Distillation and Water Analysis

Equipment

You will need a distillation set-up, a digital thermometer, a 10.00 mL volumetric pipette, a 50 mL graduated cylinder, and 2 weigh boats.

Chemicals

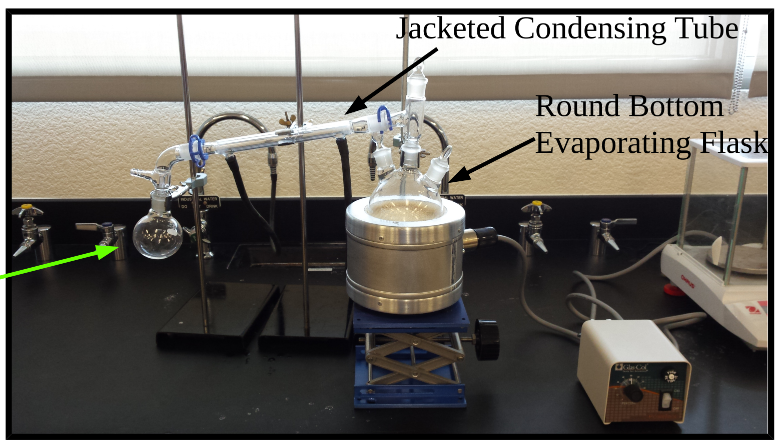
You will need about 60 mL of salt water.

Introduction

A solution consists of the solvent (what there is the most of) and the solute(s) (everything else). In this experiment you will analyze a sample of a salt solution which has sodium chloride (NaCl) as the solute and water as the solvent.

You will separate the water from the sodium chloride by a process called distillation. Here is a picture of a the glassware you will use for your distillation.

Round bottom flask where the distillate collects.



The salt solution is placed into the round bottom evaporating flask on the right, and heated (the silver cylinder is a heating mantle called a thermowell). As the solution boils, the water evaporates and travels as a gas through the glass cylinder in the middle (called a jacketed condensing tube) where it is cooled by water and condenses back into liquid form. The liquid then collects in the round bottom flask on the left.

Experiment #4

When a solution is distilled, the component with the lowest boiling point evaporates first, leaving the other components behind. In our experiment water evaporates leaving the salt behind in the evaporating flask.

The density of a salt solution is different than that of pure water. You will measure the density of the solution before and the density of the water afterwards to see how successful you were.

You will also measure the mass of the solution before the distillation, the mass of the salt left behind, and the mass of the water collected. This will enable you to calculate the mass percent of salt in the original solution:

$$\text{Mass Percent Salt} = \frac{\text{Mass of salt left behind}}{\text{Mass of solution before distillation}} \times 100$$ **(Equation 1)**

You will also calculate the percent difference between the density of your water and the known value for the density of pure water at the temperature of your water:

$$\text{Percent Difference} = \frac{\left|\text{True Value} - \text{Experimental Value}\right|}{\text{True Value}} \times 100$$ **(Equation 2)**

NOTE THE ABSOLUTE VALUE LINES!!!

You will get the true value from the included table below.

To use the table, find the temperature to the ones place in the left column. Move across that row until you get to the column that corresponds to the number in the tenths place of your temperature. The number in that cell is your density.

For example, if your temperature is 14.7 °C, your density is shown by the intersection of the green cells (0.999144 g/mL).

Density of Water (g/mL) as a Function of Temperature (°C)

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.999841	0.999847	0.999854	0.999860	0.999866	0.999872	0.999878	0.999884	0.999889	0.999895
1	0.999900	0.999905	0.999909	0.999914	0.999918	0.999923	0.999927	0.999930	0.999934	0.999938
2	0.999941	0.999944	0.999947	0.999950	0.999953	0.999955	0.999958	0.999960	0.999962	0.999964
3	0.999965	0.999967	0.999968	0.999969	0.999970	0.999971	0.999972	0.999972	0.999973	0.999973
4	0.999973	0.999973	0.999973	0.999972	0.999972	0.999972	0.999970	0.999969	0.999968	0.999966
5	0.999965	0.999963	0.999961	0.999959	0.999957	0.999955	0.999952	0.999950	0.999947	0.999944
6	0.999941	0.999938	0.999935	0.999931	0.999927	0.999924	0.999920	0.999916	0.999911	0.999907
7	0.999902	0.999898	0.999893	0.999888	0.999883	0.999877	0.999872	0.999866	0.999861	0.999855
8	0.999849	0.999843	0.999837	0.999830	0.999824	0.999817	0.999810	0.999803	0.999796	0.999789
9	0.999781	0.999774	0.999766	0.999758	0.999751	0.999742	0.999734	0.999726	0.999717	0.999709
10	0.999700	0.999691	0.999682	0.999673	0.999664	0.999654	0.999645	0.999635	0.999625	0.999615
11	0.999605	0.999595	0.999585	0.999574	0.999564	0.999553	0.999542	0.999531	0.999520	0.999509
12	0.999498	0.999486	0.999475	0.999463	0.999451	0.999439	0.999427	0.999415	0.999402	0.999390
13	0.999377	0.999364	0.999352	0.999339	0.999326	0.999312	0.999299	0.999285	0.999272	0.999258
14	0.999244	0.999230	0.999216	0.999202	0.999188	0.999173	0.999159	0.999144	0.999129	0.999114
15	0.999099	0.999084	0.999069	0.999054	0.999038	0.999023	0.999007	0.998991	0.998975	0.998959
16	0.998943	0.998926	0.998910	0.998893	0.998877	0.998860	0.998843	0.998826	0.998809	0.998792
17	0.998774	0.998757	0.998739	0.998722	0.998704	0.998686	0.998668	0.998650	0.998632	0.998613
18	0.998595	0.998576	0.998558	0.998539	0.998520	0.998501	0.998482	0.998463	0.998444	0.998424
19	0.998405	0.998385	0.998365	0.998345	0.998325	0.998305	0.998285	0.998265	0.998244	0.998224
20	0.998203	0.998183	0.998162	0.998141	0.998120	0.998099	0.998078	0.998056	0.998035	0.998013
21	0.997992	0.997970	0.997948	0.997926	0.997904	0.997882	0.997860	0.997837	0.997815	0.997792
22	0.997770	0.997747	0.997724	0.997701	0.997678	0.997655	0.997632	0.997608	0.997585	0.997561
23	0.997538	0.997514	0.997490	0.997466	0.997442	0.997418	0.997394	0.997369	0.997345	0.997320
24	0.997296	0.997271	0.997246	0.997221	0.997196	0.997171	0.997146	0.997120	0.997095	0.997069
25	0.997044	0.997018	0.996992	0.996967	0.996941	0.996914	0.996888	0.996862	0.996836	0.996809
26	0.996783	0.996756	0.996729	0.996703	0.996676	0.996649	0.996621	0.996594	0.996567	0.996540
27	0.996512	0.996485	0.996457	0.996429	0.996401	0.996373	0.996345	0.996317	0.996289	0.996261
28	0.996232	0.996204	0.996175	0.996147	0.996118	0.996089	0.996060	0.996031	0.996002	0.995973
29	0.995944	0.995914	0.995885	0.995855	0.995826	0.995796	0.995766	0.995736	0.995706	0.995676
30	0.995646	0.995616	0.995586	0.995555	0.995525	0.995494	0.995464	0.995433	0.995402	0.995371
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9

Procedure

You will work in groups of 2 or 3, no more than 3 per group.

1.) Using a Sharpie marker, write the names of the people in your group on your round bottom evaporating flask.

2.) Place a weigh boat on a balance and tare the balance. Weigh your round bottom evaporating flask (the one with 3 openings), using the tared weigh boat to hold the flask steady. Record the mass of the evaporating flask to 3 places past the decimal in the data section**(A1)**.

3.) With the evaporating flask and weigh boat still on the balance, tare the balance. Remove the evaporating flask from the balance (be careful not to lose your tare!) add about 50 mL of salt water to the evaporating flask using your graduated cylinder. The exact volume does not matter, do not bother trying to get exactly 50 mL.

4.) Place the evaporating flask with the salt water in it back on the tared balance and record the mass of the salt water to 3 places past the decimal in the data section**(A2)**.

5.) Weigh the 100 mL round bottom flask and record the mass to 3 places past the decimal in the data section**(A3)**.

6.) Following the step by step instructions, assemble the distillation apparatus. Everyone will perform the step together, following the instructor's example.

7.) Turn the power supply to 50% and begin the distillation.

SOMEONE MUST BE WATCHING THE DISTILLATION AT ALL TIMES!

8.) While the distillation is occurring, keep one person by it at all times. Meanwhile, someone else measure the mass of 10.00 mL of the salt water using a 10.00 mL volumetric mass to transfer the salt water to a tared weigh boat on the balance. Record the mass of this 10.00 mL of salt water to 3 places past the decimal in the data section**(A4)**.

9.) When it looks like there is almost no water left in the evaporating flask lower the lab-jack so that the heating mantle is no longer touching the evaporating flask. Turn off the power supply.

DO NOT LET THE EVAPORATION FLASK GO COMPLETELY TO DRYNESS!

10.) Let the evaporating flask cool before removing it.

11.) Remove the 100 mL round bottom flask that contains the distilled water and weigh the flask with the water in it. Record the mass to 3 places past the decimal in the data section**(A5).**

12.) Using a 10.00 mL volumetric pipette measure the mass of 10.00 mL of the distilled water from the 100 mL round bottom flask into a tared weigh boat on the balance. Record the mass of this 10.00 mL of the distilled water to 3 places past the decimal in the data section**(A6).**

13.) Measure the temperature of the distilled water in the 100 mL round bottom flask in degrees Celsius using a digital thermometer. Record this temperature to 1 place past the decimal in the data section**(A7).**

14.) Once the evaporating flask is cool, remove it from the distillation apparatus and place it in an oven until next week.

15.) When you come back the following week, remove the round bottom evaporating flask from the oven. Let it cool and then weigh it in a tared weigh boat on the balance. Record the mass to 3 places past the decimal in the data section**(A8).**

NAME:____________________ **SECTION:**___________

Data and Analysis

Data:

Mass of evaporating flask:____________________**(A1)**

Mass of salt water:____________________**(A2)**

Mass of 100 mL round bottom flask:____________________**(A3)**

Mass of 10.00 mL of salt water:____________________**(A4)**

Mass of 100mL round bottom flask + distillate:____________________**(A5)**

Mass of 10.00 mL of distillate:____________________**(A6)**

Temperature of distillate:____________________**(A7)**

Mass of evaporating flask with dry salt:____________________**(A8)**

Analysis:

1.) Calculate the density of the salt water using **Equation 3.** Here m is **(A4)** and V is 10.00 mL. Show all of your work including units and significant figures.

$$d=\frac{m}{V} \quad \textbf{(Equation 3)}$$

Density of salt water:______________________**(A9)**

NAME:___________________ **SECTION:**___________

2.) Calculate the density of your distilled water using **Equation 3.** Here m is **(A6)** and V is 10.00 mL. Show all of your work including units and significant figures.

Density of distillate:_____________________**(A10)**

3.) Calculate the percent difference between the density of your distilled water and the True Value using **Equation 2.** Here you will read the True Value from the table on page 3 using the temperature recorded for **(A7)** to find the density of water at your temperature. The Experimental Value in **Equation 2** is what you calculated for **(A10).** Show all of your work including units and significant figures.

Percent difference for density:_____________________**(A11)**

4.) Comment on the purity of your distillate (the distilled water).

5.) Calculate the mass of the distillate. This will be **(A5) – (A3).** Show all of your work including units and significant figures.

Mass of distilled water:______________________(A12)

6.) Calculate the mass of the salt in the solution. This will be the mass of the salt left in the evaporating flask. This is **(A8) – (A1).** Show all of your work including units and significant figures.

Mass of salt in the solution:____________________(A13)

7.) Calculate the total mass of the distillate and the salt. This is **(A12) + (A13).** Show all of your work including units and significant figures.

Total mass of distillate + salt:____________________(A14)

8.) Calculate the percent difference between the mass you started with, **(A2)**, and what you ended up with, **(A14)**. The calculation is:

$$\text{Percent Difference} = \frac{\left|\mathbf{(A2)} - \mathbf{(A14)}\right|}{\mathbf{(A2)}} \times 100$$

Show all of your work including units and significant figures.

Percent difference:____________________(A15)

9.) Calculate the mass percent of salt in your solution. The calculation is the mass of the salt residue **(A13)** divided by the mass of the original solution **(A2)** times 100:

$$\text{Mass Percent Salt} = \frac{\textbf{(A13)}}{\textbf{(A2)}} \times 100$$

Show all of your work including units and significant figures.

Mass percent salt in your solution:____________________(A16)

TURN THIS LAB IN NEXT WEEK
TURN IN PAGES 6 - 9