**Student Name:**

* Carefully read the entire document. Insert values, calculations, and explanations where necessary
* Please be mindful of document formatting when done.

**This Lab Report component contains 85 points. The remaining 15 points for this experiment are earned by completing the Lab Quiz questions.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Report Component** | **Points Available** | **Criteria & Maximum Point Deductions** | **Points Earned** |
| **Notebook Prep** | **0** | –5 for live experiments for incomplete notebook preparation according to the “Laboratory Notebook Guidelines” document | NA(Remote) |
| **Title Page, Results Statement, and Overall Formatting of document** | **10** | –7 Title page not present–5 Missing Results Statement–3 Results statement lacking experimental findings–3 Incorrect Title Page format–5 Overall document formatting is ‘sloppy’ |  |
| **Lab Data Section/Data Tables** | **15** | –1 to –15 Based on correct insertion of missing values as determined from video (units, Sig Figs, and magnitude) |  |
| **Lab Calculation Section** | **20** | –1 to –20 Based on correct calculations (final number, and some degree of work shown where necessary) |  |
| **Post-Lab Questions** | **20** | –1 to –20 Based on Answer Key. |  |
| **Discussion & Conclusion** | **20** | **Include 1-2 paragraph explanation of the general principles used in the experiment, how they relate to each other, the results of the experiments, and whether they were accurate.****See specific requirements later in this document.**Limited to a maximum 1-2 paragraphs–1 to –5 Poor grammar, punctuation, sentence structure or not writing in past tense. |  |
| **Total points (out of 85):**  |

(Remove this and insert your title page and results statement here)

**General Directions: All work should be completed and typed directly into this word document whenever possible. Alternatively, students may insert images of hand-written work/calculations. Save the file with your last name in the title (i.e. Student\_Density\_Lab.) Upload the completed document to Canvas in the correct assignment tab by the due date.**

**Specific Directions:** This lab has two Parts: Part A and Part B. Complete all data sections by typing in data after (1) reading the background and (2) watching the appropriate experiment videos carefully. After reporting necessary data in “Data Tables”, complete the “Calculations and Results Section” that follow. Then, write a ~1-2 paragraph “Discussion/Conclusion” for the entire lab (Part A+B). This should include a brief explanation of the general principles (in your own words) used in the experiment and how they relate to each other, the results of the experiments, and whether they were accurate according to your calculations.

# BACKGROUND

Density is a physical property of a substance and is defined as its mass per unit volume:

$Density=\frac{Mass}{Volume}$ Typical units: ( $\frac{grams}{mL} )$ or $(\frac{grams}{cm^{3}})$ **(1)**

To determine the density of a substance, both its mass and volume must be measured. In the laboratory, the mass of a substance is easily and accurately determined on a balance. However, there are several ways to determine the volume of an object. For a given mass measurement, the accuracy and precision of the calculated density depends on the method used to determine the volume.

In this experiment, you will determine the density of metals.

In **Part A**, two different methods will be used for finding the volume of the metal slug. In the first method, the volume of the metal will be determined by volume displacement *.i.e.*, the volume of water the metal cylinder displaces when it is immersed in the water.

In the second method, geometry will be used to calculate the volume of the metal cylinder shape. By measuring the height and diameter of the metal cylinder and using the equation for volume of a cylinder (**V = π r2 h**), the volume of the unknown metal can be calculated. The mass is measured in the balance and then the density can be determined using Equation 1.

**Recall: Accuracy and Precision of Measurements**

***Accuracy*** refers to the closeness of experimental measurements to the “correct”, “true” or “accepted” value.

***Precision*** refers to the reproducibility of data, how close the measured values are to each other.

For example, if you weighed an object that is known to weigh 10.00 g, four times on several different balances, the most accurate balance would be the one **whose average measured mass is closest to 10.00 g**. Percent error is a way to calculate the accuracy of a measured value.

$\% Error=\frac{|Experimental value-True value|}{True value} x 100$ (3)

In this equation, the experimental value is the measured value of the substance. If several measurements have been recorded, then the experimental value is their average. The true value is the known value or the value with absolutely no error*.*

A variation on percent error is “percent difference”, where a similar mathematical formalism is used to compare two values where neither is known as the true value. Percent difference is usually used qualitatively, to compare when two independent measurements of the same quantity asses how much the measurements differ.

$$\% Difference=\frac{|value \#1-value \#2|}{Average of \#1\#2} x 100$$

# Procedure: Determining the Density of Solid

Part A1: Density from Water displacement

**Video for Part A1: Measuring Density of a Metal**

<https://www.youtube.com/watch?v=h7owl6gC_wk>

.*Video* *Copyright: K-Class Science Channel*

**15 Points Total for Correct Lab Data and Results Section:**

**6 Points Total. Data Collection Part A1** Complete this data table using the data obtained contained in the video above. Be sure to use proper units. The appropriate unit for volume is in this experiment is mL.

|  |  |
| --- | --- |
| Mass of iron block  |  |
| Water level before adding iron  |  |
| Water level after adding iron  |  |
| Mass of aluminum block  |  |
| Water level before adding aluminum  |  |
| Water level after adding aluminum  |  |

Part A2: Geometric Measurement of Volume

**Data Collection Part A2**

**The height, diameter, and mass of an “unknown metal” cylinder have been measured and the values given below.** Given the below data, determine the density of the unknown metal. **Compare this density from part A2 to the densities obtained for aluminum and iron blocks in Part A1.** Based on this comparison, determine which metal is the unknown most likely? To scientifically determine this, calculate and compare the “percent differences” in densities between part A1 and part A2.

Mass of metal cylinder 17.782g

Height of cylinder 5.00cm

Diameter of cylinder 1.25cm

**9 Points Total. Results Sheet**

 Complete the results table below. Include proper units and significant figures.

|  |  |  |
| --- | --- | --- |
| **Method** | **Density** | **% Difference in Density (A1 vs A2)** |
| **A1 aluminum** |  |  |
| **A1 iron** |  |  |
| **A2 unknown** |  | **--------** |

Identity of unknown metal based on above information: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**20 Points Total. Lab Calculation Section**

**General Directions for inserting calculations:**

1. **Either insert photos of your (neatly) written out calculation,**

 **Or**

1. **Type out the equations that you are solving. Remember to include proper units!**
* For this choice, use the “Insert🡪Equation” function in MS Word. This is a good opportunity to practice typing equations.

**Show examples of the following calculations from the laboratory procedure below.**

**5 Points.** Show volume and density calculations from iron part A1:

(delete this and type your relevant equation here or insert picture of calculation)

**5 Points.** Show volume and density calculations from aluminum part A1:

(delete this and type your relevant equation here or insert picture of calculation)

**5 Points.** Show volume and density calculations from part A2:

 (delete this and type your relevant equation here or insert picture of calculation)

**5 Points.** Show **% difference** calculations between both metals in part A1 and the unknown from part A2.

(delete this and type your relevant equation here or insert picture of calculation)

**Discussion/Conclusion Statement (20 points):**

[Insert Discussion/Conclusion paragraphs here. Discussion and conclusion statements should be stand-alone paragraphs that anyone could read and quickly understand what you determined, how precise and/or accurate your results were, sources of error, potential improvements to the experiment and applications of the experiment to a broader topic. Some discussion of the topics and how they relate is expected]

**(8 points for thorough discussion).** For this first experiment, discuss Parts A1 and A2. Which method was more accurate based on % error or difference?

**(8 points for thorough discussion).** Can you think of any sources of error in either method? How would these errors affect your calculated numbers?

(4 points). Find a real-world application of density and discuss it. Include a citation for your source.

**(20 points) Post Lab Questions: Density**

1. **2 Points.** The level in the graduated cylinder used in the lab procedure video should be estimated to = within \_\_\_\_\_mL (\_\_\_\_\_significant figures)
2. **10 Points**. A student finds that 24.96 g of water at 24.9 °C (density= 0.9971 g/cm3) is required to completely fill an empty flask. The water is removed and completely dried; granular solid copper weighing 51.24 g is then added to the flask. With the copper present in the flask, it was determined that 19.24 g of water was required to fill the remaining space in the flask completely. Show all work and determine the following:
3. Volume of the empty flask

Type or Insert an image of answer here

1. Volume of the copper

Type or Insert an image of answer here

1. Density of the copper

Type or Insert an image of answer here

1. If this flask could be filled completely with solid copper, what would be the mass of that copper?

Type or Insert an image of answer here

1. **8 Points.** You are given 3 unknown cylinders each with masses of exactly 25.00 g. Your choices of metal have the following densities: Zn 7.14 g/mL, Fe 7.87 g/mL and Ni 8.91 g/mL. Each unknown is placed into a graduated cylinder filled with water. The following displacements are recorded:

Cylinder A: 3.2 mL Cylinder B: 2.8 mL Cylinder C: 3.5 mL

Identify the metal each Cylinder is made of:

A=\_\_\_\_\_\_\_\_ B=\_\_\_\_\_\_\_\_ C=\_\_\_\_\_\_\_\_

[Type or Insert an image of answer here]