

Determine percent composition of alcohol in an unknown solution

Abstract

Vlabs interface has many short problems for solving, for the student. One of them is to determine the percentage of alcohol in a given solution. Few simple concepts are used to solve this problem. Teachers can use this example to demonstrate that, the science students learn in class, are utilized in various job scenarios and occupations later on. Items provided to the student are,

- Weighing scale
- Measuring cylinder
- Conical flask
- A 70% standard solution of alcohol and 1 M alcohol
- Two unknown percentage solutions

Concepts covered

- Students can learn about molarity to v/v percentage conversion,
- Weigh solutions and calculate density
- Drawing a standard graph
- Find m and c values from a $y=mx+c$ line graph
- Finding unknown value from the standard graph

Use the Vlabs interface to measure density of liquids, draw a standard graph and find the composition of unknown solution

Calculate densities of water and known percentage of alcoholic solution

Plot a graph using the experimental points

For plotting a 2D graphing program or use a graph paper to draw a standard / reference graph

x axis is % of alcohol (0-100)
y axis is density value

This yields a straight line plot, for function $y=mx+c$

If experimental points do not fall on a straight line, perform a linear fitting to find values of m and c

Measure the density of the unknown composition solution
From the reference graph, find the % alcohol present in the unknown

Determination of alcohol density

Density of a liquid can be measured by using a specific gravity bottle, pycnometer or hydrometer.

A weighing scale and a volumetric flask measurement is needed to complete this experiment

From the provided standard solutions in the vlabs interface, pour out known volume of standard alcohol solution and measure their weight

An assumption made here is that, volume change is independent of percent concentration

Calculate density with the equation density = mass/volume

Convert 1M concentration to v/v percentage

Common mistakes

Taking alcohol to be denser than water

Thinking with higher percentage alcohol, solution is denser

Introduction

To measure the density of a liquid, usually, a hydrometer, specific gravity bottle or a pycnometer is used. Present day, we also see, highly sensitive and precise digital densitometers. They give the output reading of the density of the solution. However, in the absence of such equipment, student can modify the procedure to find concentration of alcohol in an unknown solution.

Students can draw a standard reference graph with % alcohol composition vs density. This can be used to find % composition of unknown solutions. The assumption made here is that, volume change is independent of percentage concentration.

To start,

1. Open the **Vlabs** interface.
2. From the **File** menu in the **Load Homework** option
3. Select **Molarity and Density**, from the sub-menu select **Alcohol Density problem**. Read the description and problem.

Procedure:

1. From the **Stockroom Explorer** double-click to select **Alcohol Beverage A** and **Alcohol beverage B**.
2. From the glassware menu select two 250 mL Erlenmeyer flasks. (You may also use volumetric flasks if desired.)
3. Right-click on the flasks and rename the flasks as A and B.
4. From the Select tools menu, select Scale.
5. Place flask A on the scale, and click on TARE button.
6. Drag and place Alcohol Beverage A on flask A.
7. In the Transfer amount input bar type 50 and click on the Pour button to transfer 50 mL to flask A.
8. Note that mass of the solution on the scale is shown as 48.9713g.

9. *Density = Mass/Volume*

Density Alcoholic Beverage A = 48.9713 g /50 mL = **0.979 g/mL**

Repeat same procedure with Alcohol Beverage B.

1. Place flask B, on the scale and click on TARE button.
2. Drag and place Alcohol Beverage B on flask B.
3. In the Transfer amount input bar type 50 and click on Pour button to transfer 50 mL to flask B.
4. Note that mass of the solution on the scale is shown as 45.9169g

Density of Alcoholic Beverages B = $45.9169 \text{ g}/50 \text{ mL} = \underline{\underline{0.9183 \text{ g/mL}}}$

Density of 70% Alcohol

1. From the Stockroom Explorer select Alcohol 70% and 1M Alcohol.
2. We will take two more 250 mL Erlenmeyer flasks from the glassware menu.
3. Right-click and rename them as 70% alcohol and 1M alcohol.
4. Let us place 70% alcohol flask on scale and tare it, then pour 50 mL of Alcohol 70%.
5. The mass of 70% alcohol on the scale reads 44.0824 g

Density of 70 % Alcohol = $44.0824 \text{ g}/50 \text{ mL} = \underline{\underline{0.881648 \text{ g/mL}}}$

Convert Molar concentration of 1M alcohol to v/v percentage (calculation)

1. Molecular weight of ethanol = 46.07
2. Density of absolute ethanol (100%) = 0.789 g/ml
3. In 1M solution, 46.07 g of alcohol is present
4. Volume of 46.07g of alcohol is $46.07/0.789 = 58.39 \text{ mL}$
5. That is 58.39 mL of alcohol is present in 1000 mL
6. Then in 100 mL of solution, $58.39/10 = 5.8 \text{ mL}$ of alcohol is present.

That is 1 M of alcohol is 5.8% alcohol

Density of 1 M alcohol

1. Let us place 1M alcohol flask on scale and tare it then pour 50 mL of 1M Alcohol.
 2. The mass of 1M alcohol on the scale reads 49.5299 g
 3. Density of 1M alcoholic Solution = $49.5299/50 = \underline{0.9905 \text{ g/mL}}$
- % of alcohol in beverage A = ----- %
 - % of alcohol in beverage B = ----- %

Calculation of density of the unknown samples

- Draw a graph with the two knowns as 1M and 70% alcohol.
- $y = mx + c$ graph is obtained, I have used Grace/QtGrace software for plotting, you may use your choice program for this purpose or plot on a graph paper. density.agr file is the plot file from Grace program.
- Draw a straight line, Either the fit data, or if using graph paper, to find the unknowns.
- Data fitting gives $m = -0.001704$ and $c = -1.0009$
- For beverage A, $0.979 = -0.001704 * x + 1.0009$, $x = \underline{12.85 \%}$
- For beverage B, $0.9183 = -0.001704 * x + 1.0009$, $x = \underline{48.48 \%}$

