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Oxidation and Salt

Abstract:
The reaction on iron in water, air, and sodium chloride can be observed. In this lesson students will create a situation that will show this process and give them the opportunity to hypothesize what, why, and how. They will keep records and do an oral and written presentation on how the results supported or disproved their hypothesis.

Grade level:
9-12

In Class Time:
1 class period to introduce the experiment. 5 minutes everyday for 2-4 weeks to record data (may go as long as you wish). 2 class periods to discuss and analyze data. 1 class period to allow for student presentations.

Utah State Core Standard:
Standard 1: Students will understand that all matter in the universe has a common origin and is made of atoms, which have structure and can be systematically arranged on the periodic table.
Standard 2: Students will understand the relationship between energy changes in the atom specific to the movement of electrons between energy levels in an atom resulting in the emission or absorption of quantum of energy.
Standard 3: Students will understand chemical bonding and the relationship of the type of bonding to the chemical and physical properties of substances.
Standard 4: Students will understand that in chemical reactions matter and energy change forms, but the amounts of matter and energy do not change.

AAAS 2061 Benchmark:
Matter on earth and in the universe is made of atoms that have structure, mass and a common origin. The periodic table is used to organize elements by structure. A relationship exists between the chemical behavior and the structure of atoms. The periodic table reflects this relationship.

Atoms form bonds with other atoms by transferring or sharing electrons. The electron configuration arrangement of electrons in an atom, particularly the valence electrons, determines how an atom can interact with other atoms.

The types of chemical bonds holding them together determine many of the physical properties of compounds. The formation of compounds results in a great diversity of matter from a limited number of elements.

In a chemical reaction new substances are formed as atoms and molecules are rearranged. The concept of atoms explains the conservation of matter, since the number of atoms stays the same in a chemical reaction no matter how they are rearranged; the total mass stays the same. Although energy can be absorbed or released in a chemical reaction, the total amount of energy and matter in it remains constant. Many reactions attain a state of equilibrium. Many ordinary activities, such as baking, involve chemical reactions.

Solutions make up many of the ordinary substances encountered in everyday life. The relative amounts of solutes and solvent determine the concentration and the physical properties of a solution.

Terminology:

- **Exothermic:** Characterized by or formed with evolution of heat.
- **Endothermic:** Characterized by or formed with absorption of heat.

Intended Learning Outcomes:

- Students will apply prior knowledge from class regarding elements, electron activity, chemical reactivity, and bonds.
- Students will be introduced to solute concentration and demonstrate the ability to determine a 1:5 dilution on paper and during the experiment preparation.
- Students will make observations, record data, make predictions, identify variables, plan an experiment, analyze data, draw conclusions, and use reference sources to assist in preparation of their oral presentations.

Introduction:

Rust, the oxidation of iron is caused by the interaction of oxygen, water, and iron. There is over $100 billion of damage done every year in the United States alone (Chang, General Chemistry 3rd. edition.). Atoms given up by the iron cause the reduction of atmospheric oxygen to water. Iron creates two areas for the redox reaction to occur; one is the cathode (the more noble metal) and the other is the anode (the less noble metal). The electrolyte, or conductor is the water. Salt increases the conductivity of the water, which increases the reaction with the iron. In the electrochemical process involved in rust formation the H+ ions are supplied by H2CO3 (atmospheric CO2 and H2O) which forms when CO2 dissolves in water.

Review:

Everything in the world is composed of atoms, tiny particles that vary from chemical to chemical. When you combine two different atoms (different chemicals) you get an element. Atoms form bonds with other atoms by the transfer or sharing of electrons. All matter contains these bonds. For example, water is composed of hydrogen and oxygen atoms. Atoms react to each other based on their electronegativity i.e. whether or not they carry an electrical charge of positive or negative. You have heard the saying that opposites attract- this is where it came from!

During chemical reactions energy and matter may change in form but the amount of matter and energy does not change.

Corrosion i.e. oxidation causes over $100 billion of damage every year in the United States alone (Chang, General Chemistry 3rd edition). One of the most recognizable forms of oxidation in society is rust. In hopes of preventing rust we clean, wax, paint and treat many objects. It seems to be everywhere.

There are many kinds of rust; brown or red, black and any combination thereof. Brown or red rust is caused when oxygen, water and iron combine to form ferric oxide

(Fe2O3). Black rust is magnetite (Fe2O4). Both are forms of iron oxides. The difference is based on the availability of oxygen. If oxygen is readily available, for example if the iron is exposed to the air, then if forms the red/brown rust. If oxygen is limited the reaction is changed to form black magnetite. Salt mixed with water simply changes the conductivity of the water by binding a sodium molecule to the oxygen decreasing the availability of oxygen. This affects the reaction of iron with oxygen in the oxidation process.

For rust to occur there must be water. In humid areas rust is a prevalent problem whereas in dry area like the desert, rust is less of a problem but still exists. There are, of course, water molecules in the atmosphere.

Materials:

- De-ionized water
- Sodium Chloride (table salt not iodized)
- Conical tubes (50ml graduated)
- Black bolts ½ inch in diameter and 1-2 inches long
- Conical tube racks
- Acetone or some other de-greaser for the bolts
- Sandpaper 100 grit
- Centrifuge (recommend 2000 RPM for 5 minutes)
- Scale (used to measure salt and sediment)
- Data Sheet

Procedure:

- Clean all bolts to be used with the acetone or some other de-greaser prior to class.
- Divide the class into groups of four to six.
- Ask each group to hypothesize what will happen to steel bolts placed in various salt concentrations and water.
- Have each group design their experiment with preset salt concentrations of 0,5,10, and25%.
- Have each group sand (rough up) their bolts.
- Weigh and record all bolts.
- Label all conical tubes with the appropriate salinity percentage (0%,5%,10%,and 25%).
- Prepare the solutions:
  9. Add 25ml de-ionized water to the 50ml conical tube for 0% salinity.
  10. Add 1.25g of sodium chloride to another tube and fill to the 25ml mark with the DI water for 5% salinity.
  11. Add 2.5g of sodium chloride to another tube and fill to the 25ml mark with the DI water for 10% salinity.
  12. Add 6.25g of sodium chloride to another tube and fill to the 25ml mark with the DI water for 25% salinity.
- Mix solutions until sodium chloride is dissolved (heating the DI water will help).
- Place the bolts ***GENTLY*** in the solution (tipping the tubes will help to prevent spills).
- Submersion just to the top of the bolt is preferred. This gives the students the opportunity to see the reaction both submerged and as the water begins to evaporate (remember the atmosphere is also a factor).

- Have students record their observations daily. Looking for visible rust.

Lesson Plan:

- Write lab procedure on the board prior to class.
- Explain to the students that they will be assessing each other on **both** their listening skills **and** their presentations.
- Inform the class that they will be expected to do an oral presentation with visuals to the class based on their results and how they prove or disprove their groups' hypothesis. A written report will accompany the oral presentation and will be due on the day of the presentation. This will be graded. Outside resources and a reference page are required. One class period will be provided for library access (if computers are available in your room they may be used as well).
- Briefly review the introductory lesson on oxidation.
- Emphasize the need for safety in the lab and review safety rules.
- Divide the class into groups; each group measuring one complete set of salinity solutions.
- Remind each group to record their procedure and amounts in their journals.
- Assist groups as needed.
- Place all experiments in an area where observations can be made easily.
- Assign daily observations and recordings of all tubes. (Looking for observable rust).
- When observable changes have started to occur, direct the students to answer the following questions (see study guide at the end of the lesson):

9. What solution provided the first reaction?
10. What are some possible reasons for this first reaction?
11. What changes did you notice when the water started to evaporate?
12. How can you explain the different reactions during submersion?
13. How are technologies applied in society to control oxidation?
14. Identify several of the technologies used in your area.
15. Are these reactions exothermic? Explain.

8.Are these reactions endothermic? Explain.

Post Assessment:

- Let the students assess each other on their presentations using the rubrics provided (see attached).
- Assess the students' answers to the questions about their experiments for accuracy and understanding.
- Assess the students on their contribution to discussions during the process based on their ability to bring new information to the class.
- Assess the students' answers on the study guide.
- Assess written reports for accuracy, understanding, utilization of outside resources, and proper format.

LISTENING SKILLS RUBRIC:

EXCELLENT-5- The student is attentive, courteous and sensitive to the ideas, tone and purpose of the presentation; Intellectual curiosity, attention to the task, and sensitivity to others help to create a productive climate in and for the group.

PROFICIENT-4-The student is attentive and courteous; purposefully and confidently listens to the presentation.

SATISFACTORY-3-The student is courteous and willing to listen to others; accepts ideas of others.

LIMITED-2-The student is easily distracted; lacks confidence to receive ideas easily and clearly; may use language, tone or nonverbal behavior inappropriate for the occasion; is an insecure member of the group.

POOR-1-The student is uninvolved in the activity and lacks courtesy.

EFFECTIVE COMMUNICATION STANDARDS

EXCELLENT-5-Clearly and effectively communicates the main idea and provides support that contains rich, powerful detail; uses multiple methods of communication in highly creative and imaginative ways; creates a product that exceeds conventional standards.

PROFICIENT-4-Clearly communicates the main idea and provides suitable detail in style and tone consistent with the audience's knowledge; uses two different methods of communication; creates a product that clearly meets conventional standards.

SATISFACTORY-3-Communicates important information but not a clear overall structure; attempts to use two methods of communication, but is unsuccessful.

LIMITED-2-Communicates for a specific purpose but makes significant errors or omissions; creates a product that does not meet conventional standards.

POOR-1-Communicates information as isolated pieces in a random fashion; tone or style inappropriate for audience; uses only one method of communication in an incorrect was; creates a product that does not address the majority of the conventional standards.

RUBRIC SOURCE: Lesson plan by Terri Lusk pulled from uen.org

NAME:

STUDY GUIDE

4. WHAT SOLUTION PROVIDED THE FIRST REACTION?

5. WHAT ARE SOME POSSIBLE REASONS FOR THIS FIRST REACTION?

6. WHAT CHANGES DID YOU NOTICE WHEN THE WATER STARTED TO EVAPORATE?

7. HOW CAN YOU EXPLAIN THE DIFFERENT REACTIONS DURING SUBMERSION?

8. HOW ARE TECHNOLOGIES APPLIED IN SOCIETY TO CONTROL OXIDATION?

9. IDENTIFY SEVERAL OF THE TECHNOLOGIES USED IN YOUR NEIGHBORHOOD?

7. ARE THE REACTIONS EXOTHERMIC? EXPLAIN.

8. ARE THE REACTIONS ENDOTHERMIC? EXPLAIN.

9.WHAT WAS YOUR ORIGINAL HYPOTHESIS? IS IT BEING SUPPORTED BY YOUR OBSERVATIONS?