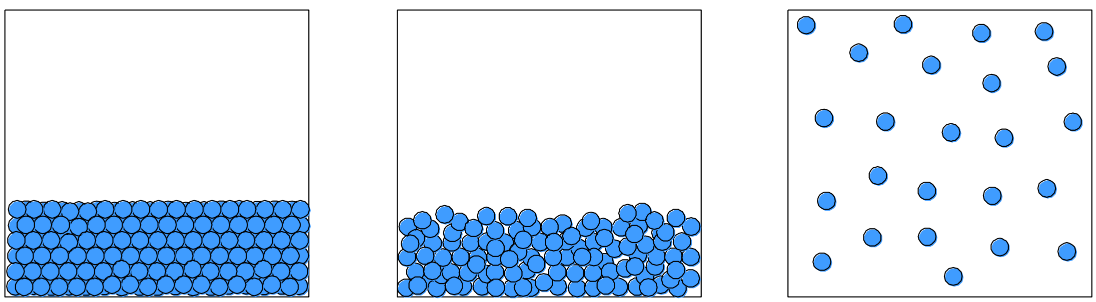
GCC CHM 107LL

States of Matter

Introduction

Substances can exist in three physical states (or phases): solid, liquid or gas. The difference between these phases is the possible movements of the atoms and molecules. This is related to the attraction between individual molecules and the temperature. In the solid state, molecules have relatively little energy and are held very close together in a rigid organized pattern. This keeps both the shape and the volume of the solid constant. The molecules in a solid only vibrate in place. The molecules in a liquid are also close together but flow around each other. Thus liquids have a constant volume, but not constant shape. High energy molecules move almost independently in a gas and are spread far apart. There is a great deal of empty space in a gas. Thus gases fill a container completely top to bottom, and assume its shape. Compressing a gas reduces the amount of empty space between molecules (and under certain conditions), gases can actually be liquefied (condensed) this way. Solids and liquids are basically incompressible.

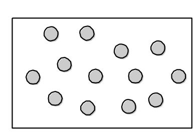


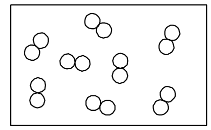
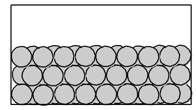
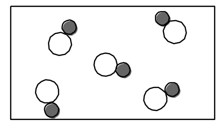
Solid Liquid Gas

Although more than one hundred elements exist; only two naturally occur in the liquid state. All other liquids are compounds. The two liquid elements are bromine and mercury. Many elements naturally occur as gases: hydrogen, nitrogen, oxygen, fluorine, chlorine, and all the noble gases (Group VIIIA elements). The remaining elements exist as solids.

It is important to remember that some elements occur with two atoms bonded together making a molecule. We call them **diatomic** elements, and they are as follows: H_2(g), N_2(g), F_2(g), O_2(g), I_2(s) Cl_2(g), and Br_2(l). Note the subscript 2 represents how many atoms of that element are bonded together in one molecule. You can easily remember these by the saying, "Have No Fear Of Ice Cold Beer!"

In chemistry, it is important to understand the difference between **elements, compounds, and mixtures**. A sample contains an element if there is only one type of atom in the sample. When someone says "atom", you should visualize a single sphere. The word compound means that two or more different atoms bonded together. A mixture contains different atoms and/or compounds. We can represent elements and compounds by drawing pictures of them. Here are some examples.

This picture could represent the element helium gas, He(g). The atoms are spread out like a gas and are not bonded together. The sample is pure since each atom is the same.	

This picture could represent a diatomic element like nitrogen gas, $N_2(g)$. The molecules are spread out like a gas and contain two of the same type of atom. This sample is pure since each molecule is the same.	
This picture could represent a solid element like pure gold, Au(s), because the atoms are very ordered and are all the same type.	
This picture could represent a gas, but it would be a compound not an element since the bonded atoms are different from each other. The sample is pure since each molecule is the same. It could be carbon monoxide gas, CO(g).	

Procedure

A. Watching animations.

Your instructor will show you several animations on the states of matter. These will help you answer some questions on your report sheet.

B. Densities of solids, liquids, and gases.

Gases: Note: gases cannot be weighed directly in air because of the "buoyancy effect" -- the same effect that causes you to feel "lighter" in a swimming pool. You will produce a gas with a chemical reaction, and weigh all the products except the gas. By subtracting the mass of the products (except the gas) from the mass of the reactants, you can calculate the mass of the gas.

> **CAUTION:** Hydrochloric acid, $HCl_{(aq)}$, is corrosive and can cause chemical burns as well as damage to clothing. Any hydrochloric acid spilled on skin must be rinsed immediately with water for 15 minutes. Any acid spilled on your work area must be neutralized, then the entire area should be washed and dried.
> **CAUTION:** Powdered $CaCO_3$ is a severe irritant. Rinse any spills up immediately and avoid breathing the dust.

1. Measure 10.0 mL of 2 M HCl (Hydrochloric acid) in your small graduated cylinder and carefully pour it into a 125mL Erlenmeyer flask using a funnel. Measure another 10.0 mL of acid and add it to the flask for a total of 20.0 mL.
2. Obtain a test tube containing about 4.0 grams of powdered $CaCO_3$ (Calcium carbonate) from the supply cart. This has been measured out for you.
3. Examine your balloon to make sure that it is free of holes. Stretch the balloon over the end of the test tube containing the $CaCO_3$. Invert the test tube and tap it to allow (most of) the $CaCO_3$ powder to drop into the balloon.
4. Place the balloon over the top of the Erlenmeyer flask but **DO NOT allow the CaCO3 to fall into the flask at this point**. See picture to the right.

5. Weigh the entire setup as seen in the picture. First make sure the balance reads 0.0000 grams with the door closed. (Push the O/T button if not) Write down **all** the numbers you see for the mass. This is the mass of the flask/balloon + reactants.
6. Remove the flask from the balance. Invert the balloon over the Erlenmeyer flask and shake the powdered $CaCO_3$ into the HCl. The gas produced is CO_2 (Carbon dioxide).
7. When the balloon has reached maximum size, estimate its volume by comparing it to the spherical glass flasks provided at the instructor's cart.
8. Slip the balloon off the Erlenmeyer flask to allow the CO_2 to escape.
9. Reattach the balloon and again weigh the setup. This is the mass of the flask/balloon + all products except the CO_2 gas.
10. Return the dry **unwashed** test tube to the supply cart. Keep the balloon in your tub.
11. Pour the "leftover" slurry into the waste container provided. Rinse everything you used with water. Do not dry the inside of the flask or cylinder.
12. Calculate the mass of the CO_2 gas.

Liquids: Note: Liquids can be weighed in a container, and the weight of the container subtracted to obtain the liquid weight.

1. Weigh an empty 10.0 mL graduated cylinder.
2. Add 10.0 mL of deionized water and reweigh (cylinder + water).
3. Calculate the mass of the 10.0 mL of water.

Solids: Note: Nonreactive solids (glass, pieces of metal, plastic) can be weighed directly on the balance. Chemicals used for experiments must be weighed in containers, however. Choose a metal from the supply cart, assume the volume is 10.0 mL and weigh it.

Density: The term that scientists use to compare the relative masses of equal volumes of materials is density. In the metric system, density is expressed as grams per milliliter. To calculate the density, divide the mass (in grams) of the sample by the volume (in mL) of the sample. Thus the unit for density is g/mL. (This is similar to calculating the gas mileage of your car by dividing the number of miles traveled by the number of gallons of gas used. The unit is miles/gallon or miles per gallon). Calculate the density of CO_2 gas, water, and the solid you used. Round off the density to 4 places past the decimal for the gas, and the densities for water and the solid to 2 places past the decimal.

Example: Pretend a liquid weighs 14.5354 grams and has a volume of 12.4 mL.
Density = 14.5354 g / 12.4 mL = 1.17 g/mL

C. Separating a Mixture

A **mixture** can be separated by physical methods, that is, by methods that don't require chemical reactions. Common separation methods include filtering, distilling, and evaporating.

Your task is to separate a mixture of sand and salt. Obtain one vial of the sand with salt mixture per group and develop your own procedure to separate the mixture. Get your instructor's approval and initials for your procedure BEFORE you begin. Once you have successfully separated the sand from the salt, show your instructor and get initials again.

States of Matter Report Sheet Name: ______________________________

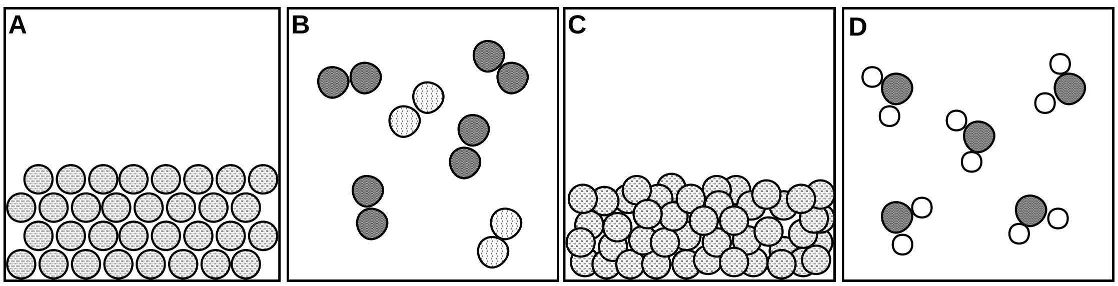
GCC CHM 107LL Lab Partner: ___________________________

A. Watching Animations

In the boxes below, draw **gas** samples made of **A**) atoms, **B**) a diatomic element, **C**) a pure compound, and **D**) a mixture.

A	B	C	D

Match the following figures with their most likely sample by putting the letter for each figure in front of each description below the images.



________ Solid zinc metal

________ Pure liquid mercury

________ Pure H_2O in the gas state

________ Mixture of oxygen and nitrogen gases

In the box below draw a picture of **ten atoms** in the solid state.

Circle the correct answers.

	Do atoms in the solid state move? Yes No Do solids have a constant shape? Yes No Do solids have a constant volume? Yes No

In the box below draw a picture of the **same ten atoms** in the liquid state.

Circle the correct answers.

	Do atoms in the liquid state move? Yes No Do liquids have a constant shape? Yes No Do liquids have a constant volume? Yes No

In the box below draw a picture of the **same ten atoms** in the gas state.

Circle the correct answers.

	Do atoms in the gas state move? Yes No Do gases have a constant shape? Yes No Do gases have a constant volume? Yes No

B. Densities of solids, liquids, and gases.

Gases:

Mass of flask/balloon + reactants ________________ g

Mass of flask/balloon + all products **except** CO_2 ________________ g

Mass of CO_2 gas ________________ g

Estimated volume of CO_2 gas ________________ mL

Liquids:

Mass of graduated cylinder + water ________________ g

Mass of graduated cylinder only ________________ g

Mass of water ________________ g

Volume of water ________________ mL

Solids:

Material composing the solid ________________

Mass of solid ________________ g

Volume of solid assume volume = 10.0 mL

Density Calculations: Divide mass by volume. **Show setups in the blanks**

CO_2 gas _____________g / ________________mL = _______________ g/mL

Water _____________g / ________________ mL = _______________ g/mL

Solid _____________g / ________________ mL = _______________ g/mL

According to the above calculations, which state of matter is least dense? ___________

Which state of matter is most dense? __________________

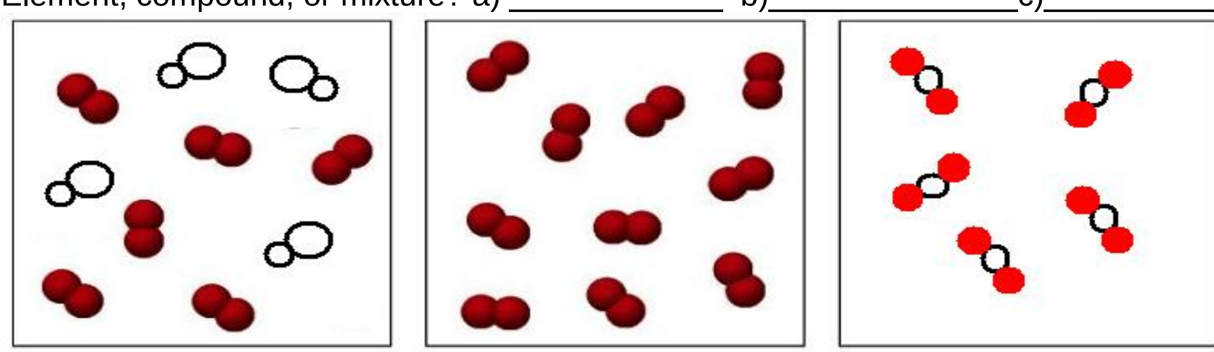
C. Separating a Mixture

Explain your procedure for separating sand and salt. Include details.

Instructor approved procedure _______ Instructor saw successful separation _____

Post-lab questions:

1. What is the only naturally occurring liquid element that is not diatomic? ________
2. What element occurs naturally as a diatomic solid? ______________
3. Draw two ozone molecules (O_3) in this box.
4. Why would a gram of solid CO_2 take up so much less space than a gram of CO_2 gas? (They each contain the same number of molecules)
5. Element, compound, or mixture? a) ____________ b)______________c)_____________



(a) (b) (c)