

Making Measurements and Working in the Chemistry Laboratory



The purpose of this experiment is to familiarize you with the techniques of working with common equipment in the chemistry laboratory and to gain an understanding of the role of measurement and precision in using that equipment. Specifically, you will be measuring length, mass, liquid volume, and temperature. Results you obtain will be compared with those of other students in order to show the amount of uncertainty in a measurement. This will be expressed in terms of the number of significant figures in the measurement. You will also practice methods of making solutions, heating, and filtering.

All measurements inherently have some uncertainty, which is determined by the piece of equipment you are using and your ability to take its readings. The most common method of expressing uncertainty in a value is to use significant figures. The number of significant figures in a value consists of all the digits in a measurement that you can definitely read, plus the first digit of which you are uncertain. For example, if a student measures and records a mass of 86.2 g, it is understood that the last digit (in this case, 2) is uncertain. Furthermore, if four students measured the mass of this object and came up with readings of 86.2 g, 86.3 g, 86.1 g, and 86.3 g, the average mass is 86.225 g. However the readings show that it is the tenths of a gram we are not sure of, and therefore any digits after that position are not valid or meaningful. The average mass should be quoted as 86.2 g, which has three significant figures to match what was originally measured. The uncertainty can be quoted as ± 0.1 g, which shows that the measured values show variation from the average by 0.1 g above and below the quoted value.

Also, the terms precision and accuracy are commonly used in describing measurements. Precision refers to how consistent measured values are. The greater the number of significant figures obtained, the better the likelihood for more precision. Accuracy on the other hand refers to how close a value is to the commonly accepted "correct" value. For instance, a series of values such as 1.98 g, 1.97 g, and 1.98 g show a high degree of precision. However, if the correct value is 1.85 g, then the results obtained are not accurate, perhaps because there is some source of error unaccounted for.

Using the centigram balance is the most typical way of measuring mass in a chemistry laboratory. It is important to check that the balance reads zero when no object is on the pan before beginning to use it. If an adjustment is necessary, check with your instructor before proceeding. Since balances can be put out of adjustment when moved, it is better if possible that the balances stay in one location in the lab and that you go to the balance rather than bringing it to your bench. It is good technique when weighing chemicals to weigh them on a piece of paper or other object such as a watch glass or beaker to prevent damage to the pan.

When measuring the volume of a liquid, you will notice the surface of the liquid is curved. This is called the *meniscus*. The correct way to take a volume reading is to position your eyes level with the bottom of the meniscus, and read the value at that point.

When making solutions, chemists refer to the substance that gets dissolved as the *solute* and the substance (usually water) that does the dissolving as the *solvent*. Furthermore, a solute that dissolves reasonably well is said to be *soluble*. In this experiment, calcium hydroxide is the solute and water is the solvent.

OBJECTIVES

1. to measure the length of some items and use combined class results to understand how to express the precision of those measurements
2. to measure the mass of various items and use combined class results to understand how to express the precision of those mass measurements
3. to measure the mass of a certain volume of water measured with three different pieces of equipment and use combined class results to understand how to express the precision of the volume measurements
4. to obtain practice in the techniques of dissolving, heating, and filtering

SUPPLIES

Equipment

centimetre ruler
centigram balance
graduated cylinder (25 mL)
volumetric pipet (25 mL)
pipet filler
plastic measuring spoon
2 beakers (250 mL)
beaker (100 mL)
ring stand
ring clamp
bunsen burner and wire gauze (or hot plate)
thermometer

filter funnel
filter paper
stirring rod
test tube (18 mm × 150 mm)
wash bottle
heat resistant pad
straw
paper "stickie" approximately 7-8 cm square
30 pins (≤ 2.5 cm long)
lab apron
safety goggles

Chemical Reagents

calcium hydroxide, $\text{Ca}(\text{OH})_2$

PROCEDURE

Part I: Measuring Length

1. Measure the length of the side of a square "stickie" provided to the nearest 0.1 mm and record this value in your copy of Table 1.

Part II: Measuring Thickness

1. Measure the total thickness of all the sheets of paper making up this book, excluding the cover, to the nearest 0.1 mm. Exclude the covers and the very first and last pages which are slightly thicker than the rest.
2. Determine the number of sheets of paper you measured (numbered pages divided by two and additional sheets not part of the regular numbering).
3. Record your results in your copy of Table 2 and in the manner suggested by your instructor to compare results with the rest of the class in order to obtain the class average.

Part III: Measuring Mass

1. Obtain at least 30 pins in a small beaker.
2. Using a centigram balance, measure the mass of one pin. (For this part of the experiment, it is permissible to weigh items directly on the pan).
3. Count out 30 pins and measure the total mass of them.
4. Record your results in your copy of Table 3 and in the manner suggested by your instructor to compare results with the rest of the class to obtain the class average.

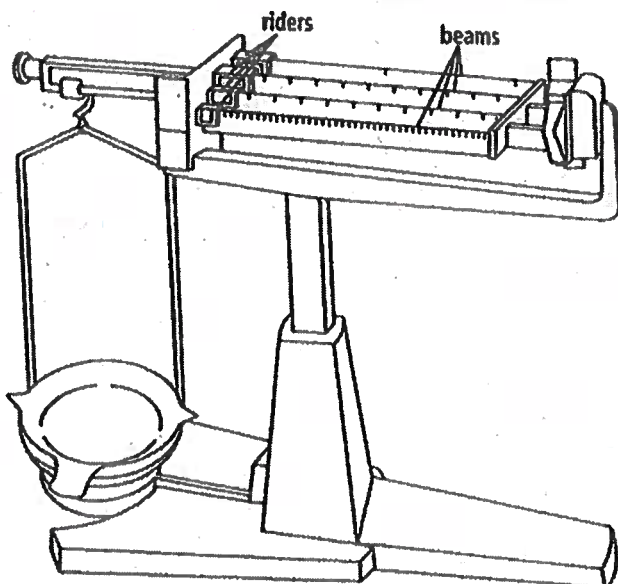
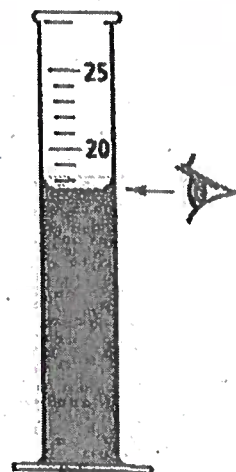


Figure 1A-1 A common type of centigram balance

Figure 1A-2 Reading a graduated cylinder. Your eye should be level with the top of the liquid. Take the reading at the bottom of the meniscus, the curved surface of the liquid. The correct reading for the volume shown in the figure is 17.5 mL.

Part IV: Measuring Liquid Volume

1. Determine the mass of a clean, dry 100 mL beaker and record this value in Table 4.
2. Using the graduations on the side of the beaker, add water until you have added 25 mL, then determine and record the mass of beaker and water.
3. Empty and dry the beaker. Measure 25 mL of water as measured in a 25 mL graduated cylinder and add it to the beaker. Determine and record the mass of beaker and water.
4. Empty and dry the beaker. Using a 25 mL volumetric pipet and a pipet filler, measure 25 mL of water and add it to the beaker. Your instructor





Calcium hydroxide and its solution limewater are skin irritants. Wash any spills on your skin or clothing with plenty of water.

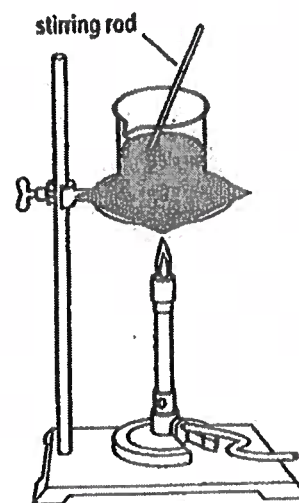
will give directions for the type of pipet filler available to you. Determine and record the mass of beaker and water.

5. Also record your results in the manner suggested by your instructor to compare results with the rest of the class and obtain the class average.

Part V: Preparing a Solution

1. Put on your lab apron and safety goggles.
2. Using a plastic measuring spoon, obtain about 10 mL (2 teaspoons) of calcium hydroxide, Ca(OH)_2 and transfer it to a 250 mL beaker.
3. Add approximately 150 mL of water and stir to mix thoroughly to begin the dissolving process.
4. Since the calcium hydroxide is not very soluble, you will need to heat up the solution to increase the rate of dissolving. If using a bunsen burner, set up the beaker on a ring stand with ring and gauze as shown in Figure 1A-3, or use a hot plate if available. Heat the beaker until the temperature of the contents reaches approximately 60°C . Do not let the thermometer rest against the bottom of the beaker, but instead hold it in the middle of the solution.

Figure 1A-3 Heating the calcium hydroxide and water



5. Maintain this temperature for about 10 min, stirring occasionally with a stirring rod, never with the thermometer. It is to be expected that some of the calcium hydroxide will be left undissolved. Then turn off the burner (or hot plate), remove the beaker to a heat resistant pad and proceed to Part VI.



Your thermometer is made of glass and can easily break, leaving sharp edges that cut.

Handle your thermometer gently. If your thermometer breaks, call your teacher. If it contains mercury, be aware that mercury liquid and vapor are very poisonous.

Part VI: Filtering a Solution

1. Obtain a piece of filter paper and fold it in half, then in half again. Separate the still-folded paper to make one thickness on one side and three on the other so that the shape becomes a cone, as shown in Figure 1A-4.

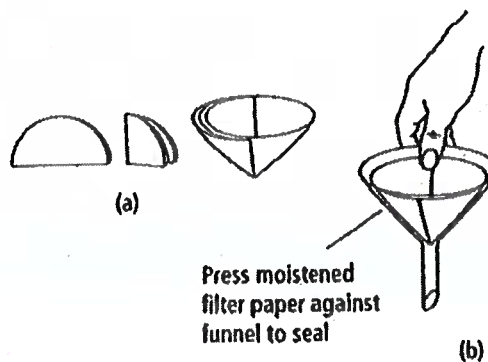


Figure 1A-4 (a) Folding the filter paper into a cone (b) After adding a small portion of water to moisten the paper, press to seal it to the funnel

2. Place the paper cone in a filter funnel and use a wash bottle to wet it slightly to hold it in place. Place the funnel in the ring clamp on the ring stand, in such a way that the tip of the funnel touches the side of a clean, dry 250 mL beaker.
3. Carefully pour the contents of the beaker a portion at a time into the filter funnel and allow it to drain through. Pour it down a stirring rod as shown in Figure 1A-5. Keep the funnel about three-quarters full to increase the speed of filtration. It is not necessary to wash the last of the precipitate into the funnel since you are discarding the retained solid anyway. Adding water would then dilute the saturated solution.
4. When the filtering is complete, discard the filter paper and contents. The clear liquid obtained through the process of filtering is called the *filtrate*. It is a calcium hydroxide solution, also known as limewater.
5. Half fill a test tube with your limewater and bubble your exhaled breath through a straw into it until a change occurs. Observe and record the change.

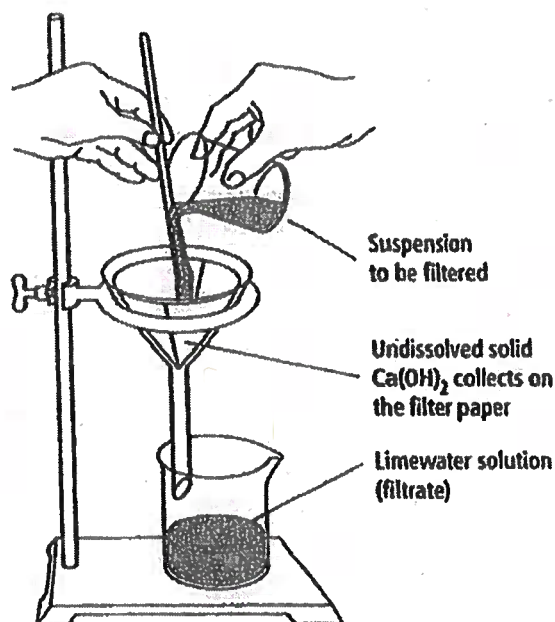


Figure 1A-5 Use a glass stirring rod and pour the liquid down it. This makes a more even flow and avoids splashes. Ensure that the stem of the funnel touches the side of the beaker.

REAGENT DISPOSAL

Place the leftover limewater solution in the container designated by your instructor. Discard the filter paper and contents.

POST LAB CONSIDERATIONS

It is important for you to submit your results for Parts I to IV so that class averages can be obtained and you can see the variability of measurements of the same quantity. The mass of your empty beaker in Part IV should also be reported, not to obtain an average mass, but to show how the masses of apparently identical pieces of glassware can be considerably different. Students often

make the erroneous assumption that, for example, all 100 mL beakers will have the same mass.

When measurements are used in calculations such as multiplication or division, the number of significant figures quoted in the calculated result is determined by the number of significant figures in the least precise quantity used.

The limewater solution you prepared is important in a chemistry laboratory since it is used as a test for carbon dioxide, CO_2 . When CO_2 is blown into limewater or shaken with it, a white precipitate of calcium carbonate (CaCO_3) is formed, which gives the solution a milky appearance. If a solution of limewater is left in an open beaker, a white layer appears on the surface as CO_2 from the air reacts with it. For this reason, limewater must always be kept in closed containers.

EXPERIMENTAL RESULTS

Part I: Measuring Length

Table 1 (Remember to use the correct number of significant figures.)

Length of "Stickle" (cm)	Other Groups Results
COMPLETE IN YOUR NOTEBOOK	

Part II: Measuring Thickness

Table 2

Thickness of This Book (cm)	Class Average	Number of Sheets of Paper
COMPLETE IN YOUR NOTEBOOK		

Part III: Measuring Mass

Table 3

Mass of One Pin (g)	Class Average	Mass of 30 Pins (g)	Other Groups Results
COMPLETE IN YOUR NOTEBOOK			

Part IV: Measuring Liquid Volume

Table 4

Mass of 100 mL beaker = g		
Mass of Beaker + 25 mL Water (Measured in Beaker)	Mass of 25 mL Water (Measured in Beaker)	Other Group's Results
COMPLETE IN YOUR NOTEBOOK		
Mass of Beaker + 25 mL Water (Graduated Cylinder)	Mass of 25 mL Water (Graduated Cylinder)	Other Group's Results
COMPLETE IN YOUR NOTEBOOK		
Mass of Beaker + 25 mL Water (Volumetric Pipet)	Mass of 25 mL Water (Volumetric Pipet)	Other Group's Results
COMPLETE IN YOUR NOTEBOOK		
List of masses of 100 mL beakers used by all other laboratory groupings:		

Part VI: Result of blowing exhaled air into the limewater solution:

ANALYSIS OF RESULTS

1. Refer to your measurements of your "stickie" in Table 1.
 - a. After comparing the length of your "stickie" to those of other members of the class, express the length of the side in centimetres to the correct number of significant figures.
 - b. Calculate the area of the square "stickie" in square centimetres and quote the answer to the correct number of significant figures, which is the same as the number in the length measurement.
2. Refer to your measurements of the paper thickness in Table 2.
 - a. ~~After comparing the thickness of the paper in this book to those of other members of the class, express the thickness in centimetres to the correct number of significant figures.~~
 - b. Using the number of pages of paper comprising the book, calculate the thickness of one sheet of paper, to the correct number of significant figures.
3. Refer to your pin masses in Table 3.
 - a. After comparing your mass of one pin to those of other members of the class, express the mass to the correct number of significant figures.
 - b. After comparing your mass of 30 pins to those of other members of the class, express the mass to the correct number of significant figures.
 - c. From this value, calculate the mass of one pin to the correct number of significant figures.

4. Refer to your mass and volume measurements in Table 4.
 - a. Observe all the values for the masses of an empty 100 mL beaker. Which is the greatest? Which is the smallest?
 - b. Given the fact that 1 mL of water has a mass of 1 g, convert the masses you obtained for the three different ways of measuring 25 mL to a volume in millilitres.
 - c. Calculate the class average for each of the three methods and state the value to the correct number of significant figures. Which value is closest to the desired volume of 25 mL? Which piece of equipment gives the most precise results?

FOLLOW-UP QUESTIONS

1. A strip of copper is 15.2 cm long, 2.8 cm wide, and 0.2 mm thick. What is its volume in cubic centimetres, to the correct number of significant figures?
2. Magnesium metal is usually sold to chemistry labs as long strips of ribbon in a flat roll. If you required the mass of a 5 cm piece of magnesium ribbon and found it had a mass of 0.04 g, how could you obtain a more accurate mass reading for this 5 cm piece?
3. Arrange the three pieces of equipment you used to measure volume in order of increasing accuracy. Recall their shape and explain the reason for the increasing accuracy.
4. A student forgot to measure the mass of an empty 100 mL beaker before adding about 2 g of a chemical to it, and decided to simply obtain the mass of another empty 100 mL beaker instead. Would this be a satisfactory alternative? Refer to Analysis of Results 4a and determine the maximum amount the error in mass could be using the beakers in your class, expressed as a percentage of the required mass of 2 g.
5. In Part V, you dissolved a solute in some water to make a solution. If you had needed to know how much solute dissolved, how could you have determined this?

CONCLUSION

1. Generally state how you decided how many significant figures you must record when making measurements.
2. State how you should round off answers from calculations involving significant figures.