Electrolytes in Solution Demonstrations: Irene Walsh

Teacher's Guide

Goals

- To show ways to give concrete examples of chemical concepts
- To improve students' understanding by visual illustration of basic principles

The Demonstrations

These demonstrations are intended to facilitate the teaching of concepts that are related to electrolytes in solution: dissociation of strong and weak electrolytes, aquatic self-dissociation, concentration, and logarithmic scales. These demonstrations facilitate students' understanding of new concepts. This should create the foundation for more abstract topics which are derived from these basic ones.

SAFETY

Wear goggles at all times during demonstration as should all students observing it!

Demonstration #1—Studying Electrolytes With a Light Bulb Conductor

Materials

- Mounted light bulb with two conductors, connected to a battery/electricity
- A 500 ml beaker
- 50 ml 1M HCl and 50ml 1M CH_3COOH

Instructions

Immerse the conductors of the lamp in a strong electrolyte solution inside the beaker. Discuss. Then, wash the beaker and change the electrolyte to a weak electrolyte. Discuss the difference.

Lecture Notes

Looking at what happened, explain what's in the solution that allows it to conduct electricity.

What is an electrolyte? A substance that conducts electricity when dissolved in water.

What happened when we changed the solution? Is this an electrolyte? What's the difference between the solutions?

What does that mean about the amount of ions in here? There are fewer ions.

Suppose I told you that the molar concentration of both solutions is the same (1M HCl and 1M acetic acid). Why, when we put a substance in water, do some conduct and some not?

It has to do with the dissociation. There is more dissociation in HCl.

Demonstration #2—Nuts and Bolts Analogy of Electrolytes

Materials

- Overhead projector
- 5 bolts
- 5 nuts
- 5 bolts with nuts screwed on them
- A petri dish

Instructions

Model a molecule by putting a screwed nut and bolt on the overhead projector. Then put the free nuts and bolts in the petri dish to represent a strong (completely dissociated) electrolyte in solution. Discuss. Then add some screwed nuts and bolts to the petri dish and explain about weak electrolytes.

Lecture Notes

This is a compound [nut and bolt]. We put it in water, and that happens [dissociation]—add free bolts and nuts.

What kind of electrolyte is this?

Add screwed bolts and nuts. Based on what we've just said, what can we say about this substance? It's only partially dissociated.

Demonstration #3—Conductivity in Water

Materials

- A neon glow-bulb
- A 500 ml beaker with water

Instructions

Immerse neon light bulb in water.

Lecture Notes

This is called a neon glow-bulb.

What did we see before, when we put a light bulb in water? It didn't light.

Immerse the glow bulb in water. Can you see a little glow here? A purplish light.

If you see a little glow here, what does it mean? There are ions in water.

There are two kinds of ions in the water. If there were ions, what would the water be doing? Dissociating.

Which ions are these? Hydroxide and hydronium ions.

Demonstration #4—Water Dissociation

Materials

- A stative and clamp
- A meter stick
- Picture clips
- Paper signs with $[H^+]$ and $[OH^-]$ written on them.
- Test tubes with 1M NaOH and 1M HCl.
- A piece of Zn metal
- Phenolphthalein (pp) indicator

Instructions

Attach the paper signs on both ends of the meter stick. Hang the meter stick from its middle by the clamp on the stative. Raise or lower the sides of the stick like a seesaw to demonstrate higher or lower concentrations of ions in solution, respectively. To represent ionic interactions in solution, use two meter sticks which attach physically to one another, and pull them up or down. Relate the chemical properties of the solutions to the demonstration, such that the students understand the concepts of acidic and basic solutions.

Use pp indicator in base and in metal acid to demonstrate indicator.

Lecture Notes

Show a test tube with base and add pp indicator into it. It turns red.

Tell me whether it's got more hydroxide or more hydronium? More hydroxide.

What did we learn about pp indicator in our study? It turns pink in the presence of OH^-.

Put a metal in the acidic solution. What happens in the presence of this? We get more hydronium ions.

How do we know that there is more hydronium in it? Because it's releasing some hydrogen gas.

Demonstration #5—The Logarithmic Scale

Materials

- A long string, on which little signs are hung to represent the powers of ten. The string should be marked off with 1cm markings, beginning at 10^1, and going on to 10^3.

Lecture Notes

When you first heard about acids and bases there was another term that you were introduced to: pH level.

Do you remember anything about pH level?

We really haven't talked yet about pH, but I would like to tell you that $pH=-log[H_3O^+]$. What is a log?

Present your string and explain how you made it.

If I have a hydronium ion concentration which is 10^{-1}M, it would be quite a lot bigger than a hydronium ion concentration of 10^{-2}M.

pH is based on a logarithmic scale. Do you know of any other thing that's based on a logarithmic scale? It happens in Japan a lot: earthquakes.

When they say the earthquake had a magnitude of seven on the Richter scale, vs. an earthquake which had a magnitude of six on the Richter scale, it's how many times stronger? 10 times stronger.

Teaching Tips From Ms. Walsh

One of the things about teaching is to be flexible. It is not their fault if they don't get it. You need to think of another way to explain. This is provided that they're working and that they are focused on what they are doing.

I spend a lot of time during the year thinking of ways to explain and present things.

I think that the nuts and bolts are effective. They are something that the kids can see when we start talking about dissociation and we start doing problem. They often have problem seeing that you have more parts than you had in the beginning.

They say on the blackboard that if the hydronium ion concentration is greater, than the solution would be acidic.

I think that one thing that people should know in teaching, is that even though the students are tenth and eleven graders, a lot of them are still on the concrete operational level, and chemistry has abstract concepts connected with it. And I've found through the years, that if you can give them concrete examples of things, they really seem to understand it.

Even students who are very bright will sometimes be able to do the mathematics but not have a really good understanding of what is going on. Sometimes just by using these little concrete analogies they get a much better understanding. This is what I found in the past.

Comment

These demonstrations may be very useful for a wide range of topics that relate to the chemistry of solutions. They give a proper introduction for a chemistry lesson: start off with a demonstration, and go on to the more complicated mathematics, after the students have a basic picture in their heads of what they're dealing with.

References: Links

http://dbhs.wvusd.k12.ca.us/Chem-History/Arrhenius-dissociation.html
Arrhenius' 1867 paper on ions in solution.

References: Readings

Morikawa, T., and Williamson, B.E. (2001) "Model for Teaching About Electrical Neutrality in Electrolyte Solutions," *Journal of Chemical Education,* Vol. 78, No. 7, pp: 934-936.