

Introduction to Inquiry – The Floating Egg Problem

Purpose

The objectives of this lab were to determine the density of an H₂O and NaCl solution that will float an egg, and to gain experience with volumetric glassware used to contain and deliver liquid substances.

Introduction

In this lab we were to determine the amount of lye (sodium hydroxide) to be added to water to make a solution that is used for making soap. However for safety reasons we substituted table salt (NaCl, sodium chloride) for lye. We were to determine an easy way to manufacture this solution in a hypothetical third world country with limited resources. In the past the proper mixture for the solution was established by floating an egg in the solution. If the egg floated just below the surface of the solution, the mixture was correct.

Procedure

- 1) Obtain a raw egg
- 2) Weigh egg
- 3) Measure volume of egg by displacement in H₂O
- 4) Obtain a large beaker (in excess of 1000ml) and weigh
- 5) Measure 1000ml H₂O and weigh
- 6) Add NaCl in 10g increments until egg just floats
- 7) Weigh 25ml volumetric flask
- 8) Measure 25ml of solution in volumetric flask
- 9) Weigh solution and flask
- 10) Weigh 100ml beaker
- 11) Measure 50 ml solution in buret
- 12) Empty contents of buret into 100ml beaker
- 13) Weigh beaker and solution
- 14) Empty solution from beaker, dry, and reweigh
- 15) Measure 25ml of solution in volumetric pipette
- 16) Empty contents of volumetric pipette into 100ml beaker
- 17) Weigh beaker and solution
- 18) Empty solution from beaker, dry, and reweigh
- 19) Measure 10ml of solution in mohr pipette
- 20) Empty contents of mohr pipette into 100ml beaker
- 21) Weigh beaker and solution
- 22) Empty solution from beaker, and dry

Data and Observations

Table 1: Egg Measurements

mass (g)	volume (ml)
48.13	42

Table 2: Volumetric Flask Measurements

Trial Number	Final Mass (g)	Initial Mass (g)	Volume (ml)
1	45.82	19.41	25

Table 3: Buret Measurements

Trial Number	Final Mass (g)	Initial Mass (g)	Volume (ml)
1	148.55	95.55	50

Table 4: Volumetric Pipette Measurements

Trial Number	Final Mass (g)	Initial Mass (g)	Volume (ml)
1	121.97	95.55	25

Table 5: Mohr Pipette Measurements

Trial Number	Final Mass (g)	Initial Mass (g)	Volume (ml)
1	106.38	95.85	10

Analysis**Part 1: Density Calculation**

$$\text{mass of solution} = \text{final mass (g)} - \text{initial mass (g)} = 121.97 \text{ g} - 95.55 \text{ g} = 26.42 \text{ g}$$

$$\text{density} = \frac{\text{mass (g)}}{\text{volume (ml)}} = \frac{26.42 \text{ g}}{25 \text{ ml}} = 1.0568 \text{ g/ml}$$

Table 6: Density of Solution

Glassware Used	Trial Number	Final Mass (g)	Initial Mass (g)	Mass of Solution (g)	Volume Sampled (ml)	Density of Solution (g/ml)
Volumetric Pipette	1	121.97	95.55	26.42	25	1.0568
	2			24.61	25	0.9844
	3			26.48	25	1.059
Mohr Pipette	1	106.38	95.55	10.53	10	1.053
	2			8.71	10	0.871
	3			9.43	10	0.943
Volumetric Flask	1	45.82	19.41	26.41	25	1.0564
	2			26.48	25	1.06
	3			26.47	25	1.059
Buret	1	148.55	95.55	53	50	1.06
	2			26.62	25	1.0648
	3			26.39	25	1.055

Trial 1 completed by: Don Alexander

Trial 2 completed by: Jill Keitges

Trial 3 completed by: Dave O

Part 2: Average Density Calculation

$$\text{Average Density} = \frac{1.0568 + 0.9844 + 1.059}{3} = 1.0334 \text{ g/ml}$$

Table 7: Average Density

	Density (g/ml)
Volumetric Pipette	1.0334
Mohr Pipette	0.9557
Volumetric Flask	1.0585
Buret	1.0599
Total Average Density	0.8502

Part 3: Egg Density Calculation

$$d = \frac{m}{v} = \frac{48.13 \text{ g}}{42 \text{ ml}} = 1.146 \text{ g/ml}$$

Part 4: Mass % NaCl Solution Calculations

$$\text{mass \% NaCl} = \frac{\text{g NaCl}}{\text{g Solution}} \times 100\% = \frac{96.59 \text{ g}}{1000 \text{ g}} \times 100\% = 9.659\%$$

Part 5: Analysis of Error

Average Deviation:

$$\delta = \frac{\sum |x_i - x_{mean}|}{n} = \frac{2.12}{12} = 0.1767 \text{ g/ml}$$

Relative STD:

$$\text{relative STD} = \frac{\text{STD}}{\text{mean}} \times 100 = \frac{0.1767}{1.0269} \times 100 = 17.21\%$$

Table 8: Standard and Relative Deviation

	Average Deviation (g/ml)	Relative Deviation
Volumetric Pipette	0.1832	17.73%
Mohr Pipette	0.1055	11.04%
Volumetric Flask	0.2083	19.68%
Buret	0.2097	19.78%
Total Deviation	0.1767	17.21%

The relative standard deviation is greater than 3-5% in each case (including the total) so an error must have been made somewhere.

Part 6: Graphic Interpretation of Data

A graph of mass NaCl vs. volume is attached in Appendix A. The slope was determined

$$\text{to be: } m = \frac{\Delta y}{\Delta x} = \frac{96.59 - 9.659}{1000 - 100} = 10.35$$

Part 7: Questions and Goals

- 1) Determine the density of the solution needed for the production of soap.
 - a) The density needed is 0.8502 g/ml.
- 2) Produce a recipe for the amount of NaCl needed to be mixed with 100kg of water for the production of soap.
 - a) The recipe is to add 9.659kg of NaCl to 100kg of water.
- 3) Determine the mass percent of the NaCl solution.
 - a) The mass percent is 9.659% NaCl.
- 4) Determine in which way the type of the following glassware used affects the value and accuracy of the calculated density.
 - a) volumetric pipette: is used to deliver a specific volume of solution, which should be fairly accurate.
 - b) mohr pipette: is used to deliver a varying size volume of solution, which might be more versatile than a volumetric pipette, but less accurate.
 - c) buret: is used to deliver a varying size volume of solution, is vary convenient to use due to its stop cock, however it might be less accurate than a device designed to deliver a specific volume of solution.
 - d) volumetric flask: is used to contain a specific volume of solution, which should be fairly accurate.

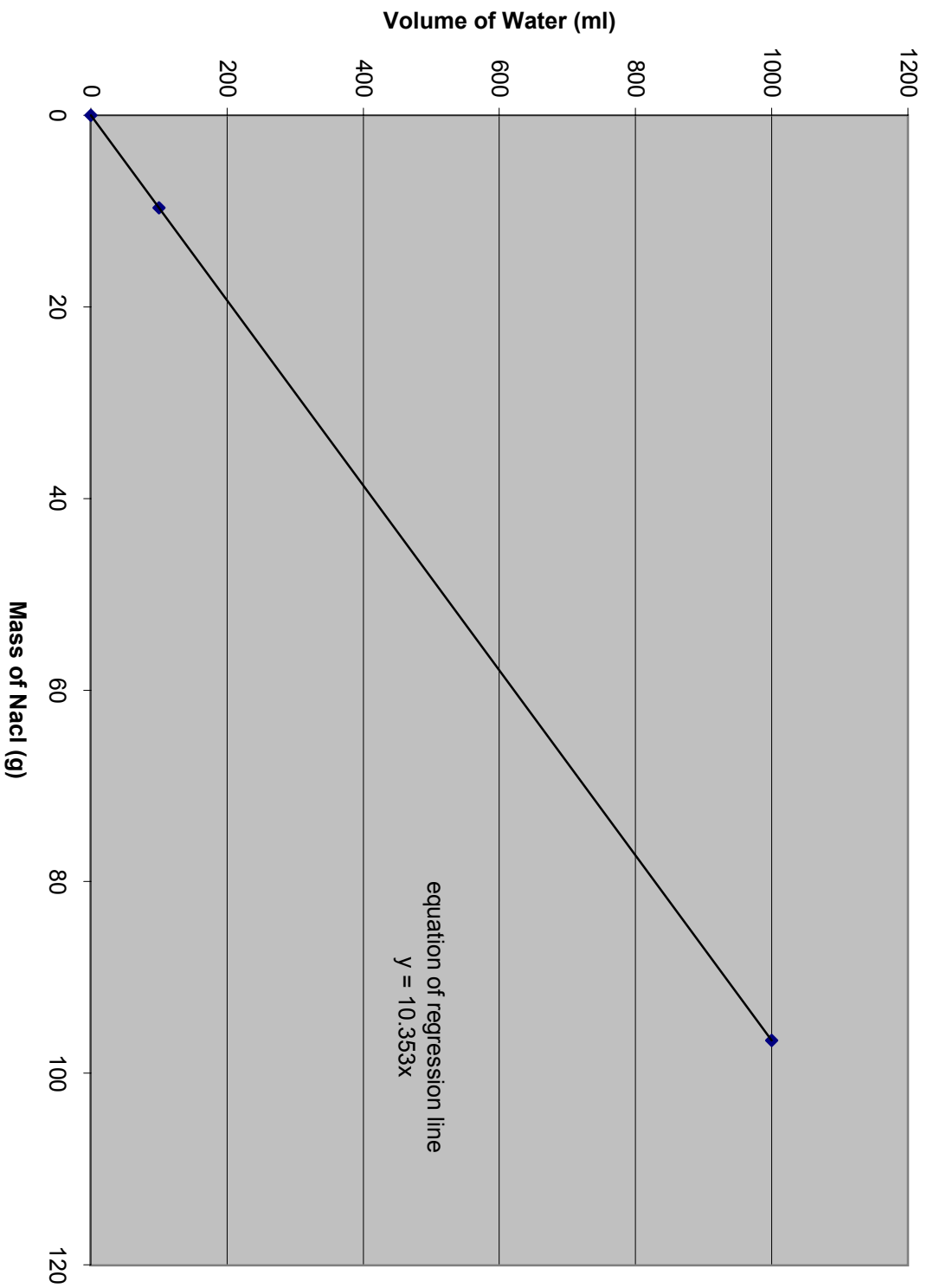
Conclusion

In this lab we determined the density of a NaCl and water solution that would float an egg. This density is said to be the correct mass percent of NaCl (we substituted NaCl for lye due to safety reasons) to manufacture soap. We also determined the density of the solution by measuring different quantities of solution in different types of glassware. One of the main goals of this lab was to determine the amount of NaCl to add to water to obtain the correct mass percent of NaCl in 100kg of water. Our recommendation is to use an appropriately large enough volumetric device to deliver 100kg of water and add 9.659kg of NaCl (or lye in the hypothetical case). Otherwise you would need to use a volumetric device of a smaller value and repeatedly add water to a container until 100kg of water has been reached. This however could allow for some error unless the person performing the measurements was very deliberate about his or her precision and accuracy.

Looking at the average and relative deviations, we noticed that significant error may have occurred. We presume that the error was due to our inexperience in performing accurate and precise measurements with the given glassware. We assume that as we gain experience and confidence in general chemistry laboratory practices, that we could reduce the percentage of error in the future.

Finally, this lab gave us practice at taking precise measurements, performing calculations, working as a team, and practice with devising and evaluating an experimental design.

Appendix A: Graph of Mass vs. Volume



◆ Series1
— Linear (Series1)