An Activity Series

Inquiry Guidance and AP* Chemistry Curriculum Alignment

Introduction

The elements are classified based on similarities, differences, and trends in their properties. Recognizing periodic trends in the physical and chemical properties of the elements is key to understanding the full value of the periodic table. Which elements more easily undergo oxidation by giving up electrons? What factors determine the ease of reduction of elements or ions? How does the relative reactivity of a group of metals or nonmetals influence their uses in commerce, engineering or medicine? Investigate these questions to reinforce key learning objectives concerning oxidation and reduction.

Opportunities for Inquiry

Oxidation–reduction reactions offer numerous guided-inquiry challenges for students to observe and interpret evidence of chemical reactions, predict products, and identify trends within groups and across series. The results may also be extrapolated to build connections between redox chemistry and essential knowledge in electrochemistry, including half-cell reactions and standard reduction potentials.

Consider these strategies for adapting classic activity series labs to integrate inquiry and scientific reasoning.

- Start with a demonstration (or two)! The reaction of zinc metal with a copper nitrate solution produces many classic "signs" of a chemical reaction, along with a bountiful deposit of a reddish-brown solid resembling copper metal. The "reverse" reaction of copper metal with zinc nitrate shows—nothing! What do these results mean? Use a series of guided-inquiry questions to ask students to identify the product of the first reaction, explain the second (non)reaction based on their knowledge of the uses of metals, and then design a guided-inquiry experiment to rank metals based on their pair-wise reactions with metal ions. For best results, we suggest a minimum of six combinations of metals and metal ions. A great critical-thinking question to cap the exercise is: If you do the corresponding reactions of other metals with silver nitrate, do you need to test expensive silver metal? Why or why not?
- The reactions of dilute aqueous halogen solutions with sodium halides require stringent safety precautions to avoid exposure to toxic halogen fumes (chlorine, bromine and iodine). We recommend that the procedure for this section of the lab be provided to students as an introductory or baseline activity. This may be accompanied by a series of scientific reasoning questions to probe the overall design of the experiment. Why is a two-phase solvent system used in this experiment? What evidence is obtained for any reaction(s) taking place in each test tube? Do halogens exhibit the same color in the aqueous and nonaqueous layers? Use the results of this experiment to explain why fluorine is an extremely toxic and dangerous substance.
- Extend the experiment to identify unknown metals based on their reactivity patterns. Tin, lead, iron, zinc, and nickel strips all have a very similar, silvery-gray appearance.
- Introduce metal alloys into the mix and investigate how the metal composition affects the properties and uses of the metals. Many different commercial brass alloys may be obtained—does their reactivity depend on or correlate with the percent composition of a specific metal, such as copper or tin?

Alignment with AP Chemistry Curriculum Framework—Big Ideas 1 and 3

Enduring Understandings and Essential Knowledge

Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern day uses range from examining the composition of materials to generating ideas for designing new materials. (Enduring Understanding 1C)

1C1: Many properties of atoms exhibit periodic trends that are reflective of the periodicity of electronic structure.

Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid–base, and oxidation–reduction reactions. (Enduring Understanding 3B)

3B3: In oxidation–reduction (redox) reactions, there is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced.

Chemical and physical transformations may be observed in several ways and typically involve a change in energy. (Enduring Understanding 3C)

3C3: Electrochemistry shows the interconversion between chemical and electrical energy in galvanic and electrolytic cells.

Learning Objectives

1.9 The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model.

1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity.

3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer.

3.12 The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws.

Science Practices

2.2 The student can apply mathematical routines to quantities that describe natural phenomena.

2.3 The student can estimate numerically quantities that describe natural phenomena.

6.1 The student can justify claims with evidence.

6.4 The student can make claims or predictions about natural phenomena based on scientific theories and models.

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