Student 1 Name: ____ Date: ____________________________

Student 2 Name: ____ Class: ____________________________

PART 1: PROPERTY INVESTIGATION

In Part 1, we will test the properties of our liquids, *copper* penny and *plastic* coin. By first measuring the density of a liquid, then by measuring the mass of a large number of drops, we can calculate the average mass of a droplet, and finally determine the average diameter of a droplet.

We determine the following quantities and recording them in Table 1 through Table 3:

I. liquid density, ρ
   - density varies with temperature and pressure

II. mass of droplet (average), $\overline{m}_{drop}$
   - this measurement will vary depending on how uniform droplets are formed

III. diameter of droplet (average), $\overline{d}_{drop}$
   - assume each droplet is a perfect sphere

IV. mass of copper penny (average), $\overline{m}_{penny}$ & mass of plastic coin (average), $\overline{m}_{coin}$
   - this measurement will vary depending on how well pennies and coins were made

V. diameter of *copper* penny (average), $\overline{d}_{penny}$, & diameter of *plastic* coin (average), $\overline{d}_{coin}$
   - assume each penny and coin is a perfect circle

Class Discussion:

Drop Formation Considerations. The **speed** that you dispense a droplet from the pipette affects the drop size. Thus, to have comparable results for the entire class, everyone needs to form droplets the same.

Speed: form a droplet (approximately) every __________ seconds.

Procedures

Materials:
- 50 mL beaker
- graduated cylinder (or graduated pipette)
- 16mL of each liquid
- electronic scale
- DI water (for cleaning)
- calculator

I. LIQUID DENSITY

1. Weigh 50mL glass beaker.
   a. Record value on TABLE 1, m_{beaker}
2. Using graduated cylinder (or graduated pipette) measure out 10mL of liquid
3. Dispense liquid into glass beaker. Weigh (beaker + liquid)
   a. Record weight on TABLE 1, $m_{(beaker+liquid)}$
   b. Calculate mass of 10mL of liquid
   c. Record mass liquid on TABLE 1, $m_{Liquid} = m_{(beaker+liquid)} - m_{beaker}$
   d. Calculate the liquid density, $\rho = \dfrac{m_{Liquid}}{V_{Liquid}}$
   e. Record liquid density on TABLE 1
4. Rinse beaker and graduated cylinder (graduated pipette) with DI water
5. Using 3-4mL of the next liquid rinse graduated cylinder (or graduated pipette) twice and dispose liquid into waste container
6. Repeat step1-4 for all liquids, recording values in TABLE 1.

II. MASS DROPLET (AVERAGE)

1. Dispense approximately 10mL of each liquid into separate 50mL beakers
2. Weigh a plastic dish
    a. Record weight of dish on TABLE 2, m_{dish}
3. Using plastic pipette slowly dispense 20 droplets of liquid into plastic dish. Weigh (dish + drops).
    a. Record weight on TABLE 2, $m_{(dish+drops)}$
    b. Calculate mass of drops, $m_{drops} = m_{(dish+drops)} + m_{dish}$
    c. Record weight of drops in TABLE 2, m_{drops}
4. Calculate the average mass of <u>one</u> drop, $\overline{m}_{drop} = \dfrac{m_{drops}}{20}$
    a. Record average mass of <u>one</u> drop on TABLE 2, $\overline{m}_{drop}$
5. Empty and dry plastic dish
6. Repeat step 2-5 for each liquid.

Materials:
- 3x50 mL beaker
- plastic dish
- 3x plastic pipette
- 16mL of each liquid
- electronic scale
- calculator

III. DROPLET DIAMETER (AVERAGE)

1. Calculate the average drop volume, $\overline{V}_{drop} = \dfrac{\overline{m}_{drop}}{\rho}$

Record average drop volume in TABLE 2, $\overline{V}_{drop}$

2. Calculate average droplet diameter, $\overline{V}_{drop} = \dfrac{\pi \cdot \overline{d}_{drop}^{\,3}}{6} \longrightarrow \overline{d}_{drop} = \left(\dfrac{6000 \cdot \overline{V}_{drop}}{\pi}\right)^{1/3}$
    a. Record average droplet diameter in TABLE 2, $\overline{d}_{drop}$
3. Repeat calculations for all liquids.

Materials:
- calculator

**** for V_{drop} (mL) & d_{drop} (mm)**

IV. MASS COPPER PENNY & MASS PLASTIC COIN

1. Make sure copper pennies are clean and dry.
2. Weigh <u>four</u> pennies together, M_{penny}
    a. Record mass of 4 copper pennies in TABLE 3, M_{penny}
3. Calculate the average penny mass, $\overline{m}_{penny} = \dfrac{M_{penny}}{4}$
    a. Record average penny mass in TABLE 3, $\overline{m}_{penny}$
4. Ensure plastic coins are clean and dry
5. Weigh <u>four</u> coins together, M_{coin}
    a. Record mass of 4 plastic coins in TABLE 3, M_{coin}
6. Calculate the average coin mass, $\overline{m}_{coin} = \dfrac{M_{coin}}{4}$
    a. Record average coin mass in TABLE 3, $\overline{m}_{coin}$

Materials:
- 4 copper pennies
- 4 plastic coins
- electronic scale
- calculator

V. DIAMETER COPPER PENNY & DIAMETER OF PLASTIC COIN

Materials:
- 2 copper pennies
- 2 plastic coins
- ruler
- calculator

1. Measure diameter of <u>two</u> copper pennies, d_1 & d_2
   a. Record diameters on TABLE 4
2. Calculate the average penny diameter, $\bar{d}_{penny} = \dfrac{d_1 + d_2}{2}$
   a. Record average penny diameter in TABLE 4, $\bar{d}_{penny}$
3. Measure diameter of <u>two</u> plastic coins, d_1 & d_2
   a. Record diameters on TABLE 4
4. Calculate the average coin diameter, $\bar{d}_{coin} = \dfrac{d_1 + d_2}{2}$
   a. Record average coin diameter in TABLE 4, $\bar{d}_{coin}$

VI. SUMMARY

1. Using the data recorded in TABLE 1, TABLE 2, TABLE 3 & TABLE 4, summarize results into TABLE 5.
2. Put away all lab materials and clean up your lab space.
3. Make sure your name and your partner's name is on the worksheet first page.
4. Answer all questions on page 5.
5. Turn in the completed worksheet.

Data Collection

TABLE 1

Liquid	m_{beaker} (g)	$m_{beaker+liquid}$ (g)	m_{liquid} (g)	ρ (g/mL)

TABLE 2

Liquid	m_{dish} (g)	$m_{dish+drops}$ (g)	m_{drops} (g)	$\overline{m}_{drop}$ (g)	$\overline{V}_{drop}$ (mL)	$\overline{d}_{drop}$ (mm)

TABLE 3

M_{penny} (g)	$\overline{m}_{penny}$ (g)	M_{coin} (g)	$\overline{m}_{coin}$ (g)

TABLE 4

Copper Penny			Plastic Coin		
d_1 (mm)	d_2 (mm)	$\overline{d}_{penny}$ (mm)	d_1 (mm)	d_2 (mm)	$\overline{d}_{coin}$ (mm)

TABLE 5—SUMMARY

Liquid	ρ (g/mL)	$\overline{m}_{drop}$ (g)	$\overline{d}_{drop}$ (mm)

Final Results

1. Which liquid had the largest density?

2. Which liquid had the smallest?

3. Which liquid formed the smallest average diameter droplet?

4. Which liquid formed the largest average diameter droplet?

5. Which liquid has the strongest cohesive force? How do you know?

6. Which liquid has the weakest cohesive force? How do you know?

7. Did the liquid with the largest density have the largest or smallest diameter droplets?

8. Did the liquid with the smallest density have the largest or smallest diameter droplets?

9. Does a relationship exist between average droplet diameter and liquid density? Support your answer with a graph. HINT: Graph $\bar{d}_{drop}$ vs ρ. *(Be sure to label both the x- and y-axes and use correct intervals on each axis.)*

    a. If you answered ***YES***. Write a statement describing the relationship between droplet diameter and liquid density.

    b. If you answered ***NO***. Make an educated guess as to why average droplet diameters may be different.