1 Measurement of the Density of a Liquid and a Solid

Purpose

The objective of this experiment is to determine the density of an unknown liquid and solid. The students will become familiar with the techniques for measuring mass and volume of several samples and graphing techniques for measuring density.

Introduction

There are information for some of basic laboratory equipments;

a) Laboratory Balance

A laboratory balance is used to obtain the mass of various objects. There are several different varieties of balances, with various limits on their accuracy. Two of these balances are pictured in Figure 1.1.

Figure 1.1 Digital electronic balances.

b) Graduated Cylinders

Graduated cylinders are tall, cylindrical vessels with graduations scribed along the side of the cylinder. A liter (L) is divided into milliliters (mL) such that 1 mL = 0.001 L and 1 L = 1000 mL.

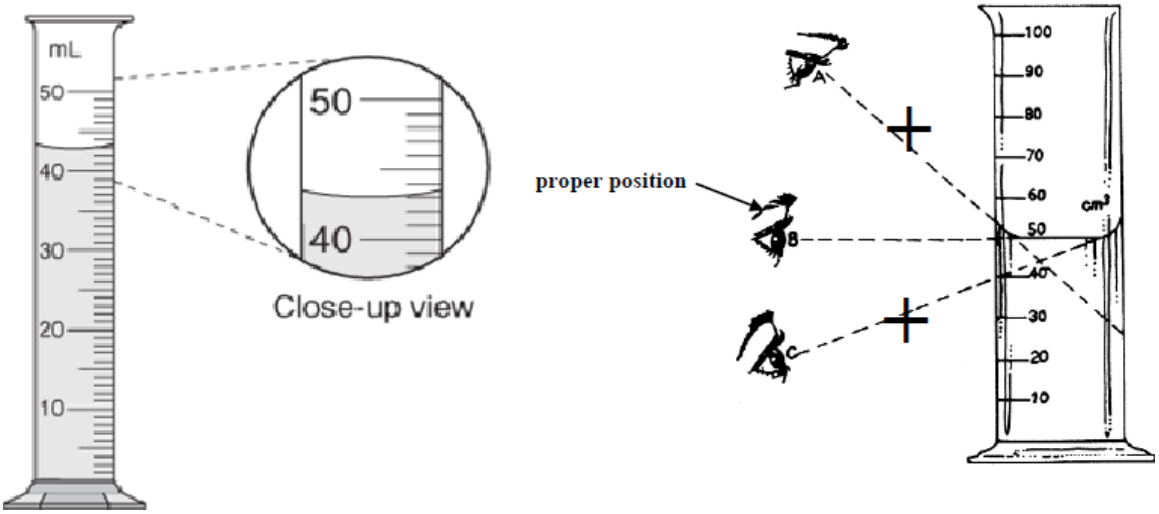

Figure 1.2 Graduated Cylinder (Proper eye position for taking volume readings. The meniscus reading here is 50.0 mL)

c) Pipets

Pipets are glass vessels that are constructed and calibrated so as to deliver a precisely known volume of liquid at a given temperature. The markings on the pipet illustrated in **Figure 1.2** signify that this pipet was calibrated To Deliver (TD) 10.00 mL of liquid. Always use a rubber bulb to fill a pipet. NEVER USE YOUR MOUTH!

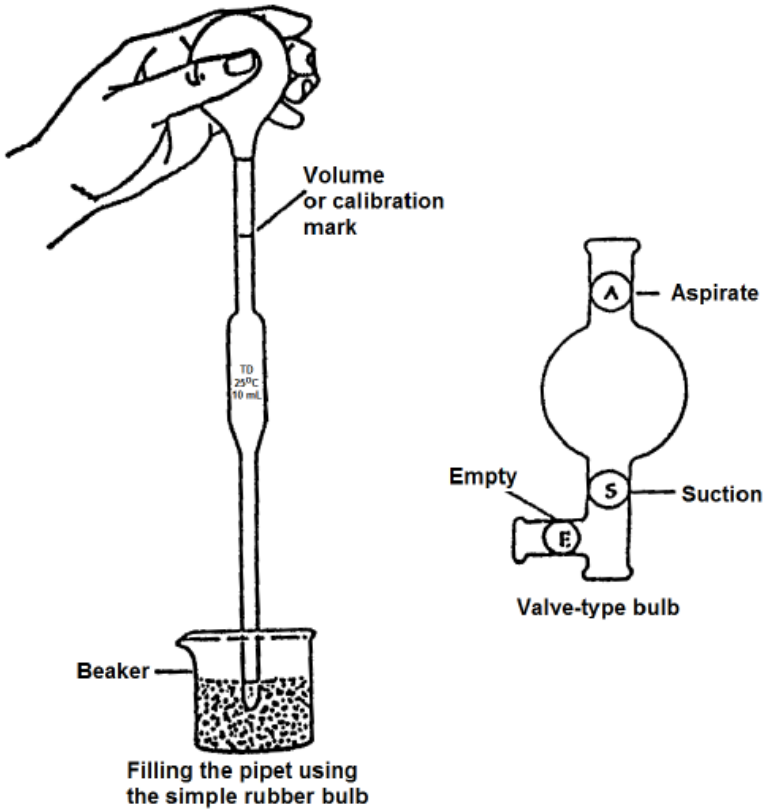

Figure 1.3 typical volumetric pipet, rubber bulbs, and the pipet filling technique

Theory

Density is an important characteristic property of a substance that can be defined as its mass per unit volume;

$$Density = \frac{mass}{volume}$$

Density of a liquid or solid is dependent on the volume and a mass of matter that is usually expressed in units of grams per milliliter (g/ml) or grams per cubic centimeter (g/cm^3), respectively. The densities of some of the substances are listed in Table-1.

Substance	Density at 25 °C ($g \cdot cm^{-3}$)
Air	0.001
Water	1.00
Ethanol	0.79
Mercury	13.6
Zinc	7.14
Table salt	2.16
Rubber	1.4
Aluminum	2.70
Copper	8.96

The density values should be determined at a specific temperature. The density values depending on the volumetric changes are generally decreasing with increasing temperature. On the contrary to volume, mass of a substance is independent from the temperature. The density of an unknown sample can be measured experimentally in two steps; first one is to measure the mass of a substance and the second step is to measure its volume. The mass of a substance can be determined readily with a balance and this process is oddly called weighing. Mass and weight terms are often used interchangeably but they are different in meaning of quantities. Weight refers to a force that gravity exerts on an object. The volume of a solid material with a regular geometric shape can be measured by a direct measurement. For example, the volume of a cube can be calculated using

Volume = length x width x thickness

The volume of an irregular shaped solid substance can be calculated by an indirect method using Archimedes principle by measuring the amount of displaced liquid (generally water) when the solid is placed in a liquid. The volume of a liquid is generally determined using a graduated cylinder, syringe, pipet and bulb.

Determination of Error and Percent Error

Error is the difference between the experimental and the theoretical values. The error and the percentage of error can be calculated respectively by

$$Error = experimental value - theoretical value$$

$$\%Error = \frac{|experimental value - theoretical value|}{theoretical value} \times 100$$

Experimental Procedure

Chemicals List	***Equipments***
Metal samples	Beaker
Unknown solution	Graduated cylinder
	Pipette
	Balance

Part I: Density of an unknown liquid

Mass measurement

1. Tare the balance before doing any measurement. The balance should read zero grams (0.00 g).
2. Weigh the empty and clean beaker and record the mass of it. Record all the digits read on the balance.
3. Take your unknown liquid from your laboratory assistant and pour it into that beaker.
4. Place the beaker filled with liquid on the balance and record the mass. Keep in mind to use the units with the values of mass

Volume measurement

5. Place your graduated cylinder on a flat surface for accurate reading.
6. Pour the unknown liquid into a graduated cylinder. The liquid will form a curvature that is called a meniscus. While reading the level of liquid, you should choose the bottom of meniscus.
7. Repeat the measurement again with pipette and beaker. Record your readings.

Part II: Density of an unknown solid

Mass measurement

1. Tare the balance before doing any measurement. The balance should read zero grams (0.00 g).
2. Weigh the unknown metal and record the mass of it. Record all the digits read on the balance. Do not forget to use the units.

Volume measurement

3. Place your graduated cylinder on a flat surface for accurate reading.
4. Fill a graduated cylinder with about 60 ml of water and record the volume by reading the bottom of the meniscus.
5. Put your metal slowly into the graduated cylinder with water. While doing this avoid splashing the water.
6. Read the volume of the unknown metal within the water and record the value with units.
7. Dry the unknown metal and return it back to your assistant.

Experiment 1 – Report (Page 1)

Name of the student:	Student ID:
Name and signature of the assistant:	Section & Date:

Data and Calculations

1) DENSITY OF AN UNKNOWN LIQUID

(3 pts) Mass of empty beaker			
(3 pts) Mass of beaker with an unknown liquid			
(3 pts) Mass of an unknown liquid			
	Measure with Pipette	**Measure with Graduated Cylinder**	**Measure with Beaker**
(9 pts) Volume of unknown liquid			
(9 pts) Density of an unknown liquid			
(3 pts) Identity of an unknown liquid			
(3 pts) Theoretical density of an unknown liquid			
(9 pts) % Error			

Experiment 1 – Report (Page 2)

Name of the student:	Student ID:

2) DENSITY OF AN UNKNOWN METAL

(3 pts) Mass of unknown metal	
(3 pts) Volume of water in the graduated cylinder	
(3 pts) Volume of water in the graduated cylinder after inserting an unknown metal	
(3 pts) Volume of an unknown metal	
(5 pts) Density of an unknown metal	
(3 pts) Identity of an unknown metal	
(3 pts) Theoretical density of metal sample	
(5 pts) % Error	

Experiment 1 – Report (Page 3)

Name of the student:	Student ID:

QUESTIONS

1. (10 pts) What is the quickest method for determining the volume of a liquid? Which one is the most accurate? Why?
2. (10 pts) What are the basic units of length, mass, volume, and temperature in the SI system?
3. (10 pts) What is the density of an object with a mass of 9.03 g and a volume of 0.1987 mL?