**Part 2: What is the Density of an Egg?**

**Objective of the Lab**

Assessing the density and the variation of density of eggs.

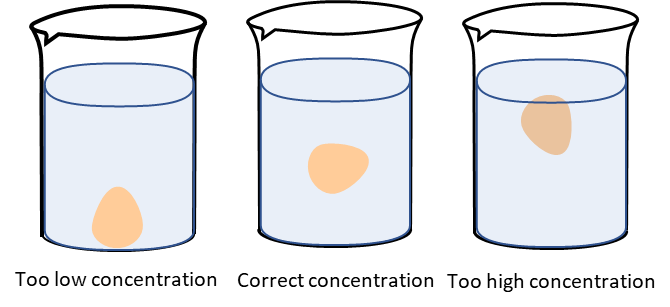
**Introduction**

Back in the days before there were digital balances, people had to get creative to devise ways for (to obtain) relatively accurate measurements, for example for density. In the process of soap making, in addition to using animal fat, wood ash was boiled to extract lye (which was mostly K2CO3 and KOH). The concentration of the lye solution was tested by gauging its density with… an egg! If the egg sank, the solution was too dilute, if it floated on the surface, it was too concentrated, and if it freely floated in the solution, it had the right concentration (see Figure 1). In fact, the buoyancy of the egg was a measure of density, which in turn was a measure of the concentration. Later, more sophisticated instruments, such as hydrometers (see Figure 2) were used based on the same principle to measure density more accurately. Even today, hydrometers are used, for example to gauge the density (and the concentration) of battery acid in car batteries.

|  |
| --- |
| Hydrometer |

There is one caveat to the floating egg problem. The eggshell (mostly CaCO3) is porous and it allows water to leave slowly. Also, when the egg starts to go bad, the organic molecules inside start to decompose and form gases, most of which also leave, otherwise the egg would blow up (and if you had the pleasure to experience a cracked bad egg, you must have smelled the gases that formed). Therefore, the mass of the egg can change over time, however its volume doesn’t change since it has a hard shell.

**Figure 1 Figure 2**



**Materials**

* 400-mL beaker
* 150 mL beaker (3)
* Spatula
* About 50 g table salt
* Plastic weighing dish
* A fresh and an older egg
* Balance

**Procedure/Observations**

|  |  |  |
| --- | --- | --- |
| **Step** | **Description** | **Observations/Notes** |
| 1. | Pour about 300 mL water into a 400-mL beaker. |  |
| 2. | Obtain a fresh and an older egg, and record their numbers and expiration dates on the data sheet. |  |
| 3. | Fill a plastic weighing dish 2/3rd with table salt. No need to weigh the dish or the salt. |  |
| 4. | Using a spatula carefully lower the fresh egg into the water. Record your observation. |  |
| 5. | Add a pea-size volume of salt to the water and carefully stir it with a glass rod, so as not to crack the egg, yet to dissolve the salt. Observe the position of the egg. |  |
| 6. | Keep adding about the same amount of salt each time, followed by stirring, to dissolve the salt until the egg starts to float and remains floating in the solution.  Note:   * You can remove the egg carefully before adding more salt to allow more effective stirring. * Make sure there are no crystals left undissolved before adding more salt. * When you think the egg is floating, allow the egg to position itself. You can also move it to the surface, to see if it moves down a bit, and push it to the bottom to see if it rises. Each time allow a few seconds for the egg to position itself. * If you added too much salt and the egg rises to the surface, add a few mL water and mix until the egg floats in the middle. |  |
| 7. | When the egg is floating, weigh three 150-mL beakers and record their masses. | Record masses in the table. |
| 8. | Transfer 10.00 mL of the solution, using a 10-mL pipet, into each weighed 150-mL beaker, weigh them again, and record their masses.  Note:   * Mark the beakers to avoid mixing them up. * Transfer the solutions back into the beaker when done weighing. | Record masses in the table. |
| 9. | Replace the fresh egg with the older one. Record your observation. |  |
| 10. | Add a few mL water to the solution and mix it well with the glass rod and observe if the egg floats. |  |
| 11. | Keep adding a few mL of water at a time, followed by mixing, until the egg floats. |  |
| 12. | Weigh three 150-mL beakers and record their masses. | Record masses in the table. |
| 13. | Transfer 10.00 mL of the solution into each weighed beaker, weigh them again, and record their masses. | Record masses in the table. |
| 14. | Dispose of the solution and clean the used glassware as instructed. |  |

**Data Table**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Fresh egg**  **Number: Exp. Date: \_\_/\_\_/\_\_)** | | | | | **Older egg**  **Number: Exp. Date: \_\_/\_\_/\_\_** | | | | |
| **Trial** | **Beaker**  **( )** | **Beaker+solution**  **( )** | **Solution**  **( )** | **Volume**  **( )** | **Beaker**  **( )** | | **Beaker+solution**  **( )** | **Solution ( )** | **Volume ( )** |
| 1. |  |  |  |  |  | |  |  |  |
| 2. |  |  |  |  |  | |  |  |  |
| 3. |  |  |  |  |  | |  |  |  |
|  |  | Average: |  |  |  | | Average: |  |  |
|  |  | Density: |  |  |  | | Density: |  |  |

**Note:** It is assumed that the volume is 10.00 mL for each measurement. Mark the appropriate units in the table.

Show your calculations of density. Use appropriate units

**Note:** Incorporate appropriately your observations and the data table in your report.

**Pre-Lab Questions**

1. How do you think the density varies with an increasing concentration of a solute?
2. Assume you place the egg in a beaker with water. Based on the soap making procedure, do you think the egg will float on the surface, sink, or float in the middle?
3. If you think it is not floating, using table salt (lye is caustic and hazardous), propose a way to make the egg float.
4. Assume that you not only made the egg float but it ended floating on the surface. Why do you think that happened? How can you rectify this situation?
5. How does the density of the egg (*d*egg) compare to the density of the solution (*d*sol) in the situation in the previous question? Circle your answer.



1. Assume that the egg floats in the middle of the liquid. How does the density of the solution compare to the density of the egg in this situation? Circle your answer.



1. Assume you have an older egg as well. How do you think the density of the older egg compare to the density of the fresh egg (more, less, the same)? Explain your reasoning.

**Post-Lab Questions**

1. Assuming you start the experiment with twice the amount of water, how much salt do you think you would need to make the egg float?
2. Considering the definition of density, and your answer to the previous question, does the density depend on the amount of solution?
3. Based on your answer to the previous question, is density an intensive or extensive property? Explain.
4. How do you think the density of a hard-boiled egg would compare to the density of a fresh and older raw egg? Explain your reasoning (Hint: the egg shell allows water to leave, but also to seep in).
5. Why do you think your body would sink in a fresh water pond, but it would float on the surface of sea water?
6. **Bonus:** Submarines can float on the surface, hover at a certain depth, or sink to the bottom. How do you think they can do that?