Laboratory Glassware Name: __________________________ Class: ___________

Accuracy, Precision, and Calibration

There are three types of containers used in lab to contain or deliver liquids: volumetric, ordinary, and disposable glassware. Volumetric glassware are containers that have been calibrated at a specific temperature to deliver or contain VERY PRECISE amounts of liquid. Examples of volumetric glassware that we will use include burets, pipets, and volumetric flasks. Ordinary glassware has less precise volume calibrations and are used whenever the volumes do not have to be measured as accurately. Examples include beakers, Erlenmeyer flasks, and graduated cylinders. Disposable glassware (or plastic ware) is used to transfer or hold liquids temporarily and may not contain any volume markings. Examples include medicine droppers and beral pipets.

How to read the level of liquid in glassware:

The "meniscus" of a liquid refers to the curvature of the liquid surface in a narrow container. If the surface of the liquid is concave (as in water), the liquid level is measured using the BOTTOM of the meniscus. If the surface is convex (upward curving) as in mercury, the liquid level is read from the top of the meniscus. It is important to position the eye at the same level as the meniscus to avoid a parallax error. Sometimes it is easier to use an index card marked with a dark line or piece of black electrician's tape behind the glassware to contrast the line between the glassware markings and the liquid level.

If the liquid level falls between the markings on graduated glassware, the student must estimate the last, uncertain digit in the recorded volume measurement. Example: our graduated cylinders have individual milliliter markings so a reading must be to the tenths of a milliliter (10.4 mL).

Care of glassware:

Glassware should be washed with a mild soap solution, rinsed with tap water, and then possibly distilled water. **If beads of water stick to the inside walls, it be should be cleaned again**. If glassware is to be dried, allow it to drain or use paper towels. NEVER SLING GLASSWARE TO REMOVE WATER. NEVER TAP GLASSWARE AGAINST THE SIDE OF THE SINK. A buret or pipet should be rinsed with a small amount of the solution to be used to remove any water droplets from the glass walls.

Burets:

Burets must be read to the hundredths of a milliliter. Note that the liquid level markings begin at the top or open end. This is because the buret is designed to deliver liquids. All volumes are measured as the DIFFERENCE between an initial and final reading.

Pipet:

The volumetric pipet is designed to deliver a single, fixed volume of liquid at a specific temperature. A graduated pipet is used in a similar fashion to the buret to deliver specific amounts of liquid. Remember to touch off the drop of liquid hanging outside the tip into the transferred liquid (it is part of the delivered volume) but DO NOT BLOW OUT ANY LIQUID THAT REMAINS INSIDE THE TIP OF THE PIPET. The pipet has been calibrated to contain this last drop of liquid.

Lab Scales: We will be using electronic lab scales throughout the course. They are extremely sensitive and easily damaged. ALWAYS REMOVE ALL ITEMS FROM THE LAB SCALES AS SOON AS THEY INDICATE STABLIZATION. 1 to 3 seconds is usually enough time for the scales to stabilize (The teacher will demonstrate how each different brand displays a stabilized reading). NEVER place a wet container on the scales. NEVER place or allow chemicals directly on the pan. Use massing papers or pans for chemicals. The TARE function clears the scales to zero. In this lab you will be finding mass by difference. Record the initial mass and then after adding or removing some component, mass again. Subtract the initial from the final mass to obtain the needed measurement.

Precision and Accuracy

Whenever a measurement is made in the laboratory, some uncertainty exists. Precision in the laboratory implies that when a series of measurements are taken they will be close in value to each other. When measurements are accurate they are close to the true value of that object.

Mass and volume depend on the quantity of a substance. Density, which is the ratio of mass to volume, is a constant and is characteristic of the substance. However, the density of a substance may vary with its temperature. In this lab the mass and volume of water will be measured, and the density of the water calculated. This value will be compared to the accepted density of water at the relevant temperature. The accuracy and precision of the measurements will be determined.

Objective:

The objective of this experiment is to determine the density of water and calculate the accuracy and precision of the density result. Density is defined as: mass / volume. Proper significant figures will be used throughout the experiment.

Procedure:

Beaker, 0.1 g lab scales, and tap water:

1. Place ~ 100 mL of tap water in an Erlenmeyer flask. Measure the temperature of the water and record it.
2. Place a clean, dry beaker on the lab scales and record the mass of the beaker on the data table sheet.
3. Remove the beaker from the balance and add **some** of the tap water into it. Using the graduations on the beaker, read and record the volume of water.
4. Place the beaker on the scales. Calculate (by subtracting the mass of the beaker) and record the mass of the water in the beaker.
5. TARE the scales and repeat steps 3 – 5 for trials 2 and 3. (Add more water, read the amount, mass).

Graduated cylinder, 0.1 g lab scales, and tap water:

1. Place a clean, dry graduated cylinder on the lab scales. Record mass. Remove from lab scales.
2. Pour some tap water into the graduated cylinder. Remember to remove any water bubbles from the liquid first and then remove any droplets from the inside or outside of the cylinder. Using the graduations on the cylinder, read the volume as precisely as possible and record on data table.
3. Place the cylinder on the scales and calculate/record the mass of the water.
4. Repeat for trials 2 & 3. Remember that you need not clean and dry the cylinder between each trial.

Volumetric pipet, 0.01 g lab scales, and distilled water:

1. Record the mass of a clean, dry beaker. Do NOT touch the beaker with your skin. Use a paper towel to handle the beaker.
2. Obtain ~ 50 mL of distilled water in a clean Erlenmeyer flask (it need not be dry). Record the temperature of the distilled water.
3. Using the volumetric pipet and the pipet filler, add some (approximately 4 to 8 mL) distilled water to the beaker. Record the actual volume of water added to the beaker.
4. Place the beaker on the lab scales and record the mass of the water in the data table (find the mass of the water by subtracting the mass of the beaker from the mass of beaker and water).
5. Repeat for trials 2 & 3.

Buret, 0.01 g lab scales, and distilled water:

1. Record the mass of a clean, dry beaker. Do NOT touch the beaker with your skin. Use a paper towel to handle the beaker.
2. Using the buret, add some (at least 10 or more mL) distilled water to the beaker. Record the volume of water added to the beaker.
3. Place the beaker on the lab scales and record the mass of the water in the data table (find the mass of the water by subtracting the mass of the beaker from the mass of beaker and water).
4. Repeat for trials 2 & 3.

Data Table:

Temperature of tap water: ____________° C   Temperature of distilled water: ______________° C

Mass of beaker used on scales: ____________ g   Mass of graduated cylinder used: ____________ g

Beaker, 0.1 g lab scales, and tap water:

Trial #	Volume of water	Mass of water	Density of water
1			
2			
3			

Average density: _________________ g/cm^3

Graduated cylinder, 0.1 g lab scales, and tap water:

Trial #	Volume of water	Mass of water	Density of water
1			
2			
3			

Average density: _________________ g/cm^3

Volumetric pipet, 0.01 g lab scales, and distilled water:

Trial #	Volume of water	Mass of water	Density of water
1			
2			
3			

Average density: _________________ g/cm^3

Buret, 0.01 g lab scales, and distilled water:

Trial #	Volume of water	Mass of water	Density of water
1			
2			
3			

Average density: ________________ g/cm^3

Water Density Tables:

Temp °C	Density g/cm^3	Temp °C	Density g/cm^3
18	0.9986	23	0.9975415
19	0.9984	24	0.9972995
20	0.9982071	25	0.9970479
21	0.9979955	26	0.9967867
22	0.9977735		

Calculations/Results:

1. Actual density of tap water at recorded temperature (from chart): _________ g/cm^3
2. Actual density of distilled water at recorded temperature(from chart): _____________ g/cm^3
3. Calculate the % error for each of the average density values:

   % error = (| actual density – average density | / actual density) x 100

	% Error
Beaker and tap water	
Grad. cyl. and tap water	
Pipet and distilled water	
Buret and distilled water	

4. Calculate the average deviation for each set of trials:

   Average deviation = [Σ (| average density – trial density |)] / 3

	Average deviation
Beaker and tap water	
Grad. cyl. and tap water	
Pipet and distilled water	
Buret and distilled water	

5. Calculate the standard deviation for each set of trials:

$$\text{Standard deviation} = \sqrt{\left[\left(\Sigma (\rho - x_1 \right)^2 / (n - 1) \right]}$$

Where ρ = density for each individual trial
x_1 = average density
n = number of trials (3 in this lab)

	Standard deviation
Beaker and tap water	
Grad. cyl. and tap water	
Pipet and distilled water	
Buret and distilled water	

Questions:

1. Which method of determining density was the most accurate? Justify your answer with numbers.

2. Which method of determining density was the most precise? Justify your answer with numbers.

3. A student completes part of this experiment using a dirty pipet. He does not notice that several drops of liquid remain in the pipet each time it is used. How would this affect the density calculations?

4. How would this experiment be affected if the balance used gives masses that are 0.2 g higher than the true masses every time it is used?

5. Sammy Airhead applied for a job last summer in the quality control lab of the Acme Pill Company. The job was to determine the amount of aspirin in aspirin tablets. He was given twelve samples of known aspirin content (325 mg) to analyze during his training session. He completed four sets of trials with three samples in each trial. Which sets had results that were:
   a. precise and accurate
   b. precise but not accurate
   c. not precise but accurate
   d. neither precise nor accurate

Set A	Set B	Set C	Set D
325 mg	300 mg	400 mg	250 mg
325 mg	325 mg	400 mg	280 mg
325 mg	350 mg	400 mg	350 mg

P.S. Sammy spent the remainder of the summer sweeping floors at the factory. Good technique is important.