RESEARCH EXPERIENCES for TEACHERS AT NORTHEASTERN UNIVERSITY

Classroom Lesson Development

Title of Lesson	Pushing Electrons
RET Project Connection	Northeastern Department of Electrical and Computer Engineering, Center for Microwave Magnetic Materials and Integrated Circuits
RET Teacher	Matthew Corcoran
School	Framingham High School
Town/District	Framingham
Subject(s) taught	Chemistry
Subjects covered in lesson	Oxidation – Reduction Chemistry
Grades appropriate	10-12
Lesson duration	+/- 2 week – but spread in several spots through the year

Goals/Objectives of lesson

- Determine the chemical species that is oxidized and that which is reduced in a redox reaction.
- Determine the number of electrons that have been transferred in a redox reaction, and use this to balance equations.
- Using prior knowledge of solubility, construct a sequence of reactions to demonstrate the different oxidation states of a given metal ion.
- Evaluate the relative ease in losing electrons for different metals (construction of an activity series.)
- Apply the activity series in the evaluation of novel situations (Statue of Liberty refurbishment, patinas, boat construction, modeling biochemical reactions.)
- Apply the activity series in the construction of an electrolytic cell.
- Use the electrolytic cell to generate current for a useful implement of student design (or instructor suggestion.)

Background information

Students at Framingham High School generally take chemistry in their sophomore or junior year, concurrently with Algebra II. Oxidation-reduction reactions (redox) are taught in two places in the curriculum: initially in the second term when students are learning patterns of reactions and to predict reaction products, and again at the end of the fourth term when students are asked to revisit redox and then apply it to electrical equilibriums in batteries (constructing electrochemical cells and electrolytic cells.)

Essential questions

- How does the movement of electrons explain chemical reactivity?
- How can the movement of electrons be harnessed?

Links to Frameworks and Standards

National

National Science Education Standards – Inquiry

- Design and conduct scientific investigations.
- Formulate and revise scientific explanations and models using logic and evidence
- Recognize and analyze alternative explanations and models
- Communicate and defend a scientific argument

National Science Education Standards – Content

- A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions)…
- In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all...

AAAS Benchmarks for Scientific Literacy – The Nature of Science

- Investigations are conducted for different reasons, including: to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.
- Sometimes scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns.
- Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but that is no guarantee against bias.

AAAS Benchmarks for Scientific Literacy – The Physical Setting

- The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others.

State

MA State Curriculum Frameworks – High School Chemistry

- 8.4 Describe oxidation and reduction reactions and give some everyday examples, such as fuel burning and corrosion. Assign oxidation numbers in a reaction.

Local

Framingham High School Curriculum – Chemistry CP1 & Honors

- Students should be able to assign oxidation numbers and account for the movement of electrons between chemical species. Reactions should include metal and nonmetal redox reactions.
- Students should be able to predict the products of a redox reaction.
- Students should be able to identify oxidizing agents, reducing agents, write half reactions, and balance oxidation-reduction reactions.
- Students should be able to determine relative potentials of metals and the difference in potential. They should use this to construct an activity series of metals.
- Students should be able to predict the voltage of an electrochemical cell, construct an electrochemical cell, and make a diagram accurate explaining an electrochemical cell.

Materials required

In Progress: some labs are still in development.

Lesson development

Few topics covered in an initial chemistry survey course present as many challenges as the study of oxidation-reduction (redox) reactions. The movement of electrons is one of the most abstract concepts students will encounter. While the spin-spray process seems remote from high school chemistry, it is based on the redox chemistry that we expect our students to understand and apply: it is the chemistry of pushing electrons to manipulate matter.

In our classrooms, redox is taught as a separate type of chemistry in a specific and defined unit on oxidation-reduction reactions. This meets the state frameworks, but leads students to isolate the concepts in their minds. In the laboratory, however, redox is not a confined “unit of study” but a basic, underlying principle that is routinely applied to create the products desired. To replicate these laboratory experiences, I plan to incorporate redox chemistry throughout the school year so that the “unit” on redox is not segregated in student’s understanding but part of a natural progression. This will be accomplished through the modification of several current laboratory activities and the creation of new challenges. There are two new key challenges: constructing an activity series and using that to organize a series of color changing redox reactions; and constructing a voltaic cell in order to run a useful tool of their design. These activities will allow students to better understand the work of chemists in predicting and applying the movement of electrons as a way of manipulating matter.

References

In progress