# Chemistry Lab: Introduction to Measurement

Teacher Prep Sheet

Set up 3 graduated cylinders on each lab counter (two groups will share each set) for part A with colored water in each as shown:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Lab bench 1 | Lab bench 2 | Lab bench 3 |
| 10 mL graduated cylinder | 6.70 mL | 6.50 mL | 9.30 mL |
| 50 mL graduated cylinder | 35.3 mL | 39.4 mL | 38.8 mL |
| 100 mL graduated cylinder | 80.5 mL | 81.0 mL | 44.0 mL |

Each student group will need:

* 50 mL beaker
* 50 mL flask
* 25 mL graduated cylinder
* 50 mL graduated cylinder
* 100 mL graduated cylinder
* Electronic centigram balance
* Disposable plastic pipet
* Thermometer

**Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Hour\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Chemistry Lab: Introduction to Measurement**

**(adapted from Flinn ChemTopic Labs)**

***Introduction***

Much of what we know about the physical world has been obtained from measurements made in the laboratory. Skill is required to design experiments so that careful measurements can be made. Skill is also needed to use lab equipment correctly so that errors can be minimized. At the same time, it is important to understand the limitations of scientific measurements.

***Background***

Experimental observations often include measurements of mass, length, volume, temperature, and time. There are three parts to any *measurement:*

• its numerical value

• the unit of measurement that denotes the scale

• an estimate of the uncertainty of the measurement.

The numerical value of a laboratory measurement should always be recorded with the proper number of *significant figures.* The number of significant figures depends on the instrument or measuring device used and is equal to the digits definitely known from the scale divisions marked on the instrument plus one estimated or "doubtful" digit. The last, estimated, digit represents the uncertainty in the measurement and indicates the precision of the instrument.

Measurements made with rulers and graduated cylinders should always be estimated to one place beyond the smallest scale division that is marked. If the smallest scale division on a ruler is centimeters, measurements of length should be estimated to the nearest 0.1 cm. A 10-mL graduated cylinder has major scale divisions every 1 mL and minor scale divisions every 0.1 mL. Three observers might estimate the volume of liquid in the 10-mL graduated cylinder shown at the right as 8.32, 8.30, or 8.33 mL. These are all valid readings. It would NOT be correct to record this volume of liquid as simply 8.3 mL. Likewise, a reading of 8.325 mL would be too precise.

Some instruments, such as electronic balances, give a direct reading-there are no obvious or marked scale divisions. This does NOT mean that there is no uncertainty in an electronic balance measurement; it means that the estimation has been carried out internally (by electronic means) and the result is being reported digitally. There is still uncertainty in the last digit.

Variations among measured results that do not result from carelessness, mistakes, or incorrect procedure are called *experimental errors.* Experimental error is unavoidable. The magnitude and sources of experimental error should always be considered when evaluating the results of an experiment.

***Pre-Lab Questions***

Determine the volume of the liquids in the following cylinders:

     
a) \_\_\_\_\_\_\_\_\_\_ b) \_\_\_\_\_\_\_\_\_ c) \_\_\_\_\_\_\_\_\_ d) \_\_\_\_\_\_\_\_\_

Draw in the meniscus for the following readings:

a) 49.21 mL b) 18.2 mL c) 27.65 mL d) 63.8 mL

**Procedure**

***Part A. Volume Measurements with Graduated Cylinders***

*There are three graduated cylinders, each labeled and each containing a specific quantity of*

*liquid to which some food coloring has been added to make the volume easier to read.*

1. In Data Table A, record the maximum capacity of each graduated cylinder and the volume that each major and minor scale division represents on each graduated cylinder.

2. Observe the volume of liquid in each cylinder and record the results in Data Table A. Remember to include the units and the correct number of significant figures.

3. In Data Table A, estimate the "uncertainty" involved in each volume measurement. The estimated uncertainty is usually given as plus or minus ( ) one-half of the *minor scale division* that is marked.

***Part* B. *Comparing Volume Measurements***

4. Use tap water to fill a 30-mL beaker to the 10-mL mark. Use a disposable plastic pipet to adjust the water level until the bottom of the meniscus is lined up as precisely as possible with the 10-mL line.

5. Pour the water from the 30 mL beaker into a clean, 50-mL graduated cylinder. Measure the volume of liquid in the 50 mL graduated cylinder and record the result in Data Table B. Remember to include the units and the correct number of significant figures.

6. Transfer the water from the 50-mL graduated cylinder to a clean, 25-mL graduated cylinder and again measure its volume. Record the result in Data Table B.

7. Transfer the water from the 25-mL graduated cylinder to a clean, 10-mL graduated cylinder and again measure its volume. Record the result in Data Table B. Discard the water into the sink.

8. Repeat steps 4-7 two more times for a total of three independent sets of volume measurements. Dry the beaker and graduated cylinders between trials. Record all results in Data Table B.

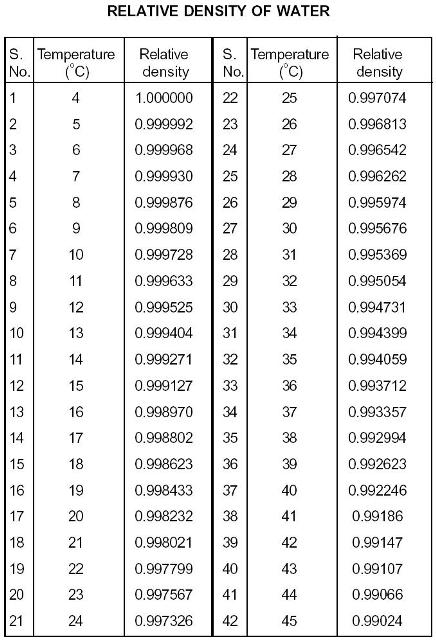
9. Calculate the average (mean) volume of water in each of the graduated cylinders for the three trials. Enter the results in Data Table B.

***Part* C. *Comparing the Accuracy of a Beaker, Flask and Graduated Cylinder***

1. Using the electronic balance, measure and record (in Data Table C) the mass of a dry 50 mL beaker, flask, and graduated cylinder.
2. Add 25.0 mL of distilled water to each piece of glassware. Add the last few drops carefully so that the bottom of the meniscus is exactly at the volume you want.
3. Use the electronic balance to measure and record (in Data Table C) the mass of each piece of glassware containing 25.0 mL of water. Subtract the mass of the empty glassware to find the mass of water in each piece of glassware.
4. Use a thermometer to record (in Data Table C) the temperature of the water used in each piece of glassware. It is not necessary to measure the temperature in all three pieces, because they should be the same. Since this glassware is small, ***do not let go of the thermometer*** as the weight of the thermometer may cause the glassware to turn over and spill. After you have recorded the temperature, pour the water into the sink and wipe down your counters.
5. Refer to the Table of Densities provided to obtain the density of water at the proper temperature. Record the density in Data Table C. You will use the mass of the water and the volume (25 mL) to calculate the observed density from the density equation, Density= Mass/ Volume.
6. Compare your observed density to the actual density by calculating and recording (show your work in Data Table C) the percent error between the actual density and the calculated density (from step 14) for each piece of glassware.

**% Error = observed density - actual density x 100**

**actual density**



**Data Table A. *Volume Measurements***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Graduated Cylinder** | **Maximum Capacity (mL)** | **Volume Given by Major Scale** | **Volume Given by Minor Scale** | **Observed Volume** | **Uncertainty**  **( ± how many mL)** |
| **A** |  |  |  |  |  |
| **B** |  |  |  |  |  |
| **C** |  |  |  |  |  |

**Data Table B. *Comparing Volume Measurements***

|  |  |  |  |
| --- | --- | --- | --- |
| *Measured Volume of “10 mL” of Water* | | | |
| **Trial** | **50 mL Graduated Cylinder** | **25 mL Graduated Cylinder** | **10 mL Graduated Cylinder** |
| **1** |  |  |  |
| **2** |  |  |  |
| **3** |  |  |  |
| **Average** |  |  |  |

**Data Table C. *Comparing the Accuracy and Precision of a Beaker, Flask and Graduated Cylinder***

|  |  |  |  |
| --- | --- | --- | --- |
|  | **50 mL beaker** | **50 mL flask** | **50 mL graduated cylinder** |
| **a. Mass of dry**  **glassware** |  |  |  |
| **b. Mass of glassware**  **with 25.0 mL H2O** |  |  |  |
| **c. Mass of just H2O** |  |  |  |
| **d. Temperature of H2O** |  | | |
| **e. Density of H2O**  **(from table below)** | ***This will be your “known” in part g*** | | |
| **f. Calculated density**  **density = mass**  **volume** | ***This will be your “experimental” in part g*** |  |  |
| **g. % Error Between**  **Experimental and**  **Known Densities**  %Error = exp – known x 100  known |  |  |  |

***Post-Lab Questions***

1. In Part A, which graduated cylinder(s) gave the most accurate volume measurement? Explain your answer using the concept of uncertainty.

2. It is common to get different volume readings for each container in Part B. What explanation

can you offer for an apparent decrease or increase in volume? (Why aren’t the volumes exactly the same?)

3. Analyze the data you collected in Part C. Write a conclusion paragraph:

1. describing which piece of glassware (the 50 mL beaker, flask or graduated cylinder) you found to be the most accurate
2. justify why that piece of glassware is the most accurate; ***you must support your claim with factual (numerical) evidence***.