Part I – Exploring Simple Mixtures

Background

There are a wide variety of materials in the world. Some are natural and some are man-made. Some are pure substances and others are mixtures. The properties of each type of material can be explained by the composition, interaction, and arrangement of the particles that make it up. In this investigation, you will perform a series of simple laboratory tests to classify different types of mixtures. To explain your observations, you will consider how the different parts of each type of mixture interact when mixed.

To characterize each mixture, you will look for the following:

- What does it look like?
  - Visual observations can be very informative. Be sure to record everything that you see.
- Will it settle over time?
  - You will use a centrifuge to speed up any settling that might occur if we let it sit overnight.
- Can the parts be separated easily?
  - You will attempt to filter the mixture through filter paper to see if the particles are different enough in size to be filtered.
    - Atoms are about $10^{-12}$ meters in size
    - Small molecules are about $10^{-11}$ meters in size
    - The pore size on the filter paper is about $10^{-6}$ meters wide
    - The smallest size a human eye can perceive is about $10^{-4}$ meters
- How big are the particles?
  - Light can be absorbed, transmitted, or reflected. We will focus only on reflection of light
  - If light simply passes through a sample, then none of the particles were large enough to change the direction of the light. You will see the light come out the other side, but will not see it inside the sample.
  - If particles in a mixture are very large, the light reflects off the particles and you see the particles.
  - If particles are of an intermediate size, they will not be visible, but will scatter the light because they are large enough, at least 1 nm ($10^{-9}$ meters), to have a surface that the light can bounce from. In this case, you will see a beam of scattered light inside the mixture.
**Pre-lab Questions**
Define the following:

- Homogeneous mixture
- Heterogeneous mixture
- Solution
- Solute
- Solvent

**Objective**
To classify mixtures based on the results of simple laboratory tests.

**Materials**
- 18 medium-size test tubes w/ stoppers in 2 racks
- 7 funnels
- 7 small flasks (or other container to hold funnels during filtration)
- 7 filter papers
- 1 Spatula
- 1 plastic pipet
- 1 Test tube tongs
- 1 Penlight
- 1 Napkin or porous paper towel
- 1 Candle and match
- Centrifuge (in a central location)
- Tap water
- Small container of each solid:
  - Salt
  - Mud
  - Drink mix powder
  - Flour
- Small container of each liquid w/ dropper:
  - Tap water
  - Food dye
  - Milk
  - Oil

**Safety**
- **When using centrifuge, samples must be in a balanced arrangement!**
- Always wear safety goggles when handling chemicals in the lab.
- Do not consume lab solutions, even if they’re otherwise edible products.
- Always be aware of an open flame. Do not reach over it, tie back hair, and secure loose clothing.
- When lighting the match and wooden splint, be cautious with the flame.
- Open flames can cause burns. Liquid wax is hot and can burn the skin.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher’s instructions for cleanup of materials and disposal of chemicals.
Procedure
You will be working in groups of four.

1. Label 1 rack the “Filtration” rack and the other one the “Centrifuge” rack.
2. Assign each group member to create two of the mixtures in the chart below using the following directions:
   a. Label 2 test tubes for each mixture. Place one tube in each rack.
   b. Use the directions in the chart to create your assigned mixture in the “Filtration” tube and then place the tube with mixture back in the rack to be tested. (The “Centrifuge” tubes should remain empty)
   c. For the “smoke + air” tube, repeat the procedure for BOTH tubes (“Filtration” and “Centrifuge”) and set one each rack.

<table>
<thead>
<tr>
<th>Directions for creating mixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salt + water</strong></td>
</tr>
<tr>
<td>Fill about ¾ of the test tube with water. Use a spatula to collect a sample of salt about the size of a grain of rice. Add this to the tube. Put a stopper on the tube and shake it until mixed.</td>
</tr>
<tr>
<td><strong>Food dye + water</strong></td>
</tr>
<tr>
<td>Fill about ¾ of the test tube with water. Add one drop of food coloring. Put a stopper on the tube and invert it a few times until mixed.</td>
</tr>
<tr>
<td><strong>Milk + water</strong></td>
</tr>
<tr>
<td>Fill about ¾ of the test tube with water. Use a plastic pipet to add 4 drops of milk to the water. Put a stopper on the tube and invert it a few times until mixed.</td>
</tr>
<tr>
<td><strong>Mud + water</strong></td>
</tr>
<tr>
<td>Fill about ¾ of the test tube with water. Use a spatula to collect a sample of mud about the size of a grain of rice. Add this to the tube. Put a stopper on the tube and shake it until it is well-mixed.</td>
</tr>
<tr>
<td><strong>Drink powder + water</strong></td>
</tr>
<tr>
<td>Fill about ¾ of the test tube with water. Use a spatula to collect a sample of drink powder about the size of a grain of rice. Put a stopper on the tube and shake it until dissolved.</td>
</tr>
<tr>
<td><strong>smoke + air</strong></td>
</tr>
<tr>
<td>Light a candle. Use test tube tongs to hold a test tube inverted over the candle and slowly lower the tube until it touches the candle. Hold it until the candle is extinguished and a good deal of smoke collects. Remove the candle and place a stopper on the tube.</td>
</tr>
<tr>
<td><strong>Salt + oil</strong></td>
</tr>
<tr>
<td>Fill about ¾ of the test tube with oil. Use a spatula to collect a sample of salt about the size of a grain of rice. Add this to the tube. Put a stopper on the tube and shake it until mixed.</td>
</tr>
<tr>
<td><strong>Flour + water</strong></td>
</tr>
<tr>
<td>Fill about ¾ of the test tube with water. Use a spatula to collect a sample of flour about the size of a grain of rice. Add this to the tube. Put a stopper on the tube and shake it until mixed.</td>
</tr>
</tbody>
</table>

3. After mixing the contents of each tube, allow the tubes to settle for about a minute. You will not be analyzing any “leftover” solids that collect at the bottom quickly. This just means that too much solid was added to the system.
4. Closely observe the mixed portion of each tube. In the “Initial” Visual Observations column of your data table, write down observations about what you see. Pay close attention to whether or not you can see “parts” of each mixture. Be as descriptive as you can.
5. Shine the beam of a penlight through each sample. In the **Initial** Beam? column, record whether you can see the beam inside the sample, along with any other observations.

6. Use a pipet to transfer about half of the mixed portion of each sample into the corresponding empty tube in the Centrifuge rack (except “smoke + air” because that should already have the smoke.) Two people should centrifuge the samples in the Centrifuge rack while the other two filter the samples in the Filtration rack.
   a. **Centrifuge**: Place the tubes in a balanced arrangement in the centrifuge. Set the timer to spin at full speed for 2 minutes. Then, return the tubes to the rack and bring them back to your table. Be sure to handle the tubes gently, so they do not re-mix after centrifuging.
      i. **When centrifuging the “smoke+air” tube, be sure to balance it in the centrifuge with either an empty tube w/ stopper or with another group’s “smoke+air” tube.**
   b. **Filtration**: Set up 7 funnels with filter paper for filtration. Carefully pour only the mixed portion of each of the liquid samples into one of the funnels.
      i. To filter the smoke, take a plastic pipet and suction some smoke from the smoke tube into the pipet.
      ii. Wrap a napkin or porous paper towel around the tip and then expel the contents through the paper towel and into the empty test tube. Repeat this until you think you transferred all of the smoke. Stopper the new tube.
         1. In steps 6a and 6b, you will use this new tube to observe and test with the penlight.

7. When all tubes have been centrifuged and filtered;
   a. Record observations in the appropriate columns of the data table. Be sure to note any changes from the initial observations.
   b. Shine light through each sample again and record results in the data table.

8. Discard into the trash can all substances on filter papers.

9. Check with your teacher before pouring liquid samples down the drain.

10. Wash all tubes and spatulas with soap and water and return them as designated by your teacher.
# Observations and Results

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt + water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food dye + water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk + water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mud + water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drink powder + water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>smoke + air</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt + oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flour + water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analysis

1. Consider the observations and results you obtained for your samples. Categorize the eight samples into three groups, based on your observations and testing. Give each group a heading that indicates how that group is different from the others.

2. Each mixture was a combination of two things, with one being more abundant and the other being less abundant
   a. Which of your groups had the largest particle size for the less abundant part of the mixture? What is your evidence?

   b. In which of your groups were the particles of the two parts of the mixture the most attracted to each other? What is your evidence?
3. Think about the mud + water mixture. In a stream or a pond, there is a lot of muddy water. Some of the mud stays at the bottom, while some of it stays in the water.
   a. If the water from the stream could settle overnight without movement, would any of the mud stay mixed in the water? Use evidence from your exploration to justify your answer.

4. The Background stated that, “The properties of each type of material can be explained by the composition, interaction, and arrangement of the particles that make it up.” Using evidence from the exploration, discuss how the composition, interaction, and arrangement of particles caused different properties for each of your three groupings from question 1.

Conclusion
Read the information on the following page, then answer the questions that follow.
Information
You may have noticed during your mixture exploration that the distinction between heterogeneous and homogeneous matter is not always easy to make. Below are some definitions to help clarify what you observed:

- **Solution** – a solute is dissolved in a solvent. The solute is broken down to a molecular level and is evenly spread throughout the more abundant solvent, making a homogeneous mixture. The solutes and solvents may be any combination of solid, liquid, and gas.
  - Examples:
    - Air (Nitrogen would be the solvent, as it is the most abundant. All other gases are the solutes.)
    - Brewed iced tea (Water is the solvent. Molecules from within the tea leaf that give color and flavor are the solutes.)
    - Some alloys (One metal is often present in greater abundance. If the alloy is a true solution, then the individual metal atoms of the solute are spread evenly throughout the metal atoms of the solvent.)

- **Suspension** – A mixture that has visible pieces of one substance well-mixed throughout another substance. This is heterogeneous, because the parts are visible, but is different from something like fruit salad because the parts are dispersed throughout. This mixture will eventually settle and become two distinct phases. The more abundant substance is called the “dispersing medium”, and the less abundant substance is called the “dispersed phase”.
  - Examples:
    - A snow globe (The solid “snow” is the dispersed phase inside the liquid dispersing medium. This is only a suspension for a little while, as the snow eventually settles.)
    - Dust in the air (The dust is very fine and is spread throughout the air, but it will eventually settle onto a surface, due to gravity.)
    - Latex paint (If you’ve ever bought a can of paint to paint your bedroom walls, you may have noticed that the store puts it on a shaker before giving it to you. That is because some of the particles will settle over time.)

- **Colloid** – A mixture with particles that are too large to dissolve, but too small to settle out. The particles are not broken down all the way to molecule-size, and stay in clusters. In some cases, the particles may actually be very large molecules (macromolecules, like proteins). The interaction between the molecules of the dispersed phase and those of the dispersing medium stabilize the arrangement and allow it to remain homogeneous on a macroscopic level. If observed at a particle-level, this type of mixture is heterogeneous.
  - Examples:
    - Milk (A heterogeneous mixture of water and butterfat, which is shaken with a certain protein that allows it to stay homogeneous, thus being classified as a colloid.)
    - Clouds (Water particles are the dispersed phase, while air is the dispersing medium. Note that if the particles were individual molecules it would just be water vapor, and thus, a solution.)
    - Whipped cream (Air particles are the dispersed phase and cream is the dispersing medium.)
Conclusion Questions

1. Using the information above, classify each of the studied mixtures as either a solution, a suspension, or a colloid. For each mixture, identify the **solute** and **solvent** or the **dispersed phase** and the **dispersing medium**.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Suspension</th>
<th>Colloid</th>
</tr>
</thead>
</table>

2. Compare your classifications to the way that you grouped the mixtures in the analysis (Analysis Question 1). Comment on any differences in your groupings and state the evidence that allows you to classify it as you did in the above table.