Experiment 5 - Exploring Dissociation

Introduction

In this lab we'll explore **dissociation**, which refers to substances splitting into separate ions in solution. There are different ways to see if dissociation is happening, but one of the easiest is **conductivity**. Electricity can only flow when charged particles are free to move, like electrons in metal wires or ions in solution. If the solution contains only neutral molecules, then electricity can't flow. The more charged particles that can move (for a given volume of solution), the higher the conductivity. (Conductivity also depends on other factors, such as how fast the charged particles can move through the solution. If some of your data is hard to explain, it could be because one type of ion moves much faster than the others.) Here, you'll test the conductivity of solutions of different compounds and at different concentrations, to get a feel for what compounds form ions, and how this depends on concentration. Some compounds dissociate completely and are called **strong electrolytes**. Other compounds dissociate only a little bit, and are called **weak electrolytes**. Others don't dissociate at all, and are called **non-electrolytes**. We'll use conductivity probes connected to a digital display to measure the conductivity of the solutions, and you will graph the conductivity vs the concentration.

Many students confuse **dissolution** with dissociation. Dissolution means dissolving, or forming a solution. The substance that dissolves is called the **solute**, and the substance it dissolves in (here, water) is called the **solvent**. Not all substances dissociate when they dissolve: that's what we'll be measuring.

In Part 2, we will prepare a solutions by **dilution**, which means making solutions less concentrated by mixing them with more solvent. We will measure the concentration of the solutions using molarity, which is defined by

$$M = \text{(moles of solute)/(liters of solution)} \qquad \text{Eq 1}$$

For instance, a 1 M ("one molar") solution of salt has one mole of NaCl in each liter of solution. Thus, in one milliliter, there is one millimole. If you take 50 mL of this solution and mix it with 50 mL of water, what is the new molarity? The way to think about this is to recognize that however many moles were in the 50 mL of 1 M solution are now in 100 mL of solution. The new concentration is given by

$$M_{final} = M_{initial}V_{initial}/V_{final} \qquad \text{Eq 2}$$

We find the total numbers of moles in the final solution by multiplying initial volume and concentration (0.05 L * 1 mol/L), then divide this number of moles by the end volume (0.1 L), so the result is 0.5 M. You can use Eq 2 (maybe in the form $M_1V_1 = M_2V_2$) to find the new concentration each time you do a dilution. In case you encounter more complicated situations, the thing to remember is that you need to find the total number of moles, and the total volume, and divide them.

When you are making solutions of particular concentration, it's important to control the amount of water. For example, you probably need to dry your glassware before using it if it is wet, so it doesn't get diluted extra.

For this lab, you will have to "calibrate" the pipettors we use for dilution. Since we use each pipettor for only 1 volume, we don't have to do a real calibration, we'll just adjust the settings until we get the right amount.

Safety Precautions:

- Wear your safety goggles at all times.
- Be careful with the strong acids and bases (HCl, NaOH)
- If a bottle is in the fume hood, leave it there!
- Close bottles as soon as you are done using them

Waste Disposal:

- Pour your solutions into the waste bottle in the hood when you're done. Use the water squirt bottles to rinse the glassware into the waste bottle.

Procedure

Use deionized (DI) water for everything! Record all observations directly into your lab notebook.

Part 1 - Pipettor Use and Calibration

1. Get 2 pipettors with tips, probably a 5000 μL and 1000 μL (you'll need one to measure 1 mL, and one to measure 5 mL). (You may have to share the pipettors with another group since we don't have very many). Stick the tips on very firmly.
2. Get a big beaker of DI water, and another smaller beaker.
3. When using the pipettors, **be careful** not to twist the dial past the point where it twists easily, since this can break the pipettor, and they are very expensive.
4. To use the pipettor, set the dial (gently!) to the desired amount (the digit in red is the number of mL, and the digits in black are the decimal places). Wrap your fingers around the dark blue part and push down on the top part with your thumb. Before you dip it in liquid, push on the top and notice that it goes a set distance to the "stop point", then it becomes much harder to push although it will go down farther. To draw in liquid, dip the tip in the liquid, and push until the "stop point" (not beyond it!) then release the top slowly to draw in liquid. Make sure the tip stays under the liquid level the whole time, and do it slowly. To dispense the liquid, don't touch the tip to the liquid. Push down again on the top and this time push past the "stop point" to get the last bit of liquid out. Make sure the tip is not touching liquid when you release the top.
5. Put the smaller beaker on a digital balance. Tare it. Set one pipettor to dispense 5 mL, and dispense 5 mL of DI water into the beaker. The scale should read 5.00 g, because the density of water is 1.00 g/mL. If it does not, adjust the pipettor until it dispenses the correct amount of water (just twist the dial, don't worry about the new reading). When it seems to be set correctly, dispense 5 mL into the tared beaker 5 times, recording the mass after each addition in a table in your notebook. Make sure that it reliably dispenses 5.00 mL. Record the serial number of the pipettor and the precise reading of the dial that you are actually using, to 3 decimal places.
6. Repeat with the second pipettor until it correctly dispenses 1.00 mL. As before, record the 5 correct measurements, the setting you are using and the serial number.

Part 2 - Dilution

1. Take an index card with a solute (1 card / group).
2. Get a big test tube rack and 6 of the short wide test tubes.
3. Collect about 40 mL of the 0.100 M stock solution of your solute in a clean, dry small beaker. Use this for everything that follows.
4. Use the pipettor to put 10 mL of the 0.100 M stock solution in one test tube. Label it with the solute and the concentration.
5. You don't need to change tips on the pipettors between dispensing stock solution and water because the solutions don't usually stick to the tips (and because you are not dipping the tip in a shared stock bottle!). If there are any drops on the tip, just dry them with a paper towel before pipetting the next thing.
6. Into a second test tube, dispense 8 mL of the stock solution and 2 mL of DI water. Mix the solution thoroughly. Calculate the concentration of the solution in the test tube, and label it with solute and concentration.
7. Into a third test tube, dispense 10 mL of the stock solution and 5 mL of DI water. Mix, calculate the concentration and label it as before.
8. In the fourth test tube, prepare 10 mL of 0.05 M solution. Mix and label as before. In your notebook, record your calculations, and how much stock and water you added.
9. In the fifth test tube, prepare 12 mL of 0.025 M solution. Mix, label and record as before.
10. In the sixth test tube, dilute some of the 0.025 M solution (in the fifth test tube) to make 10 mL of 0.0025 M solution. Mix, label and record as before.

Part 3 - Conductivity Measurements

1. Setup your probe. Plug the LabView box into the outlet, then plug the conductivity probe into the LabView box. On the small box connected to the probe, make sure the switch is set to 0-20000.
2. Put some DI water in a clean test tube or beaker. Dip the conductivity probe in the water and swirl it. Keep the top half of the probe dry. Wait about 15-30 seconds for the reading to stabilize, then record the conductivity of the pure water. Remove the probe. (The last digit of the reading will change rapidly: just write down a number that seems in the middle of the range.) Make sure you record the correct unit for conductivity!
3. Add a scoop of sugar to the water and dissolve it. Measure the conductivity of this solution. Is sugar an electrolyte?
4. After each conductivity measurement, rinse the probe with DI water from a squirt bottle. Then dry the probe with paper towel. This prevents diluting or contaminating the solutions.
5. Measure and record the conductivity of each of your solutions from Part 1 (dip the probe, swirl, estimate the average reading after 30 seconds or so). Record your results on the board.
6. Next you will mix your solutions with another group's solutions. **Ask your instructor** which solute you should mix your solutions with (don't choose at random). Then find a group with the right solute, and mix the solutions of the same concentration. For example, pour your 0.05 M solution into their 0.05 M solution, and stir. Repeat with all solutions.
7. Measure the conductivity of the combined solutions (dip the probe carefully, since the tubes are now fuller!). Record this data on the board also.
8. Take a look at the mixtures made by other groups (compare to the stock solutions). Record any observations: was there a visible change after mixing?

9. Based on the conductivity data and your observations, decide whether you think a reaction occurred for each mixture. If so, write the equation.
10. The instructor will provide a file with the data for the whole class. Here or at home, you will import the file into an appropriate spreadsheet program. If you aren't sure how to do this, ask the instructor or a classmate to show you.
11. Graph the conductivity (*y*-axis) vs. the concentration (*x*-axis) of all the solutions on the same axes. You should use a spreadsheet program to do this (see instructions in the Reference section). Make the graph really big and choose the range of the axes carefully so you can easily see the data. You should use 20,000 μS/cm as the maximum of your *y*-range, since this is the detection limit on the probe (if you got readings higher than this, they are unreliable). If you aren't sure how to do this, ask the instructor or a classmate to show you during lab.
12. Make a copy of your graph with a y-range of about 0-750 μS/cm. This will let you see the weak electrolytes more clearly.
13. You might also want to make graphs showing the data before and after mixtures. For example, make a plot showing NaOH, HCl and the mixture of NaOH and HCl. This can help you determine which combinations reacted. What should you observe if the solutes don't react?
14. Looking at your graph, what do you notice? Which solutes are are linear (a straight line graph)? Do any of them curve? Does the conductivity match the number of ions you expect the solution has? Which are strong and weak electrolytes?

Name: Section:

Experiment 5 Pre-Lab Sheet

If you have a laptop, tablet or other device that can run a spreadsheet program, today is a great day to bring it to class!

1. (1 pt) What type of water should you use for *everything* in this lab?

2. (1 pt) Which part of the conductivity probe should you keep dry?

3. (1 pt) What should you be careful of so you don't break the pipettor?

4. (1 pt) When can you go past the stop point on the pipettor and when shouldn't you?

5. (2 pts) You will collect data for each solution in the form of (x, y) pairs to be graphed. What quantity will you put on the x-axis and what will you put on the y-axis?

6. (2 pts) Sample calculation: if you make a solution by mixing 16 mL of 0.2 M NaCl with 4 mL of water, how many moles of solute are present? What is the concentration of the solution?

7. (2 pts) If you wish to prepare 40 mL of 0.01 M NaOH and you have 0.2 M NaOH available, what should you do?