Laboratory Techniques

Introduction

In the U.S., the ***English or Imperial system of measurement*** is commonly used. (*But it is **not** used in ~99% of the world's nations including England.)* A 1975 U.S. law, *The Metric Conversion Act*, adopted metric values as the preferred system in the U.S., but only for trade and commerce. It permitted the use of United States customary units in non-business activities. What legally constitutes trade and commerce, and what is a non-business activity is still being debated. For example, a car's fuel efficiency is reported in *miles per gallon*; a person's height is given in *feet* and *inches*; ice cream is sold by the *cup*, *pint* or *gallon*; weight is measured in *pounds*; and temperature is reported in *degrees Fahrenheit*. However, most people cannot even remember the conversions for the English system (e.g. one mile equals 5280 feet or 1760 yards). A football field is 100 *yards* from goal line to goal line.

In contrast, the ***metric system***, which is used outside of the U.S., is a decimal system of measurement used by ~99% of the world's nations. It is a system where base units are used in conjunction with prefixes to represent multiples or fractions of 10. Because of its logic and simplicity, the metric system gained international acceptance with the *Treaty of the Meter*, establishing the International Bureau of Weights and Measures. Even the United States signed the treaty in 1875, but to date the U.S.'s use of the metric system is highly limited eg. 2-liter bottles for soda, cc's (cubic centimeters) in hospitals plus a few other applications. In science, the metric system is used almost exclusively, so equipment and instruments in chemistry and science labs generally measure centimeters, millimeters, milliliters, grams, etc.

Techniques

In this experiment, you will learn how to safely use a basic variety of chemistry laboratory equipment and instruments and take measurements. You will use a ***balance*** and determine by ***mass by difference*** of various samples. You will use a "***ruler"*** to measure dimensions that are straight lines (length and diameter of a cylinder, and the diameter of a marble). You will use an analog Celsius ***thermometer*** to determine the boiling point of a liquid. You will use a ***graduated cylinder*** to determine the volume of a liquid, and the volume of solids by their displacement of a volume of water. You will also use a ***Bunsen burner*** to produce a "hot" or roaring flame to boil water as well as producing a "cool" (but NOT luminous) flame. You will also measure the temperature of unknown liquids using a thermometer.

One important goal of this experiment is to record measurements correctly which will depend on the analog scale or digital read out of the measurement tool that is used, to the correct number of decimal places. Determining and recording these values is most important since it reflects the limit of the accuracy of each piece of equipment or instrument used.

Mass: *Weighing with a Balance*

Balances are used to determine the mass of a sample. The metric unit of mass is the gram. Electronic balances can be expensive and very sensitive. They are very easy to use, but must be used carefully to avoid damage. **The most important rule is *NEVER place any chemical directly on the balance pan*. Use a beaker, a watch glass, a weighing cup, or weighing paper to avoid contaminating the balance.**

There are several types of electronic balances, and each measures with a different degree of accuracy:

- An **analytical balance** measures with an **accuracy of ±0.0001 g.**
- A **milligram balance** measures with an **accuracy of ±0.001 g.**
- A **centigram balance** measures with an **accuracy of ±0.01 g.**

The more decimal places that a balance provides the more sensitive and expensive the balance. The balance type determines how a weight (mass value) is reported and the number of significant figures in the value.

The general procedure for using a centigram balance follows:

View: https://www.youtube.com/watch?v=QtnPiKSKKtI
https://www.youtube.com/watch?v=KlvnYVjwjEU

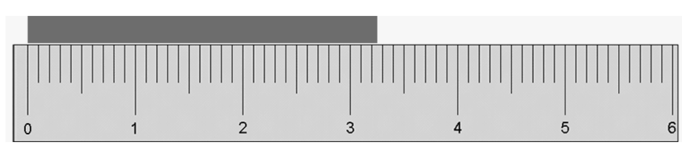
Centigram Balance

- Chemical Material to be weighed should be placed in a container on the balance pan. The container may be either pre-weighed or "tared" (as explained below).
- To weigh an object, carefully place the item on the center of the pan. Close the door and wait for the digital readout to stabilize. Read and record all the numbers in the digital readout. (***Never round any numbers reported on any electronic instrument.***) Remove the item.
- When using a container to hold chemicals, you may ***tare*** the container as follows. Place the empty container without chemical in the center of the pan. Briefly click on the front lever to zero the balance. The container is now "**tared out**", and the balance is set to read the weight of any material added to the container. Remove the container from the balance, add chemical material to it, and carefully place the container back on the center of the pan. (Do NOT re-zero the balance during this process.) Read the digital scale when stabilized as before.

Rulers: The basic metric unit of length is the meter, but the length of most objects in a chemistry lab are measured in ***centimeters*** (**cm**). A centimeter equals *0.01m or 1/10 of a meter*, so ***1m*** = ***100cm***—just like 1 dollar = 100 cents (since one cent is equal to *1/100* of a dollar).

When a measurement is taken with an analog device like a ruler, the measurement is always recorded to one more decimal place than the smallest markings on the instrument. In the following example, the **centimeter ruler** shown has numbers marked for each centimeter (cm), and the 10 smaller markings between each number representing 0.1 cm or one millimeter (mm).

On some rulers, the "0" cm mark is not at the end of the ruler, so the ruler is still accurate even if the ruler becomes rounded at the end. The length of an object is measured by placing the object at the "0" mark.

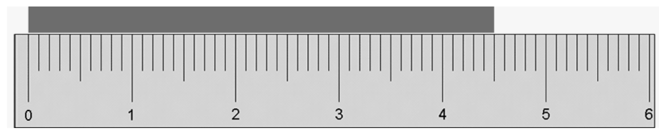


When the measurement is taken, all the digits are known with certainty, but the last digit (which is between markings) must be estimated. In the example above, the length of the gray object is clearly between 8.2 and 8.3 cm. Since the object is halfway between 3.2 and 3.3 cm and the last digit is estimated.

Possible measurements are **3.25 cm**, **3.24 cm**, or **3.26 cm**, depending on whether the rod is seen as being exactly halfway, just to the left of halfway, or just to the right of halfway, respectively. Reporting any one of the values is acceptable.

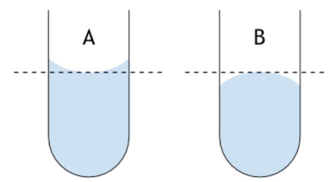
Length:
Rulers

When an object lines up exactly with a marking on an instrument, the estimated digit is 0. In the following example, the end of the gray object appears to line up with the marking for 4.5, so the length can be recorded as **4.50 cm**. If the end appears to be just to the left or to the right of 4.5, it is recorded as **4.49 cm** or **4.51 cm**, respectively.

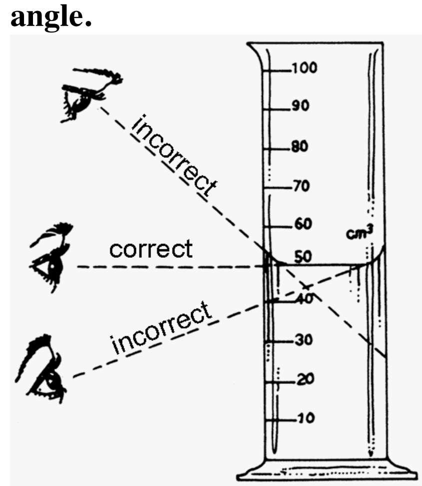


Volume:
Liquids & Calibrated Glassware

When a liquid is placed in a glass cylinder, a concave or convex surface forms; this curve is called the ***meniscus***. Calibrated glassware used in the lab is manufactured so that the volume is read where the bottom or top of the meniscus lines up with the markings on the equipment and are accurately measured (viewed) at eye level.



Parallax error results when a meniscus is viewed from an angle.



Your eye must be perpendicular to the bottom (or top) of the meniscus to measure accurately. Not viewing the meniscus on a level plane causes ***parallax***, the deceptive displacement of the meniscus to be below or above the correct position, as shown at the right.

Graduated cylinders are used to hold and deliver measured amounts of liquid. They are available in many sizes—e.g., those used in this lab can hold a maximum of 10 mL or 100 mL of liquid respectively. To insure the greatest accuracy one should use the smallest graduated cylinder that will hold the entire volume of sample within the scaled portion of the cylinder. For any graduated cylinder to be used accurately, it must be level (sitting on the counter, **NOT** handheld). Note that the graduations on all cylinders are read from the bottom up—that is, they indicate the volume **contained** in the cylinder.

Graduated Cylinders

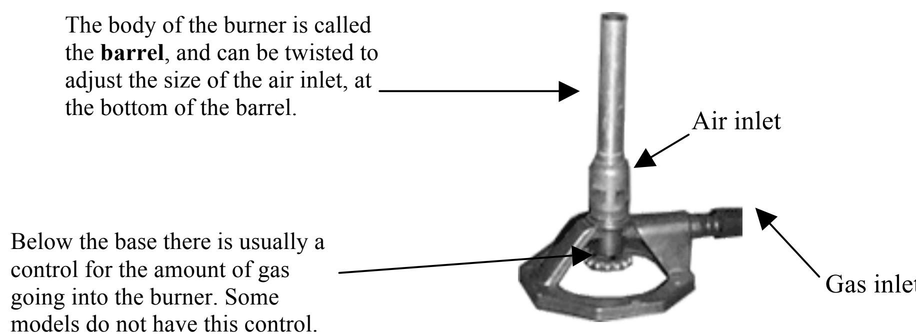
The **100 mL graduated cylinder** has a **number every 10 mL** and **shorter lines every 1 mL**. Given the large space between the markings on a graduated cylinder, one can estimate between the markings, so the volume can be recorded to ***0.1 mL***.

In the example at the right the bottom of the meniscus is closer to the marking for 36 mL than for 35 mL, so the volume of liquid can be recorded as **35.7 mL or 35.8 mL**, based on how close one sees it to the 36 mL mark.

Temperature:
Heat,
Bunsen Burners,
Thermometers

Bunsen burners are often used in a Chemistry laboratory to heat solids and solutions quickly, which raises their temperature. The burners can be controlled to produce hotter or cooler flames. Unlike hot plates, burners can be turned off immediately once a sample is heated.

Consider the image of one type of Bunsen burner below.



Controlling the amount of gas coming into the burner determines the overall size of the flame. The burner's **air inlet**, which is adjusted by screwing or unscrewing the **barrel** of the burner, determines the amount of air that mixes with the gas. The larger the air opening, the more oxygen the flame receives, and therefore, the hotter the flame.

The fuel used for the burner is commonly natural gas, which is a mixture of flammable hydrocarbon gases containing mostly methane (CH_4). Each lab work area has a natural gas jet. Each gas jet must be shut off completely when the burner is not lit. Always check the rubber tubing of the burner for holes. The heat (energy) produced is from the gas reacting with the oxygen in air and is transferred to the object being heated. The object's temperature can become very high. Skin contact must be avoided.

Bunsen Burners

To light the burner, open the gas valve on the lab bench while you are prepared to strike a match. Strike the match and immediately light the burner. If the burner does not light there is either no gas, no air, or too much gas and too much air (In this case there is a loud whooshing sound and the match [flame] keeps going out.) Adjust the barrel of the burner to allow more or less air into the gas stream until you see a "hot" blue, nearly transparent flame, with an internal cone as shown at the right. Where the gas burns completely by reacting with the oxygen in the air to produce CO_2 and H_2O.

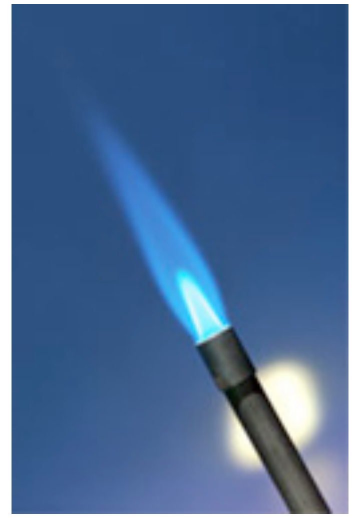
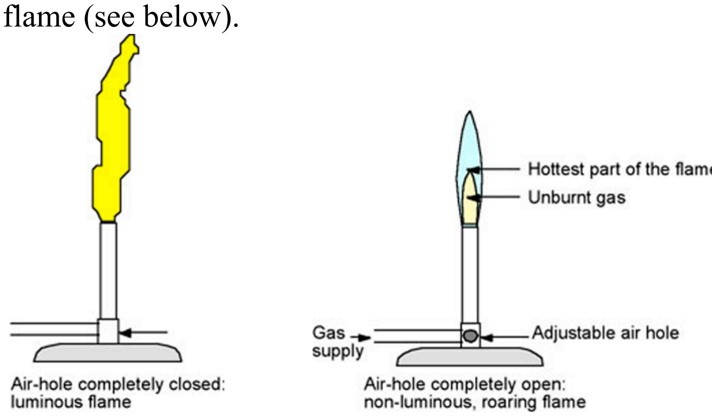


Photo of a "hot" Bunsen burner flame: Note the larger darker blue outer cone and the lighter blue inner cone. ***The hottest point of the flame is at the tip of the inner cone.***

If the air inlet is completely closed when the burner is lit, the flame will not get very hot, so the gas does not burn completely and produces CO and soot particles which incandesce to a ***large and luminous flame*** (see below). A luminous flame can be **dangerously flimsy, making it almost impossible to control and a hazard in the lab. *Thus, a luminous flame will NEVER be used in lab.*** If the air control is adjusted so enough air mixes with the gas before it gets to the flame, the methane burns more completely, indicated by a "hot" blue flame (see below).

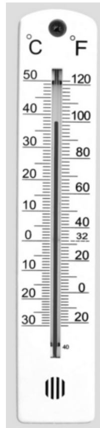


Incorrect: Luminous Flame   Correct: "Hot" Flame

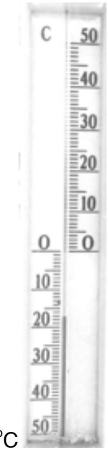
A Bunsen burner can be dangerous, particularly if used carelessly. Awareness is critical! Know whether or not the gas valve (on the lab bench) is open or closed. Always be sure the valve is closed when not using a burner and when leaving lab. Be aware of any flammable materials (including hair and clothing) that are near the burner flame. ***NEVER leave a flame unattended!***

View: https://en.wikipedia.org/wiki/Temperature

Thermometers

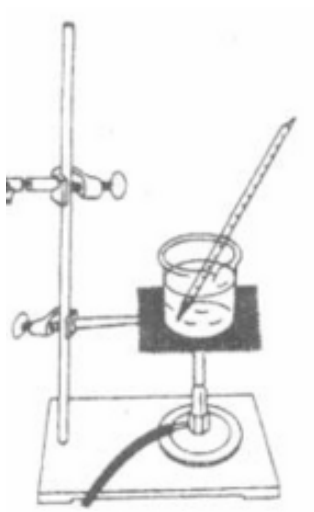


_37.2_ °C



_-17.5 °C

Boiling Liquids:



Wire gauze

Note: In the ring stand image above, the beaker and thermometer are not supported. It is best that they are supported with clamps. If not available, they should be secure, balanced, and carefully looked after.

Adapted from Seattle Central College
http://seattlecentral.edu/faculty/mvillarba/CHEM161/