NAME _____ SECTION _____

PARTNER(S)_____ DATE _____

UNCOVERING PROPERTIES OF LIQUIDS AND SOLIDS

You have had experience on a macroscopic (visible scale) with substances in the liquid and solid states in your everyday life and you have had a chance in lab to investigate gases. Before you begin this activity, close your eyes and image what a gas, liquid, and solid would look like if you could see them at the microscopic, or particle level. Write a brief description or illustrate your images here.

Keep your descriptions in mind as you investigate properties of liquids and solids in this activity. As you work, decide if your images can explain the observations you make. If not, try to modify your images to fit the phenomena you see.

Part I: Liquids

Think of the solid-liquid-gas comparison activities you performed in the *The Behavior of Gases* lab. From these activities and your experiences, list three physical (observable) differences between the gaseous and liquid state.

List two differences between particles in the gaseous and liquid states.

1. Fill up a 250 mL Erlenmeyer flask with tap water and then transfer the water into a 400 mL beaker.

   What changed about the water as you changed container? _____

What stayed the same about the water? _____

Would all liquids behave the same way? _____

If you left the water in an open beaker for a week and then came back to look at it, what will have happened? _____

If you left the water in the beaker for a week in a sunny window and then came back to look at it how might it be different from the first beaker? _____

If there had been alcohol in the beaker instead of water, and you left it on the table for a week and then came back to look at it, what might be different?

_____

2. Put some water on your fingers and wave them around in the air. What is happening to the water on your fingers?

_____

How do your fingers feel and why do you think they feel that way? (Wave some dry fingers in the air for comparison.)

_____

_____

3. Put a few drops of water on the lab table and a few drops on a piece of wax paper. Is the water "wetting" (spreading across) the table and the wax paper equally well?

_____

4. Clean a penny with soap and water and dry it. Place the penny on the table. Predict how many drops of water you will be able to put on the penny before the water spills over. Write your prediction here _____

Fill an eye dropper with water. Find out how many drops do fit on the penny by dropping water on the penny carefully. Record the number of drops here _____

From this activity with the penny would you say that water resists spilling or are the water molecules "sticky" towards each other? _____

Think of another example from your experience that would support your conclusion above. _____

4. Put a few drops of oil on a piece of wax paper. Is the oil "wetting" (spreading across) the table and the wax paper equally well?

_____

Place a newly cleaned penny on a piece of wax paper. Predict how many drops of oil you will be able to put on the penny before the oil spills over. Write your prediction here _____

Fill an eye dropper with oil. Find out how many drops do fit on the penny by dropping oil on the penny carefully. Record the number of drops here. _____

From this activity with the penny would you say that oil resists spilling or are the oil molecules "sticky" towards each other? _____

Water is a polar molecule and oil is a non-polar molecule. What does this mean?

How do you think the polarity of the molecule relates to the "stickiness" of the molecules in the liquid state?

6. Fill a small beaker with tap water. Place two drops of food coloring into the water and do not disturb the beaker. Observe and describe here what happens over the next 5-10 minutes.

Based on what you have done and seen in this activity, would you say that the particles of a liquid:

a. stay in the same place all the time b. move around from place to place

My reason for saying so is:

Summarize in your own words the properties or characteristics of the liquid state based on the activities you have just performed.

_____

_____

Is there anything particularly puzzling to you that you would like to ask about?

Part II: Solids

1. Look through the microscopes and examine the solids on display. Describe what you see.

Place a very small amount of one of the solids specified by your instructor in the open end of a capillary tube and tap it down to the closed end. The solid should be no deeper than about 0.5 cm. Find the melting point of this solid using the equipment provided. Ask for help if you are unfamiliar with the melting point apparatus.

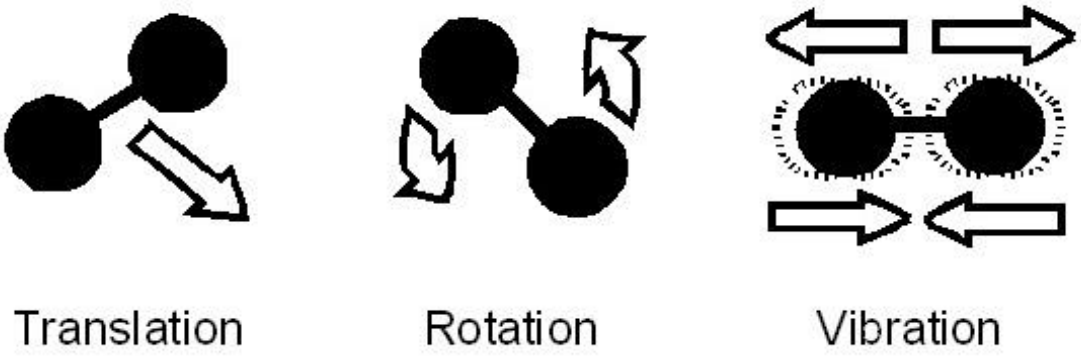
Melting point = _____

Have you ever accidentally left a plastic spoon or a plastic bowl on or near the stove. What happens to it?

How does the effect of the heat on the plastic differ from the effect of heat on the solid you put in the capillary tube?

2. Place an ice cube on a watch glass. Place a drop of food coloring on it and allow it to remain for about 2 minutes. Carefully remove and wipe the ice cube. Observe and describe what happened to the food coloring and relate how this is different from what happened when you added the food coloring to liquid water. (Ignore coloring that penetrates cracks or holes in the ice.)

Particles can exhibit three basic types of motion. The first is **translation** where whole particles change their location in three dimensional space; that is, they move from place to place. The second is **rotation** where the whole particles spin around an axis. The third type of motion is **vibration** where movement occurs within the molecule, ion or solid. During vibration, the unbonded atoms in elements or atoms that make up a particle (in ions or molecules) change position with respect to other atoms in the same particle (or other unbonded atoms in elements) without breaking bonds or overcoming intermolecular forces.



In a vibrating molecule are the bond lengths and bond angles constant? Explain.

Vibration is an intramolecular motion (occurs within the molecule or crystalline solid) which results in a change in the shape and size of the molecule. Bond lengths (distance between nuclei) or bond angles can increase and then decrease about an average value during vibration.

3. Based on what you already know from your experience and this activity, answer the following:

   If we could see the individual particles in any solid they would be (circle one):

   a. close together b. far apart

   My reason for saying that is:

   I think the particles in many solids have an arrangement of particles that is:

   a. regular b. random

   My reason for saying that is:

If an iron skillet is placed on a lit burner of the stove, the temperature of the iron will:

a. increase b. decrease c. remain the same

Because of this I think the particles of the solid are always?

a. motionless or not vibrating b. vibrating

My reason for saying this is:

All solids change to liquids (they melt) at:

a. same temperature b. different temperatures

As a solid changes to a liquid, which form of motion must now occur:

a. rotational b. translational c. vibrational

Based on this fact I can say the following about the strength of the forces holding the particles together in a solid compared to a liquid:

Name three *types of* particles that could make up the smallest pieces of various solids.

_____ _____ _____

A solid having which of the above particles might be the most difficult to melt? Why?

_____

Comparing States of Matter

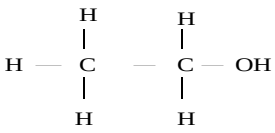
Now that you have had a chance to investigate the behaviors of solids, liquids, and gases, let's summarize and compare the three states of matter. Complete the table below with appropriate descriptive terms, such as small, fast, indefinite.

Property	Solid	Liquid	Gas
Volume			
Shape			
Relative density			
Compressibility			
Fluid?			
Space between particles			
Diffusion rate			
Motion of particles (amount and type)			
Forces between particles?			

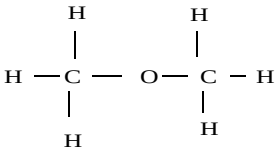
Post-Lab Questions:

1. At room temperature (25^{o}C), ethanol is a liquid while dimethyl ether is a gas. Their formulas are given below.

ETHANOL



DIMETHYL ETHER



a. What can you say about the molar masses of these two compounds? Is molar mass a factor in their state of matter at room temperature?

b. Think about the polarity of bonds and molecules. Can you determine a reason why ethanol is a liquid while dimethyl ether is a gas under the same conditions?

c. Using the ideal gas law, the definition of density, and the relationship moles = mass/molar mass, derive an equation by combining and rearranging terms that relates how gas density varies with temperature.

What are the units of gas density in this equation?

At 100^{o}C and 1.0 atm, ethanol and dimethyl ether are gases. Explain how their densities compare under these conditions and why.

d. Thinking about the characteristics of the three states of matter, make a general statement about the factors that affect density for solids and liquids compared to gases.