**Lesson 6 – Density of Liquids and Why they Float or Sink**

**Storyline Summary:**

Now that students understand more about the density of solids, introduce the idea that liquids also have density. Students discuss the contents of the Lava Lamp and why it may be helpful to understand the density of liquids. Some students may already know that density is related to sinking and floating. You could discuss this as an important factor to consider in understanding how the Lava Lamp works.

Students measure the mass of different volumes of water and other liquids and calculate their densities to determine whether the density of the liquid affects whether it sinks or floats in water.

**What Students Do**

**Part 1** – Students calculate the density of different volumes of water. (They have the volume and mass measurements from Lesson 3). Students discover that water has a density of 1 g/cm3 and stays the same regardless of the size of the sample.

**Part 2** – Students measure the mass of the same volume of vegetable oil and isopropyl alcohol to discover they all have a different density and float and sink in each other in a predictable way.

**What Students Learn**

* Density = mass/volume. The density of a liquid is a characteristic property of that liquid and can be used to identify it.
* The density of a substance is the same regardless of the size of the sample.
* The molecules of different liquids have different size and mass.
* The mass and size of the molecules in a liquid and how closely they are packed together determine the density of the liquid.
* Liquids can float and sink in other liquids depending on their densities.

**Materials & Preparation:**

**Part 1**

* Mass and Volume data for water from Lesson 3

**Part 2**

* DQB
* Water
* Isopropyl alcohol (at least 90%)
* Vegetable oil
* Graduated cylinder
* Balance that measures in grams (able to measure over 100 g)
* Dropper

***Evaluation***

The activity sheet will serve as the “Evaluate” component of each 5-E lesson plan. The activity sheets are formative assessments of student progress and understanding. A more formal summative assessment is included at the end of each chapter.

 ***Safety***

Make sure you and your students wear properly fitting goggles.

**Part 1 – Density of Water**

**ENGAGE**

**Lead a discussion about why understanding the density of liquids may be helpful in understanding why the blobs move up and down.**

By this point, students have probably mentioned that the density of the blobs in the Lava Lamp has something to do with why they float and sink. You can mention that the density of the surrounding liquid probably matters too. Use this idea to stress that to understand how the Lava Lamp works, it’s important to understand the density of liquids, and that’s what students will focus on in this lesson.

**Give each student an Activity Sheet for Part 1.**

The activity sheet will serve as the “Evaluate” component of each 5-E lesson plan. The activity sheets are formative assessments of student progress and understanding.

**Density of Water**

(From Middle School Chemistry, Chapter 3, Lesson 5)

**EXPLORE**

1. **Have students calculate the density of water to see if the density of water depends on the size of the sample.**

**Note:** In Lesson 3, students measured the mass of 25 mL, 50 mL, and 100 mL of water as part of an investigation of mass. Here, students will use their mass and volume measurements to calculate the density of water for each sample.

**Expected results**

The density of water should be close to 1 g/cm3. This is true for 100, 50, and 25 mL.

Ask students:

* + **Look at your values for density in your chart. Does the density of the different volumes of water seem to be about the same?**

Help students see that most of the values for density are near 1 g/cm3. They may wonder why their values are not all exactly 1 g/cm3. One reason could be inaccuracies in measuring. Another reason is that the density of water changes with temperature. Water is most dense at 4 °C and at that temperature has a density of 1 g/cm3. At room temperature, around 20–25 °C, the density is about 0.99 g/cm3.

Ask Students:

* + **What is the density of water in g/cm3?**

Students’ answers will vary, but most of their values should be around 1 g/cm3.

1. **Have students graph their results.**

Help students make a graph of the data on their activity sheet. The x-axis should be volume and the y-axis should be mass.

When students plot their data, there should be a straight line showing that as volume increases, mass increases by the same amount. If the points do not fall on an exact straight line, have students draw a line of “Best fit”.



**EXPLAIN**

1. **Discuss student observations, data, and graphs.**

Ask students:

* + **Use your graph to find the mass of 40 mL of water. What is the density of this volume of water?**

The mass of 40 mL of water is 40 grams. Since D = m/v and mL = cm3, the density of water is 1 g/cm3.

* + **Choose a volume between 1 and 100 mL. Use your graph to find the mass. What is the density of this volume of water?**

Whether students weigh 100, 50, 25 mL or any other amount, the density of water will always be 1 g/cm3.

Remind students that density is a characteristic property of a substance and that they have already seen this for solids. This means that the density of a substance is the same regardless of the size of the sample.

Ask students:

* + **Is density a characteristic property of water? How do you know?**

Density is a characteristic property of water because the density of any sample of water (at the same temperature) is always the same. The density is 1 g/cm3.

1. **Explain why the density of any size sample of water is always the same.**

**Project the image *Density of Water*.**

[www.acs.org/middleschoolchemistry/simulations/chapter3/lesson3.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson3.html)

Water molecules all have the same mass and size. Water molecules are also packed close together. They are packed the same way throughout an entire sample of water. So, if a volume of water has a certain mass, twice the volume will have twice the mass, three times the volume has three times the mass, etc. No matter what size sample of water you measure, the relationship between the mass and volume will always be the same. Because D=m/v, the density is the same for any amount of water.

**Project the animation *Liquid Water*.**

[www.acs.org/middleschoolchemistry/simulations/chapter3/lesson3.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson3.html)

Water molecules are always moving. But on average they are packed the same throughout. Therefore, the ratio between the mass and volume is the same, making the density the same. This is true no matter the size of the sample or where you select your sample from.

**Part 2 - Density of Different Liquids**

(From Middle School Chemistry – Chapter 3, Lesson 5)

**Materials for the demonstration:**

* Graduated cylinder
* Vegetable oil\*
* Balance that measures in grams

**\*Note:** This activity is written for students to make measurements of the mass and volume of water and alcohol and to calculate the density of each liquid. The mass and volume of oil will be measured by the teacher in a demonstration prior to students making their measurements. Emphasize to students that they should be sure to accurately measure the volume and mass of each liquid.

**ENGAGE**

1. **Demonstrate measuring the volume and mass of vegetable oil and calculating the density.**

Measuring oil in graduated cylinders is messy and difficult to clean up so it is easier if you demonstrate measuring the volume and mass of the oil and students use the data calculate density.

1. Find the mass of an empty graduated cylinder. Record the mass so students can see it.
2. Pour 25 mL of vegetable oil into the graduated cylinder.
3. Weigh the graduated cylinder with the oil in it. Record the mass in grams.
4. Find the mass of only the oil by subtracting the mass of the empty graduated cylinder from the mass of the graduated cylinder with oil in it. Record the mass of 25 mL of oil.
5. As a class, use the mass and volume of the oil to calculate density. Record the density in g/cm3.

**EXPLORE**

**2. Give students an Activity Sheet for Part 2 and have students measure the mass and volume of alcohol and calculate its density.**

**Question to investigate**

How do the densities of water, isopropyl alcohol, and oil compare?

**Materials for each group**

* Isopropyl alcohol (70% or higher)
* Graduated cylinder
* Balance that measures in grams

**Procedure**

* 1. In the chart, record the values you already have for water (from Lesson 3) and for vegetable oil from the demonstration done by your teacher.
	2. For the alcohol, find the mass of an empty graduated cylinder. Record the mass in grams in the chart on the activity sheet.
	3. Pour 25 mL of alcohol into the graduated cylinder. Try to be as accurate as possible by checking that the meniscus is right at the 25 mL mark.

4. Weigh the graduated cylinder with the alcohol in it. Record the mass in grams.

5. Find the mass of only the alcohol by subtracting the mass of the empty graduated cylinder from the mass of the graduated cylinder with alcohol in it. Record the mass of 25 mL of alcohol in the chart.

6. Use the mass and volume of the alcohol to calculate its density. Record the density in g/cm3 in the chart.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Water (25 mL)** | **Alcohol (25 mL)** | **Oil (25 mL)** |
| Mass of graduated cylinder + liquid (g) |   |  |  |
| Mass of empty graduated cylinder (g) |  |  |  |
| Mass of Liquid (g) |  |  |  |
| Density of Liquid (g/cm3) |  |  |  |

**EXPLAIN**

**3. Show the molecular models of oil, water, and alcohol to explain how the atoms and molecules affect the densities of the liquids.**

Depending on the mass and size of the molecules that make up different liquids and how closely they pack together, liquids have their own characteristic densities.

**Oil**

Project the image Oil: [www.acs.org/middleschoolchemistry/simulations/chapter3/lesson5.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson5.html)

Tell students that molecules of oil are mostly made of carbon and hydrogen atoms bonded together in long chain-like molecules.

 **Water**

Project the image Water

[www.acs.org/middleschoolchemistry/simulations/chapter3/lesson5.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson5.html)

Water molecules are made up of oxygen and hydrogen atoms bonded together. Oxygen is heavier and smaller than carbon, so a volume of water molecules is heavier than the same volume of oil molecules. This makes water more dense than oil. Also, water molecules are very attracted to each other and pack very close together. This is another reason why water is more dense than oil.

**Isopropyl Alcohol**

Project the image Alcohol

[www.acs.org/middleschoolchemistry/simulations/chapter3/lesson5.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson5.html)

Alcohol is less dense than oil. Alcohol molecules are mostly carbon and hydrogen atoms so they are similar to oil. But they also contain an oxygen atom, which makes them a little heavy. For this reason, you might think that alcohol would be *more* dense than oil. But alcohol molecules do not pack very tightly together. Because of their shape and size, alcohol molecules do not pack as efficiently as oil molecules, making alcohol less dense than oil.

**4. Ask students to predict which liquid will float or sink in the other liquids, and then demonstrate by making a density column with water, oil, and alcohol.**

**Materials for the demonstration**

* Graduated cylinder
* Water
* Vegetable oil
* Isopropyl alcohol, 70% or higher

***Note****: If you would like the liquids to be more visible, add 1 drop of food coloring to the water and another drop of a different color to the alcohol.*

**Procedure**

1.Pour about 15 mL of water into the graduated cylinder. Gradually add about 15 mL of oil. Then slowly pour about 15 mL of alcohol on top. The liquids should form layers in the graduated cylinder.

2. Show students the layered liquids in the graduated cylinder and point out that the alcohol floats on the oil while the water sinks in the oil.

**Expected results**

Alcohol floats on oil, and water sinks in oil. Water, alcohol, and oil layer well because of their densities, but also because the oil layer does not dissolve in either liquid. The oil keeps the water and alcohol separated so that they do not dissolve in one another.

**5. Discuss floating and sinking so that students know that a substance that is less dense than the liquid it is placed in floats, and a substance that is more dense than the liquid it is placed in sinks.**

**Ask students:**

* **Why does the alcohol float on the oil?**

Students should conclude that the alcohol floats on the oil because it is less dense than the oil.

* **Why does the water sink in the oil?**

Water sinks in oil because it is more dense than oil. Review with students that depending on the mass of the molecules that make up a liquid and how closely they pack together, liquids have their own densities.

**EXTEND**

**6. Discuss how understanding density could be useful in answering the question, “How does a lava lamp work?”**

Explain to students that even though they will not be able to measure the density of the actual blob material in the Lava Lamp, or determine what the material is actually made of, they will still be able to use density to understand and explain how the Lava Lamp works. The fact that the blobs sometimes float and sometimes sink must have something to do with their density or the density of the liquid they are in, or both.

Let students know that in the next lesson, students will take a closer look at density’s role in floating and sinking.