Mixing Alcohol and Water

by Period 8 Science 8 students
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Introduction/background:

The teacher asked us the question "What happens to the volume when you mix equal volumes of water and alcohol?" Most of us thought that the mixed volume would equal the sum of the starting volumes. Once we did the experiment, our curiosity took the best of us, and we wondered what would happen if we mixed 25ml of alcohol and 75ml of water, then vice versa.

Question:

What happens to the volume when you mix different amounts of water and alcohol? What happens to the density?

Expectations:

We thought that if we were to mix 50 ml of water and 50 ml of alcohol that the all around volume would end up being 100ml, because of simple math (50+50=100). Actually, most of us didn't think twice about the ending volume, we were confident it would be 100 ml. Given this, we also assumed that mixing 25 ml alcohol and 75 ml water then vice versa that the overall volume would be 100 ml as well (25+75=100).

We thought that the density would be greater when there was more water in the solution, considering that the solutions would be mixed together and water is denser, as we had calculated. When there was more alcohol, we thought it would be less dense, because we calculated before hand that alcohol was less dense than water.

Procedure:

1. We obtained 2 clean and dry 100 ml cylinders.
2. We found the mass of both of them using a triple beam balance and recorded the results.
3. In cylinder 1 we poured in 100ml of water and found the mass.
4. We calculated the density of the water sample (Density = mass of the sample / volume of the sample).
5. In cylinder 2 we poured in 100ml of alcohol and found the mass.
6. We calculated the density of alcohol.
7. We emptied both of the cylinders.
8. We poured in 50ml of alcohol in cylinder 1 and 50ml of water in cylinder 2 and then combined the two samples. We measured the volume, the mass, and calculated the density of the mixture.
9. After considering the results. We repeated the process with 75ml of alcohol and 25 ml of water and then 25 ml of alcohol and 75 ml of water.
10. In both cases we measured the volume, the mass, and calculated the density of the mixtures.

Results:

Mass of 50ml Water and 50ml Alcohol for all groups

Names	Mass of 50ml water (g)	Mass of 50ml alcohol (g)	Mass of 50ml water and 50ml alcohol mixture
B, G, J	49.80 g	38.50 g	88.00 g
D, M	48.10 g	39.50 g	86.70 g
M, N	48.90 g	38.90 g	96.50 g
H, C	46.60 g	38.50 g	88.40 g
A, S	48.80 g	38.30 g	87.40 g
M,P	49.80 g	39.00 g	88.60 g
	Mean= 48.67 g Median= 48.85 g	Mean= 38.78 g Median= 38.70 g	Mean= 89.27 g Median= 88.20 g

Volume of 50ml Water and 50ml Alcohol for all groups

Names	Volume of 50ml water (g)	Volume of 50ml alcohol (g)	Volume of 50ml water and 50ml alcohol mixture (ml)
B, G, J	50 ml	50 ml	96 ml
D, M	50 ml	50 ml	96 ml
M, N	50 ml	50 ml	96 ml
H, C	50 ml	50 ml	98 ml
A, S	50 ml	50 ml	97.5 ml
M,P	50 ml	50 ml	97 ml
	Mean= 50ml Median=50ml	Mean= 50ml Median=50ml	Mean =96.8ml Median = 96.5ml

Volume of 75ml Alcohol, 25ml Alcohol, 75ml Water and 25ml Water for all groups

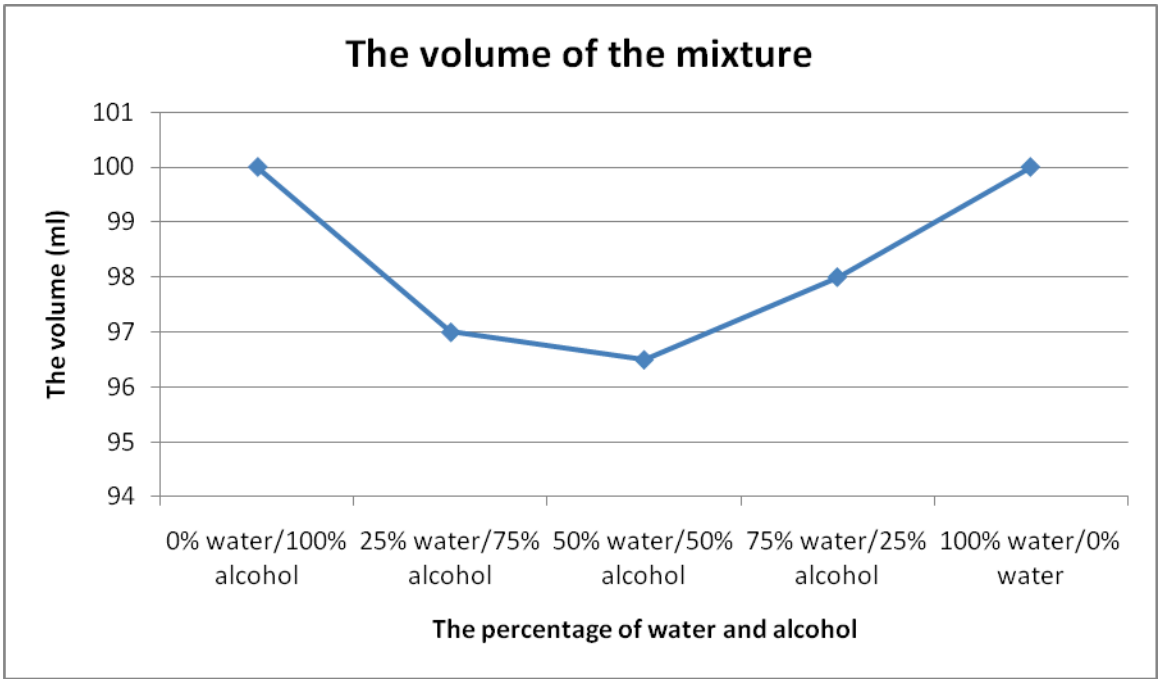
Names	Volume of 75ml water (ml)	Volume of 25ml alcohol (ml)	Volume of 25ml water (ml)	Volume of 75ml alcohol (ml)	Volume of 75ml water and 25ml alcohol mixture (ml)	Volume of 25ml water and 75ml alcohol mixture (ml)
B, G, J	75 ml	25 ml	25 ml	75 ml	98 ml	97 ml
D, M	75 ml	25 ml	25 ml	75 ml	99 ml	97 ml
M, N	75 ml	25 ml	25 ml	75 ml	98 ml	97 ml
P, C	75 ml	25 ml	25 ml	75 ml	98 ml	97 ml
A, S	75 ml	25 ml	25 ml	75 ml	99 ml	96 ml
	Mean= 75ml Median= 75ml	Mean= 25ml Median= 25ml	Mean= 25ml Median= 25ml	Mean= 75ml Median= 75ml	Mean= 98.40ml Median= 98ml	Mean= 96.8ml Median= 97ml

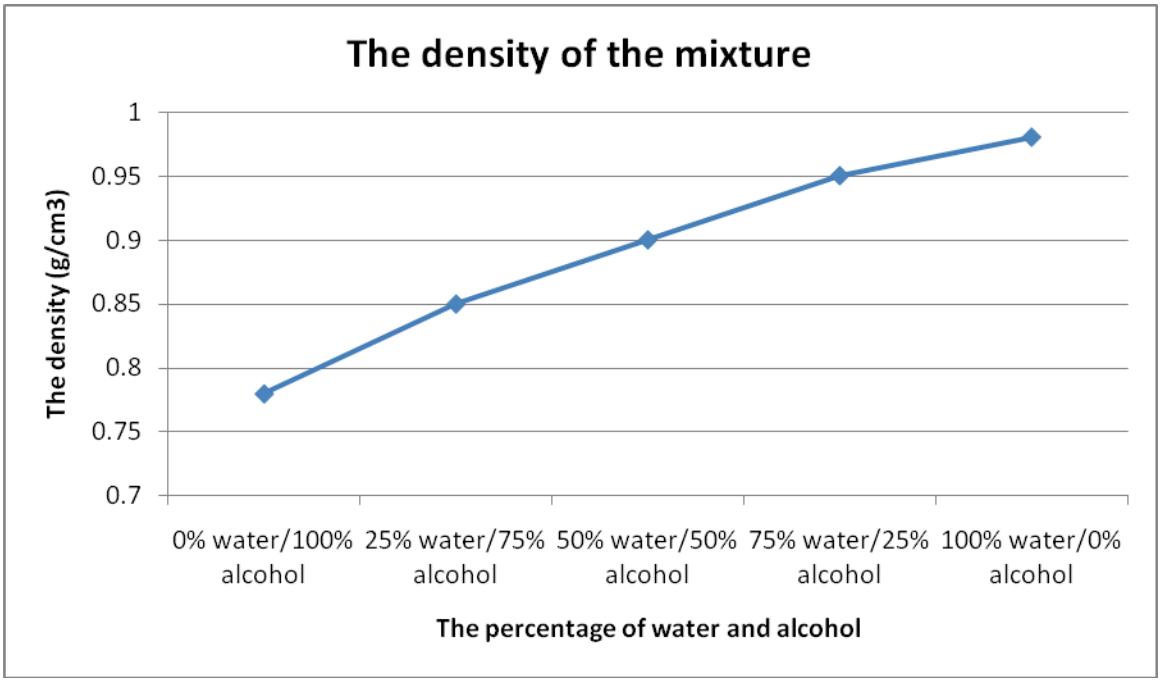
Density of Alcohol and Water for all groups

Names	Density of water (g/cm^3)	Density of alcohol (g/cm^3)	Density of 50ml water and 50ml alcohol (g/cm^3)	Density of 75ml water and 25ml alcohol (g/cm^3)	Density of 75ml alcohol and 25ml water (g/cm^3)
B, G, J	1.00	0.77	0.92	0.95	0.87
D, M	0.96	0.79	0.89	0.94	0.85
M, N	0.98	0.78	0.90	0.96	0.85
P, C	0.93	0.77	1.00	0.95	0.85
A, S	0.98	0.77	0.90	0.95	0.86
	Mean= 0.97 Median= 0.98	Mean= 0.78 Median= 0.77	Mean= 0.92 Median= 0.90	Mean= 0.95 Median= 0.95	Mean= 0.85 Median= 0.85

Comparing the mean and median volumes and densities of water, alcohol, and variously proportioned mixtures

		100% water	25% water/ 75% alcohol	50% water/ 50% alcohol	75% water/ 25% alcohol	100% alcohol
Volume(ml)	Mean	100	96.8	96.8	98.40	100
	Median		97.0	96.5	98.00	
Density(g/cm^3)	Mean	.78	.85	.90	.95	.98





Anecdotal observations:

Some observed that the lower part of the cylinder became hot when water and alcohol were mixed together. Others said the upper part became warmer. Air bubbles were located in the lower part. It looked like there were layers of water and alcohol.

Analysis:

In this experiment we predicted that the sum of 50ml of water and 50ml of alcohol would produce a mixed substance with a volume of 100ml. We predicted this because we knew that 50ml of water plus 50ml of water equaled 100ml of water. We assumed it would be the same with mixing alcohol and water, but we were proven wrong.

The volume was less than 100ml. It was about 97 ml and the density of this mixture was about .90 g/ml. This made us wonder if the same thing would happen with 75ml of water combined with 25ml of alcohol and then 75ml of alcohol mixed with 25ml of water. We predicted it would end up having a lesser volume, but we went further into the prediction to say that a mixture of 75ml of water combined with 25ml of alcohol would have a greater volume than a mixture of 75ml of alcohol and 25ml of water. As we predicted, the volume was less than 100ml for both mixtures. The density for 75ml of water and 25ml of alcohol was about .98 g/ml and the density for 25ml of water and 75ml of alcohol was about .85 g/ml.

In this experiment we were curious as to how the volumes didn't equal 100ml because basic arithmetic tells us that 50+50=100 and so does 75+25.

We saw some other patterns. When water was in the greater portion of the mixture, the density of the mixture of alcohol and water was greater than when there was more alcohol in the mixture. Along with the fact that when we added the two liquids, the resulting volume did not add up to 100ml, we noticed that "steam" rose and kind of fogged up the rest of the cylinder. Upon mixing the alcohol and water, the temperature became a lot warmer at the top part of the cylinder. The water and the alcohol were both transparent, but we could tell them apart because there were tiny bubbles in the water and the alcohol was perfectly clear. The alcohol seemed to layer over the water when they were mixed.

Some of us think that this may have happened because of the size of the particles or molecules of the water and alcohol. Our thinking is that the particles of the alcohol are bigger than the water's, and the water's particle entered into the space between the alcohol particles. If there are different sizes of molecules for every object, and when they mix, they don't always add up to what our calculation would say. We could perhaps test this idea by conducting the same experiment with substances that have different sized molecules. One group was really puzzled about how the combined volume was less than expected, so they decided to do some online research. They found that the volume is less because water molecules are much bigger than alcohol molecules. When the water molecules meet they leave spaces big enough between them because they are huge compared to alcohol molecules. This space lets the smaller alcohol molecules fit in the spaces taking up less space overall. An analogy is putting rocks in a bucket and filling it with sand, the sand goes in between the rocks. We all wonder how to decide if different sized molecules can account for the unexpected combined volume, and whether the alcohol or the water is the larger molecules. We are also curious as to why the temperature would change when molecules are just sliding into spaces.

Others of us think that the reason that the mixtures did not add up to 100ml, even though simple math would suggest it, is because there is probably a chemical reaction between the water and the alcohol. We believe that when alcohol and water mix there may have been a chemical reaction that "disintegrated" some of the water into the alcohol. A chemical reaction seems consistent with the observation of a temperature change.

Some of us proposed that that evaporation could have occurred when the two liquids mixed, resulting in less than 100ml of fluid. We postulated that when these two liquids are mixed, part of the mixture instantly evaporates, and the alcohol becomes warm. We surmised that these liquids do evaporate, but over time they somehow adapt to each other and evaporate at a slower rate. Although we concluded that the two liquids evaporate when mixed, but we couldn't find any evidence when we looked at the mass of the substances before and after the mixing. And when other students attempted to cover the top of the cylinder in order to stop evaporation, the pattern of results did not change. These students think that it is unlikely that evaporation would have

occurred before we got the cover in place. We feel that the idea of evaporation needs to be tested more extensively by arranging for the substances to mix in an enclosed container and to monitor the masses before and after mixing more carefully.

The change in temperature calls for further study as does the suspicion of layering. One student conducted some independent tests using blue food coloring first in the water before mixing and then in the alcohol before mixing. Her results have not yet been written up, but she observed the colored water remaining at the bottom of the cylinder and the colored alcohol floating at the top. As time passed there seemed to be more mixing. These results suggest that a more careful examination of how the two substances mix is in order.

Conclusion:

EACH STUDENT NEEDS TO WRITE HER/HIS OWN SUMMARY CONCLUSION.

COMMENTARY:

EACH STUDENT NEEDS TO WRITE A REFLECTIVE COMMENT ON WHAT HE/SHE LEARNED FROM THE INVESTIGATION AND THE WRITING.