Activities Guide

Workshop 8. Chemistry at the Interface

Comment

1. All activities have been peer-reviewed but not tested.
2. Some safety considerations are suggested in the activities. For full safety information, consult the MSDS sheets (go to http://msds.pdc.cornell.edu/) before doing the experiment.
3. A concise source book for further assignments, activities, and background information is *ChemSource,* version 2.1 (Orna, Mary Virginia, O.S.U.; Schreck, James O. & Heikkinen, Henry, eds.), 1998. Visit the Web site at http://intro.chem.okstate.edu/ChemSource/chemsource.html.

Glowing Pickle Demonstration: Veatta Berry

Teacher's Guide

Goals

- To learn about electrons, and how electrons can exist in different energy levels
- To see evidence of electronic transmissions from colored light

The Demonstration

In this demonstration, students see what happens when electricity is passed through a pickle. They see light glowing, and make the connection between electrical energy and light energy given off by the salt solution inside the pickle.

Materials

- Ground Fault Interrupt (GFI) wall outlet
- A big dill pickle
- 2 ring stands
- 2 clamps for the ring stands
- A Variac power supply; with the Variac you can control the electricity that is applied
- 2 forks
- A six-foot extension cord
- Heat shrink tubing—about four inches for each fork
- Paper towels

SAFETY

Electricity is extremely dangerous and can be deadly!

Take all safety considerations to make sure that no one approaches your electric circuit while you do the experiment.

Wear safety goggles at all times during the demonstration.

Open the window, because it smells!

Preparation

Make sure that the extension cord is disconnected from any electric source before beginning!

Cut off the outlet end of the extension cord.

Split the extension cords at the end for about a foot. They should be well separated so you can put the forks into the pickle.

Connect the wires of the extension cord to the forks and cover them with heat shrink tubing for safety.

Set up the ring stands about a foot apart.

Put the forks onto the ring stands with the clamps, making sure the forks are facing each other.

Make sure that no one approaches the circuit before, during and after the demonstration, while it is still connected!

The Demonstration

Put the pickle in position: stick one fork into the pickle—it is best to put all the teeth of the fork into the pickle, maybe even a little further in.

Now stick the other fork into the pickle. BE CAREFUL THAT THE FORKS DO NOT TOUCH EACH OTHER, otherwise they will arch!

WITH THE VARIAC OFF AND AT ZERO POWER, plug the extension cord into the Variac, and ONLY THEN plug the Variac into the GFI wall outlet.

LEAVE THE VARIAC POWER AT ZERO and turn on the switch.

SLOWLY turn up the voltage to 120 volts on the Variac (the standard voltage from a regular wall outlet).

The pickle will start dripping. Then it will hiss, and smoke will be seen coming out of it. Shortly after that it will start glowing yellow. Go on until it stops, or do it several times. For best results, turn off the lights.

At the end of the demonstration, TURN THE VARIAC BACK TO ZERO, SWITCH IT OFF AND UNPLUG IT. Only then can you touch the other parts of the system.

Comment

If you soak the pickle for one week ahead of time in salt solutions other than NaCl, it will glow in different colors, for example: KCl, yields pink glowing, $CuCl_2$ glows green, and so on.

Lecture Notes

I will add energy, by introducing electricity into the pickle.

You see some smoke already.

Energy is going through the solution.

(Turn off the lights) I have a glowing pickle!

Lets talk about how I can get a pickle to glow? What is going on?

I added electricity, I'm adding energy, so, what inside that pickle is actually glowing? The electricity excites the sodium inside the NaCl solution to emit yellow light.

References: Links

http://www.exploratorium.edu/cooking/pickles/activity-kosher_dill.html
How to make a pickle battery, with illustrations.

References: Readings

Weimer, P.M., and Battino, R. (1996) "The Incredible 'Glowing' Pickle and Onion and Potato and...," *Journal of Chemical Education,* Vol. 73, No. 5, p: 456 (abstract only).

Energy Levels Laboratory: Veatta Berry

Teacher's Guide

Goals

- To relate period numbers with energy levels in atoms
- To show evidence of how scientists have learned about energy levels of electrons

The Laboratory

In this laboratory, students conduct flame tests, in order to gather evidence about the electronic energy layers of the different atoms. They see that different atoms glow in different colors, and discuss the reasons for this. They identify atoms in an unknown solution, from their results.

Materials for Each Group

- A Bunsen burner and matches
- Wood splints soaked with metal solutions such as Na^{+}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Cu^{+2}, Li^{+}, and K^{+}
- A solution of an unknown salt

SAFETY

Wear goggles at all times during the laboratory.

When working with fire, take care not to burn your hands or equipment. Work away from flammable and explosive chemicals.

Lecture Notes

This is the beautiful crimson red, but there is another one that will be orange-reddish, and you have to be really descriptive to distinguish between them.

You are going to do an unknown, and should be able to identify it.

This is one of the fine labs.

Teaching Tips From Ms. Berry

They enjoy looking at the colors, and when they see the metal ions from the unknown, they say, "Oh, yes, I remember, this must be copper, it looks exactly like the copper solution from my known copper solution."

It's a way to first introduce them to analytical chemistry. By using the known, we can identify unknown things.

It's incorporated into the subject of electrons, and they start to see other parts of chemistry at the same time.

References: Links

http://www.creative-chemistry.org.uk/activities/flametests.htm
How to do flame tests in the lab, with teacher and student notes as well as technical notes.

References: Readings

Bare, W.D., Bradley, T., Pulliam, E. (1998) "An Improved Method for Students' Flame Tests in Qualitative Analysis," *Journal of Chemical Education,* Vol. 75, No. 4, p: 459.

Energy Levels Laboratory: Veatta Berry Students' Guide

Goals

- To relate period numbers with energy levels in atoms
- To show evidence of how scientists have learned about energy levels of electrons

The Laboratory

In this laboratory, you will conduct flame tests, in order to gather evidence about the electronic energy layers of the different atoms. You will then try to identify atoms in an unknown solution.

Materials for Each Group

- A Bunsen burner and matches
- Wood splints soaked with metal solutions such as Na^{+}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Cu^{+2}, Li^{+}, and K^{+}
- A solution of an unknown salt

SAFETY

Wear goggles at all times during the laboratory.

When working with fire, take care not to burn your hands or equipment, and work away from flammable and explosive chemicals.

Instructions

Light the flame, and get started.

Pick up one of the soaked splints, and briefly put it in the flame. Be careful not to burn the wood.

See the color and describe it. Draw the color with pencils.

Relate the different metal ions with the colors in the table:

Metal	Color	Description/Drawing

Energy Levels Laboratory: Students' Guide, page 2

Try an unknown solution. Describe what you see: ______________________________

Identify which metal ion it is. Explain: ______________________________

Arrange the metal ions by width of energy levels from their color: ______________________________

Explain the chemistry behind it: ______________________________

Flame Test Demonstration and Activity: Al DeGennaro

Teacher's Guide

Goals

- To learn about electronic states through flame tests
- To relate the chemistry of atomic structures to cases from everyday life

The Demonstration and Activity

In this lesson, students get a feeling for the relationship between color and electronic states by observing a flame test demonstration. They learn about useful applications for classroom chemistry and practice scientific thinking and reasoning skills.

Materials for Each Group

- A Bunsen burner
- Matches
- Solutions of different metal ions: sodium chloride, lithium chloride, calcium chloride, barium chloride, strontium chloride, copper chloride and potassium chloride
- Wooden splints soaked in the solutions

SAFETY

Wear safety goggles at all times during the demonstration.

When working with fire, have a fire extinguisher nearby, remove all flammable and explosive chemicals away, tie your hair back and be careful.

Lecture Notes

I am going to show you evidence of excited states in atoms. Remember that I told you I could use either electricity or flame? So I will do it by flame, using a Bunsen burner.

What I want you to do during the demonstration is to keep track of the colors that you're seeing.

Put a wooden splint soaked with the metal salt solution into the flame.

Sodium chloride is first: I want you to think about the colors of the spectrum in the Roy G. Biv (abbreviation for: red, orange, yellow, green, blue, indigo, violet). What color would you call that? Orange.

Lithium chloride is next. What color is this? Red. It will give you the borderline.

Calcium chloride is orange, but it is not the same orange as before, so we want to change. Maybe we will make the sodium yellow-orange and this plain orange?

You could actually use this, to figure out which atoms there are in a chemical. So, if I mix these (solutions) up, and ask you what this is, you will know what it was because you recorded the color.

This is what the chemists do. They measure every element that they can think of and they publish it all in books: these are the colors that belong to this element, and so on.

And so, a chemist can figure out if there is an unknown. They say, "What is this stuff? I want to know what it is." They can check it with a flame and see what colors come out, and then, they can figure out what it is.

Here is the task for the day. This is a simulation of the real thing. First of all, if there is an accident, somebody usually sues somebody. Also, what a lot of people are not aware of is that judges, and jury, have to address other people who are experts, called "expert witnesses."

So you are going to play the role of the expert witnesses. This lady is suing a company, a chemicals company. And you are going to explain to the judge whether the witness is right or wrong.

Because the judge has to decide whether this lady deserves the four million dollars, or is wrong. That's what you have got to decide.

For five minutes, carry on a discussion about the case with your colleagues at the table.

Teaching Tips From Mr. DeGennaro

I had to think of something that would at least make it seem useful. They are interested in lawsuits and they are interested in explosions.

Astronomers and people who observe explosions, can tell what blew up, by the spectra of the elements which are coming off. Satellites can tell whether it was a construction explosion, whether it was a chemical weapon, and so on. And it's not that hard, all they have to do is look at the colors of light.

It's related to the same thing that they say—that you don't really understand things until you teach them. Well, you don't really understand things until you verbalize it. And I am sure that for some kids, telling the story will be more effective. But I just can't listen to 80 stories, so I ask them to write it out.

I'd say that everybody verbalized to me that the worker was wrong, but to compose a coherent thought and put it on paper really cements the learning for most of the kids.

Students' Products

"We are given this prompt which says that we have been contacted by the State of Maryland. A lawsuit is going on against a chemical company, and a worker who was injured in an explosion claims that unsafe conditions near a Potassium Chloride tank resulted in an explosion, and she's suing the company for four million dollars."

Dear state officials,

As a chemical expert working on this case, I look only at the facts. In this case, the facts show that the worker is wrong, in thinking that potassium chloride tank exploded.

The witnesses recall seeing a bright, green flash. These positions conflict. I saw an experiment with the colors of burning elements. Some of the elements tested included potassium chloride and copper chloride.

Each type of atom has a different amount of space between its orbitals. This requires more or less energy for the electrons to make the jump. Different amounts of energy produce different colors of light when they pass through an electron. Thus each different chemical element produces different colors of light when receiving a surge of energy. Witnesses to the explosion at the Useful Chemical Company, report seeing a bright green flash of light as the explosion occurred. Potassium chloride, the chemical in question, does not produce a green flash of light when it receives a surge of energy.

References: Links

http://www.fbi.gov/hq/lab/handbook/examelem.htm
From the FBI Handbook, a discussion of elemental analysis.

References: Readings

McKelvy, G.M. (1998) "Flame Tests That Are Portable, Storable, and Easy To Use," *Journal of Chemical Education,* Vol. 75, No. 1, pp: 55-56.

Flame Test Demonstration and Activity: Al DeGennaro

Students' Guide

Goals

- To learn about electronic states through flame tests
- To relate the chemistry of atomic structures to cases from everyday life

The Demonstration and Activity

In this lesson, you will be looking for the relationship between color and electronic states by observing a flame test demonstration. You will then apply what you learn to a practical situation.

Materials for Each Group

- A Bunsen burner
- Matches
- Solutions of different metal ions: sodium chloride, lithium chloride, calcium chloride, barium chloride, strontium chloride, copper chloride and potassium chloride
- Wooden splints soaked in the solutions

SAFETY

Wear safety goggles at all times during the demonstration.

When working with fire, have a fire extinguisher nearby, remove all flammable and explosive chemicals, tie your hair back, and be careful.

Instructions

Watch the demonstration of flame tests, and fill in the colors in the following table:

Salt	Color
Sodium Chloride	
Lithium Chloride	
Calcium Chloride	
Barium Chloride	
Strontium Chloride	
Copper Chloride	
Potassium Chloride	

Explain the chemistry of the process: ____________________

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What can you say about the difference between energy levels in these metal atoms?______________________

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Read the following story:

> Ms. Steinway, a worker in the Useful Chemical Company, is suing the company for injuries suffered during a chemical explosion in the company. She claims that she was hurt, when a KCl tank exploded due to inadequate safety measures, which were undertaken by the company. Eyewitnesses to the explosion, report that they saw a bright green flash of light.

You are the chemical expert witness in court. You have to determine whether Ms. Steinway is telling the truth, using chemical evidence.

Explain your claims: ____

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Identifying Solutions Laboratory: Felix Muhiga

Teacher's Guide

Goals

- To find out what is in the mystery solution
- To learn about real life application of forensic chemistry

The Laboratory

In this laboratory, students identify cations by conducting drop tests with different anions, which yield colorful solutions. They use the array of information to identify an unknown solution, which contains one of the metals. The use of well plates requires the use of very small amounts of solutions.

Materials for Each Group

Procedures and safety issues can be found using the keywords cation, analysis, experiment, or on the following site:

http://intro.chem.okstate.edu/ChemSource/chemsource.html

Comment

The color tests are conducted in a well plate, using very small amounts of solutions, and the grid of the table is matched to the grid of the well plate.

A partial table (as extracted from the video) would be:

	OH^-	I^-		
Ag^+		Deep brown		
Cu^{+2}		Pale yellow		
Zn^{+2}	White			
Pb^{+2}		Bright yellow		
unknown				

Lecture Notes

In this forensics laboratory, we are going to find the chemical composition and ionic content of a given solution.

There are many ways to find out the chemical composition of solutions. We will use just one. We have six different solutions. You are encouraged to work as integrally as you can, and see if you can identify only the cations which are in solution.

Each ion gives a different color, and that's how we can tell them apart. We can tell silver and copper apart because when we test them using iodide, one gives us a pale yellow, and the other gives us deep brown.

Any time that we add Iodide to the solution and we get pale yellow, we know that it must be copper.

Now that you have finished your grid, you have to get the secret ingredients and identify ions. This grid will serve as a basis for comparison, and be able to tell whether we have silver or copper in these two solutions.

It may be zinc, so you have to run another test, to confirm whether it is zinc or not. Add the hydroxide, and if it turns white you know that it must be zinc.

You mix Cu^{+2}, Ag^{+}, and Zn^{+2} salts and Pb with these solutions, because each of them will give you a distinct color.

You may not make the distinction between the different shades of yellow; it is better for you to have them, so you can compare.

We now have all the information that we need to identify the cations.

Come over, take one of the unknowns, and test them with all anions that you have. Within your table, ought to be the ion that is contained in the unknown.

This is one of the things that I want you to find out. You have to decide: do you think one test is sufficient, two or three, to help you distinguish between the cations?

We have now seen what lab analysts have to go through to identify different solutions, whether they are looking for trace elements in solutions or if they need to know what different elements are in the solutions.

In this activity, if I needed to find out whether lead is present in drinking water, which of these tests would I have to perform, just one, to decide whether there is lead in the water? Which anion would be most helpful? Why? Iodide, because it turns bright yellow.

We are able to tell the presence of lead only by seeing the bright yellow color.

Why is it that we could conclude that copper was not within the mystery solutions? Because we know that in any circumstances, copper would be colored, and we don't see any color in the solutions.

What did you find the unknown solutions to be?

Polymer Strength Laboratory: Al DeGennaro

Teacher's Guide

Goals

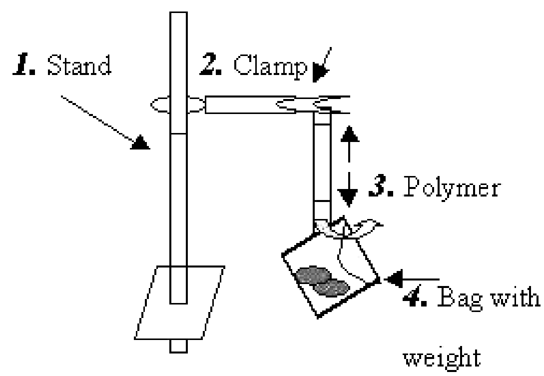
- To learn about the properties of polymers
- To let students experiment on their own and materialize concepts

The Laboratory

In this laboratory, students measure the strength of two polymers Handy Wrap and Saran Wrap, by hanging different weights on it and measuring the stretching that results. The apparatus used to measure is described. Students investigate freely by trying different cuts through the polymers.

Materials for Each Group

- The measuring instruments:



Preparing the Measuring Apparatus

a. Cut a piece of polymer.
b. Cover the edges of the polymer with duct tape.
c. Measure the length of the polymer piece and mark it.
d. Hook it on one end to a clamp.
e. On the bottom end, hang an open ring hook.
f. Tape some duct tape to the corner of a ziplock bag.
g. Make a hole through it.
h. Hang it on the ring hook which is fastened to the edge of the polymer.
i. Put tire weights inside bag and measure the polymer again.
j. Do it for different polymers and for different directions of cutting within the same polymer (see below).

SAFETY

There are no special requirements. All materials used are safe.

Lecture Notes

The purpose of the lesson is to think back to polymers, the little video clip that you watched yesterday. You will notice that there are chains in polymers, and we are attempting to figure out which way those chains go.

I have a little model to show that: I have here about five or six pieces of twine a lot like a string, if you have a string which is all twisted together.

It's pretty strong, when we pull it in a longitudinal direction. If you pull it very hard, it will break. But, it is relatively easy to pull a strand apart: if you play with when you are bored, you can completely unravel it, if you pull it sideways.

Now, in order for it to stretch, lengthwise, the strands have to slide between each other. But they don't want to do it in that twine, because there are little fibers which are attracted to each other.

If I had slippery things, then they would be more likely to slide. But that's why it stretches in one direction, much better than it does in the other.

Today we are going to compare polymers. I have a small piece of plastic wrap, with duct tape on each end. There are two marks, which are exactly 10 cm apart. I used a ruler to mark them.

What we are going to do is to measure how this plastic wrap changes when we add weights at the end.

The apparatus for this is actually an invention, here at Westminster High school, I don't know if it is used anywhere else.

I have here a small metal hook, I have a ziplock bag that has duct tape, and a hole punched through it. The weights that we are going to use are weights that you have used before, the tire-weights.

If you put a tire-weight in the bag very carefully, such that you don't yank it downwards, and let it hang, it might stretch the plastic, or it might not.

You are going to test two kinds of wrap: one is a Handy Wrap, and one is a Saran Wrap.

Saran Wrap is stronger.

You have some serious stretch, do you need a meter stick?

Teaching Tips From Mr. DeGennaro

The people who are actually taking science with the idea of pursuing a science career are few and far between. My more challenging target is the other 80% of students who will never study science in college.

I have to convince those students that science is valuable, not only to society, but also that it is valuable for them personally.

This is something that they can actually test. That's a product that they have seen before. It's not some chemical name that I have written up there that they have never heard of. It's not some jar of chemicals that they have never heard of. That's some product that they have. And what some of them have probably thought of is whether one kind is better than the other.

This lesson went great, it's difficult to predict what students will get totally engaged in. But in each class, I would say that every single kid was focused on what was going on.

They were improvising: they solved their own problems. Some kids had the stands, with books on it, and some kids holding it, kids crawling around on the floor. My feeling at that time was that I had to stay out of it.

Other than walking around and seeing who is comprehending and who isn't, I don't want to change what they are doing. Even if they are not technically following the directions, they are doing their own science in their own little world, and that is so much more valuable than me lecturing to them on what is important.

Students' Reflections

For extra credit we tested Saran Wrap and Handy Wrap, and we did it because we wanted to test bonds, if we could manipulate the way of bonds, or we could change the way that they are going… the bonds either go up and down or they go sideways.

We found that if you cut it one way and the bonds are going up and down- it would stretch, and if you cut it the other way, and the bonds are going side to side, then it would be very strong.

In class, the clear wrap could only support 10 ounces, but when we cut it vertically, it held about 44 ounces so it tripled the amount that it could hold.

At first I didn't really understand why it was doing that, because we only did one day on polymers. But then, once we did this, I saw that if you cut it one way, and then you cut it in a different way, it made a really big difference, and once I saw that, I really understood it then.

References: Links

http://www.chemheritage.org/EducationalServices/faces/teacher/poly/activity/physprop.htm

http://www.chemheritage.org/EducationalServices/faces/teacher/poly/home.htm

References: Readings

Kim, A., and Musfeldt, J.L. (1998) "Understanding Chemical Structure/Physical Property Relationships in Polymers Through Molecular Modeling and Thermal Analysis Techniques," *Journal of Chemical Education,* Vol. 75, No. 7, pp: 893-897.

Discussing Chemistry and Advertising: Tom Pratuch

Teacher's Guide

Goals

- To make the connection between chemistry concepts and advertising
- To summarize the course on chemistry and to look to the future

The Discussion

A discussion is held about the use of chemical concepts for advertising. Are concepts like *natural, organic,* and *chemical free* used as their chemical meaning, or are they misleading the public? The students use what they learned in chemistry to discuss these topics.

Lecture Notes

I have arranged you in small groups, so you can start your discussion there, because you are going to get your thoughts together, and get things organized.

After 20-25 minutes of small groups, you are going to turn your chairs facing this way, and we will have a moderator leading this discussion.

We are going to talk about chemistry in advertising. One side would argue that there is no problem in the way that words are used in advertising, despite their chemical meaning. The other side will argue the problem in advertising: what it does to people's understanding of chemistry, of chemicals, of what's healthy and what's not.

Is the mission clear? You are free to get up and grab any of the books or check something on the Internet (key-words: food, advertising).

The Debate

Problem With Advertising Chemistry	No Problem With Advertising Chemistry
Organic means that it contains carbon, so it means that it is false advertising, because the market gives society the idea that *organic* means no chemicals.	**Organic** products are not faultily advertised because the government specifies the amount of pesticides to use in organic food.
Chemical–free: Chemical is any substance used by or formed in a chemical reaction. Water and glucose are chemicals, those are all things that are natural. So trying to tell people that a chemical is bad and we shouldn't eat it is wrong, because we eat chemicals and we are made of chemicals, it's part of life.	**Chemical–free:** What we are talking about is not chemical compounds like water, but about things, which are added to it to make it impure, not the pure substance itself.
We have a lot of things which contain chemicals, like the milk that comes from the cow. Just because it comes directly from the cow does not mean that it is **chemical-free:** we feed her chemicals.	If the food is marketed as being **organic,** it does not mean that it has no chemicals added to it, it just says that it's grown without certain levels of pesticides, that's all that is regulated by the government.
When they say that it's **organic,** the fact that it does not contain pesticides does not make it organic. What makes it organic is the fact that it has or does not have carbon in it.	When something is labeled as **organic** that's what it means in terms of advertising. It is correct in terms of the law. They think, "Oh, it's good for you, that's what they mean, if it's bad for you or not."

You have a good point there, let's put a little spin on that, that will make us progress instead of getting locked in.

Both sides have valuable points about the issue. But now let's take it one step further. You came to this chemistry class at the beginning of the year with a certain mind set, mostly terror.

You've spent a year of learning chemistry, and you look back at the way you used to think of what it meant for someone to advertise food in a certain way: "organically grown," "nature's own," pick a phrase.

Think back to the way you used to view that. You may or may not have changed from this time, and now take the points which you are arguing about and move it up one level.

Students: Open Discussion

When you came here, what did you think organic was, what did you think they meant by chemical-free?

Some chemicals are made for the body without adding fat or calories to the food. It says that some chemicals help save lives instead of people thinking that it's bad.

It's not that all foods have food coloring and not all cookies have to have food coloring and other stuff added to it.

In our research, we found that if we didn't put yeast in food it would be flat, and sometime you want to add salt to it, too.

Summary—Mr. Pratuch

There is a point there: If bread is all natural bread from organic wheat, but you have to have added salt to it, it is a chemical….

Teaching Tips From Mr. Pratuch

That was the goal of these things: to take the year of chemistry, and spend some time at the end of the year, discussing issues that may or may not be directly chemistry.

But using their year of chemistry experience, to draw and synthesize a view or an understanding, be able to develop it, to explain it to others, defend it, change it, so they have a sense of science, more than just this set of facts, that there is an atom or an element. What did they really realize out of learning chemistry?

References: Readings

Editor's Page—Jacobs, M. (1998) "Cheers for Chemical Companies," *Chemical & Engineering News,* Vol. 76, No. 39, p: 1.

Roediger, A. (2000) "Let's Talk About It! Using a Graded Discussion Procedure To Make Chemistry Real," *Journal of Chemical Education,* Vol. 77, No. 10, pp: 1305-1306.

Reese, K.M. (1999) "Newscripts," *Chemical & Engineering News,* Vol. 77, No. 38, p: 96.