answer with the correct units and number of significant figures. (4 points)
- 2) What volume of water is contained in each of the four pieces of glassware? (4 points)
- a) The small test tube
  - b) The large test tube
  - c) The 400 mL beaker
  - d) The Florence flask
- 3) What is the number of your unknown metal slug? \_\_\_\_\_ (4 points)  
What is the mass of your metal slug?
- 4) What is the mass of the salt sample c) you handed in? (4 points)
- 5) What is the mass of the salt sample d) you handed in? (4 points)