An Electric Idea: Instructor Guide

Title

An Electric Idea

Author

Dr. Ruth Lawrie
311C Williams Hall
Kent State University
Kent, OH 44242
mlawrie@kent.edu

Discipline

Chemistry and Biochemistry

Target Audience

High school chemistry class or second semester general college chemistry

Keywords

Redox, voltaic cells, electrolysis, electroplating, electron transfer, half reactions, balanced redox equation

Length of Time/Staging

Two 50 minute classes

Abstract

In this problem, students learn to describe the processes occurring in a classic metal displacement type redox reaction, differentiate between spontaneous and nonspontaneous redox

processes, differentiate between voltaic and electrolytic cells, and predict voltages for electrochemical cells.

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Student Learning Objectives

1. To recognize redox reactions as electron transfer processes.
2. To write half-reactions and balanced overall equations for redox reactions.
3. To differentiate between simple metal displacement and coating of one metal with another through electrolysis.
4. To describe in molecular terms the processes occurring in voltaic cells and electrolytic cells and to differentiate between the two types of cells.
5. To predict spontaneity of redox reactions.
6. To predict voltage (cell emf) for voltaic cells.

Student Resources

Any general chemistry textbook

Web resources

Author's Teaching Notes

This case study is intended for high school chemistry students who are being introduced to redox reactions for the first time or for second semester college students who have some knowledge of redox reactions, but have not yet encountered electrochemistry.

The case study is best introduced by using Ms. Livewire's demonstration, which is very easy to set up.

The key ideas to which students should be guided towards are:

1. Representing the electron transfer process through half reactions and overall balanced redox equations.
2. Being able to describe, at a molecular level, the changes that are taking place in the copper wire and silver nitrate solution.
3. Recognizing that the Ms. Livewire's demonstration is a spontaneous process, in which one metal is actually replaced by another—which has no possible application for plating jewelry. Most students have no difficulty with this concept.
4. Recognizing that electroplating is also a redox process, but one which is not spontaneous and requires an external electric current. Many students will not recognize that in this process one metal is, in fact, inert and the exchange of electrons takes place between a metal and a solution of its own salt. Students also sometimes do not perceive electroplating as an electron transfer process.

5. Students usually do not have difficulty describing a voltaic cell for Question 3, but often miss the significance of the salt bridge. It is easy for students to become side-tracked with the technical details of making a homemade battery small enough for the purpose; they will need to be guided towards considerations of separate cell compartments, salt bridge, calculating voltage.
6. Students should be guided towards producing labelled diagrams for both types of cell, and producing a table comparing the properties of voltaic *vs.* electrolytic cells.

Assessment Strategies

Students were assessed by means of a 20-minute quiz containing questions such as:

A standard electrochemical cell produces a potential difference of 2.71 volts. The cathode of this cell is copper. Using the table of reduction potentials, the anode of the cell is found to be:

1. sodium
2. magnesium
3. chromium
4. nickel

In the reaction 2 Na (s) + 2 H_2O -> 2 NaOH (aq) + H_2 (g) identify the substance which undergoes oxidation.

1. Na
2. NaOH
3. H_2
4. H_2O

A certain galvanic (electrochemical) cell is constructed as follows: A strip of aluminium metal in contact with a solution of Al^{3+} ions, a strip of an unknown metal M in contact with M^{2+} ions in solution, a voltmeter and a KNO_3 -salt bridge. The reading on the voltmeter is 1.53 V under standard conditions. The Al/Al^{3+} redox pair acts as the ANODE of the cell.

a. Show by calculation that the unknown redox pair is Pb^{2+}/Pb.

b. Write a balanced equation for the overall cell reaction, using the half-reaction method to balance.