Chemistry Glassware Techniques and Measurement

Objectives

- Identify common laboratory equipment used in general chemistry.
- Select appropriate equipment based on the precision, accuracy, and capacity of the measurement needed.
- Describe the purpose of and select the appropriate equipment to measure length, temperature, volume, and mass.
- Judge the reasonableness of calculations and answers.
- Explain proper safety measures that need to be considered when handling common laboratory glassware and equipment
- Calculate the density of a liquid or solid from experimental data.

Materials

1 Digital Scale (500 g capacity)	1 100-mL Beaker	Caliper
1 Pipet	1 250-mL Beaker	Ring stand
1 Burette	1 10-mL Graduated Cylinder	Thermometer
60 mL of Unknown Solution	1 50-mL Graduated Cylinder	

Introduction

Measurement in the Lab

There are a variety of instruments used to measure quantities such as temperature, volume, and mass, in the chemistry laboratory. The appropriate instrument or glassware is chosen to reflect the measurements required in a given experiment.

Measuring devices display a scale indicated by lines (on glassware) or a certain number of decimal places (on balances). It is important to read and interpret these scales accurately. All values read from laboratory measuring devices are expressed with the proper number of significant figures reflecting the precision and accuracy of the equipment being used. Always consider significant figures with each measurement and be mindful of the uncertainties involved with making that measurement.

Measuring Temperature

Thermometers are instruments calibrated to measure the temperature of whatever the bulb or probe is touching. Commonly, thermometers are glass tubes filled with mercury or colored alcohol; and they operate on the principal that the liquid inside them will expand as it heats up and contract as it cools, thus measuring the temperature of its surroundings. It is important to remember the significant digit rules and always record one more digit than there are lines. For the thermometer shown in Figure 1, the temperature should be reported as 44.5°C.

Measuring Volume

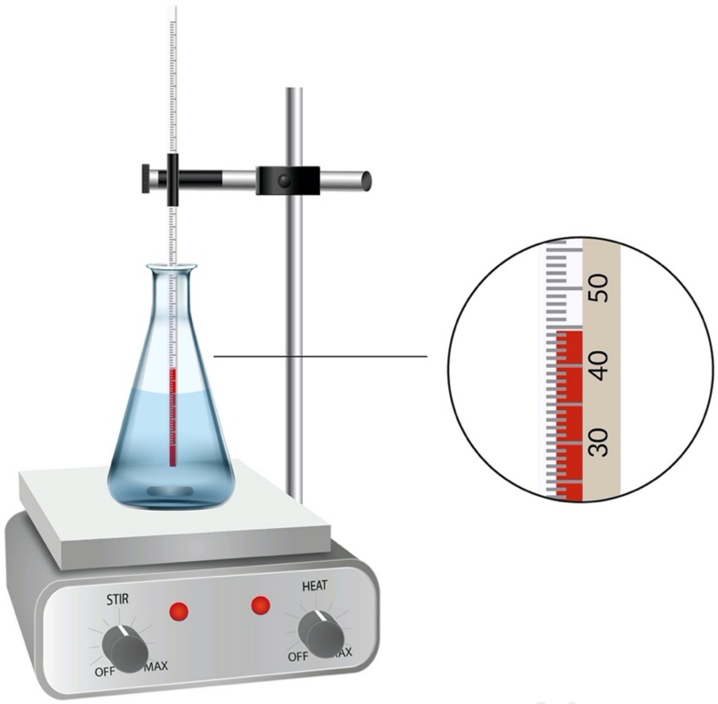

Figure 1 Temperature Reading

A variety of glassware is used to contain or deliver liquids in the laboratory. The most common glassware used in the general chemistry laboratory are beakers, graduated cylinders , and Erlenmeyer flasks. General glassware, such as beakers and Erlenmeyer flasks, provide only an approximate measure of volume and cannot be used when precision and accuracy are a concern. *Volumetric* laboratory glassware includes pipettes, burettes, and volumetric flasks. Volumetric glassware is calibrated by the manufacturer. Whenever interpreting volumes from volumetric glassware, it is important to read the value correctly. A characteristic of liquids in glass containers is that they curve at the edges. This curvature is referred to as the **meniscus**. When liquids are in glass, the meniscus will curve up at the edges and down in the center. Therefore, to read the volume correctly, your eye should be level with the top of the liquid and read the bottom of the meniscus as shown in Figure 2.

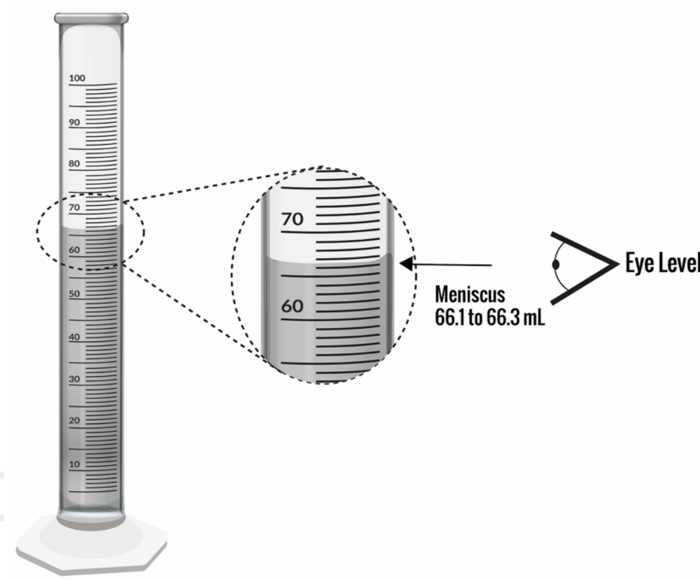

Figure 2 Proper Reading of Meniscus

Graduated cylinders are designed to contain a range of volumes of a liquid. They are marked with a vertical scale along their length and measure volume by measuring the height of a column of liquid. A tall graduated cylinder with a small diameter is more accurate than a short one with a large diameter. Pipets and burettes are glass tubes that are calibrated "to deliver" (TD) a very precisely known amount of liquid at a given temperature. They are usually marked with the amount, the precision with which they can deliver that amount, and the temperature at which the

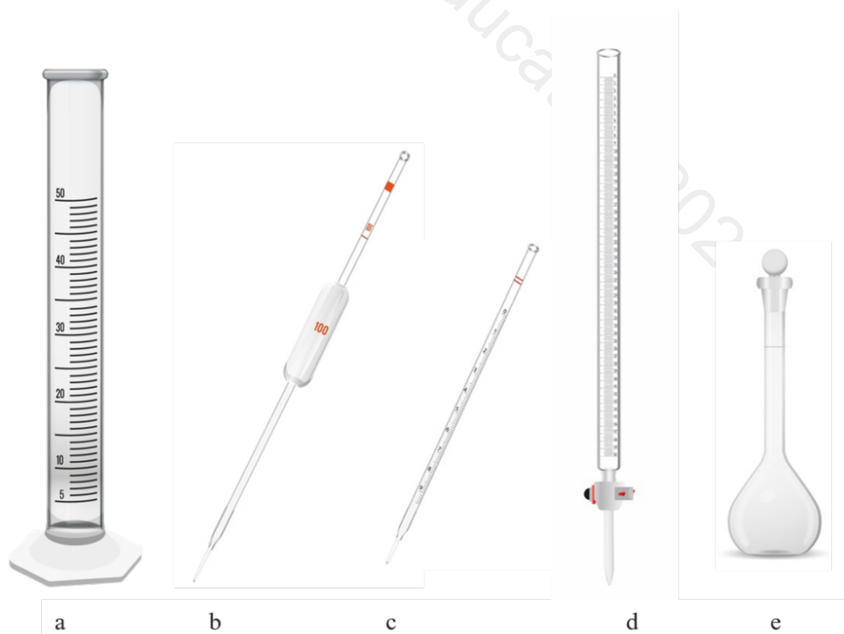

Figure 3 Volumetric Glassware a) Graduated cylinder b) Volumetric pipet c) Graduated pipet d) Burette e) Volumetric flask

pipet or burette was calibrated. Various types of glassware are illustrated in Figure 3. Volumetric glassware is designed to measure one specific volume of liquid.

Density – A Physical Property of Matter

Why do some objects sink, and other objects float when they are tossed into water? The answer to this question can be explained by the concept of density. Density is a physical property, and it is an important intrinsic quantity that is often used to help identify substances in the chemistry laboratory.

Water has a density of ~1.0 g/mL. Therefore, an object with a density less than water (< 1.0 g/mL) will float, and an object with a density greater than water (> 1.0 g/mL) will sink. The formal definition of density is represented by the following mathematical equation and is defined as the ratio of an object's mass per unit volume:

$$\text{density} = \frac{\text{mass}}{\text{volume}} \quad \text{Equation 1}$$

According to Equation 1, density is equal to the ratio of the mass of a sample to the volume it occupies. The density of a solid is normally expressed in grams per cubic centimeter (g/cm3), the density of a liquid in grams per cubic centimeter or grams per milliliter (g/mL), and the density of a gas in grams per liter (g/L). To determine the density of a substance, you must measure both the mass and volume of the same sample. Density is then calculated by dividing the mass by the volume as indicated in Equation 1.

Mass measurements are performed using a variety of balances and can be obtained directly or by difference. An appropriate balance is chosen to provide the desired precision for the experiment that you are performing, and each has a different capacity and level of uncertainty.

Figure 4 Digital Balance

Direct weighing involves placing objects, such as beakers or weighing boats, directly on the pan of the balance and recording the mass. Weighing by difference involves taking two measurements. First, the mass of an empty container is obtained and noted. Second, an object (or reagent) is added to the container and the new mass is recorded. Subtracting the initial mass from the final mass represents the mass of the object being measured.

Percent Error

In the procedure, you will be asked to determine experimentally the density of a known substance and then calculate the percent error in your determination. Percent error is defined by the Equation 2:

$$\text{Percent Error} = \frac{\text{Error}}{\text{Accepted Value}} \times 100 \qquad \text{Equation 2}$$

The "error" is the difference between the experimental value and the accepted value. Error is expressed as an absolute value, i.e., a numerical value without regard for algebraic sign. Absolute value is indicated by enclosing the quantity between vertical lines. Thus Equation 2 becomes:

$$\text{Percent Error} = \frac{|\text{Experimental Value} - \text{Accepted Value}|}{\text{Accepted Value}} \times 100 \qquad \text{Equation 3}$$

Density of material is an intensive property of matter because it does not depend on the amount of substance being measured. Depending on the measuring devices that we use and the care we take in our measurements, we will have some amount of error in the values that we calculate.

Procedure

Part I – Density of unknown liquid

1. Obtain a 100-mL beaker and put about 60 mL of unknown solution into it.
2. Mass a clean dry 10-mL graduated cylinder on an analytical balance. Record the mass using the appropriate number of significant figures and units. (Use the same balance for future weighing to ensure accuracy in mass recordings.)
3. Pour 10 mL of solution into the 10-mL graduated cylinder and weigh it on the same analytical balance used previously. Record the mass using the appropriate units and number of significant figures. Make sure to look at the volume reading and record your observation.
4. Empty and dry the graduated cylinder. Repeat this process four more times for a total of five trials.

Part II – Density of Water

1. Inspect the equipment provided at your bench and identify the burette, beaker, balance, and caliper.
2. Properly prepare and fill the burette with deionized water (DI water) (Figure 5).
3. Look at the lines on your burette and read the volume to two decimal places (one- hundredth if a milliliter). For example, 1.01 mL. Record the initial volume. (Note – The markings on the burette start with 0.00 mL at the top!)
4. Record the mass of an empty 100-mL beaker.
5. Dispense a small volume of DI water into your pre-weighed beaker. The volume you dispense for this first measurement is your choice (3 mL, 5 mL, any volume is fine). Record the mass on your data table. (Note: When reading the balance – read the mass to two decimal places (one-hundredth of a gram). For example, 8.65 g.)
6. Record the final volume in the burette. Remember to record the volume to two decimal places.
7. Empty the beaker and measure the mass of the empty beaker.
8. Add a new sample of water (3 – 5 mL) into the beaker and record the volume dispensed.
9. Measure the mass of the beaker + water and record it in the data table.
10. Repeat steps 7 – 9 three more times (for a total of five).
11. Pour about 50 mL of DI water into the beaker. Measure and record the temperature of the water.

Figure 5 Burette

Report Sheet – Chemistry Glassware Techniques and Measurement

Measurements with Graduated Cylinder

Enter the mass of the clean dry 10-mL graduated cylinder (g) ___________

Mass Measurements of 10-mL graduated cylinder with 10 mL unknown liquid

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Mass (g)					

Using a Burette

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Initial volume of burette (mL)					
Final volume of burette (mL)					
Mass of water dispensed (g)					

Density of an Unknown Liquid using Graduated Cylinder Measurements

	10-mL grad. cylinder + 10 mL unknown liquid (g)	10-mL grad. Cylinder (g)	Volume of liquid (mL)	Density (g/mL)
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Trial 5				

Density of Water Using Burette Measurements

	Initial vol of burette (mL)	Final Vol of burette (mL)	Mass of water dispensed (g)	Density (g/mL)
Sample 1				
Sample 2				
Sample 3				
Sample 4				
Sample 5				

Record the temperature of the DI water (°C) ____________

Percent Error

Calculate the percent error for density using the graduated cylinder.

Calculate the percent error for density using the burette readings.

What does the percent error tell you about the accuracy of the measurements?