

## Redox Reactions for Artists Activity 8

**Why?** Artists use oxidation reduction chemistry in a variety of ways: to produce interesting jewelry effects, to anticipate surface alterations to metallic sculptures, and to create unusual ceramic glazes.



[www.beadinggem.com/2008/12/verdigris-jewelry-by-painted-metal.html](http://www.beadinggem.com/2008/12/verdigris-jewelry-by-painted-metal.html)



<http://www.andreageile.co.uk/images/Oxidized.jpg>



[gonzalezraku.com/images/web\\_pots\\_002.jpg](http://gonzalezraku.com/images/web_pots_002.jpg)



[images.search.yahoo.com/images/view?back=http%3A%2F%2Fimages.search.yahoo.com%2Fsearch%2Fimages%3Fp%3Dniobium%2Bjewelry%](http://images.search.yahoo.com/images/view?back=http%3A%2F%2Fimages.search.yahoo.com%2Fsearch%2Fimages%3Fp%3Dniobium%2Bjewelry%2F)

Written by Dr. Cheryl Coolidge, Colby-Sawyer College  
in collaboration with Dr. Shari Litch-Gray, Chester College

**Learning Objectives:**

- Be able to identify the chemical component oxidized and the components reduced
- Explain the use of redox reactions in art applications

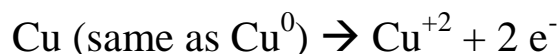
**Concepts and Vocabulary:**

- Oxidation
- Reduction
- Half reaction
- Activity series

**Model and Definition:**

An oxidation reduction reaction (redox for short) is one that involves an exchange of electrons between atoms or ions. The species that gains electrons (negative charge) is reduced; the species that loses electrons is oxidized. This gain or loss of electrons is reflected as a gain or loss of charge in inorganic compounds. If the charge goes down, a reduction has occurred. Conversely, if charge increases, an oxidation has occurred. By definition, an element in its elemental form has its charge assigned as zero. If the charge is zero, it is often not shown but understood.

An oxidation is always accompanied by a reduction, but sometimes the oxidation and reduction reactions are split into “half reactions” for clarity in the accounting. Electrons are represented as  $e^-$ . Chemical species that are present in the reaction vessel but do not participate directly in the reaction are referred to as “spectators”. During the course of an oxidation reduction reaction the physical properties of the participating atoms can change drastically, as shown below in the reaction of copper with nitric acid. The half reaction of copper in this reaction can be represented as:



plenrich.com

**Critical Thinking Questions:**

1. Describe the appearance of elemental copper,  $\text{Cu}^0$ .

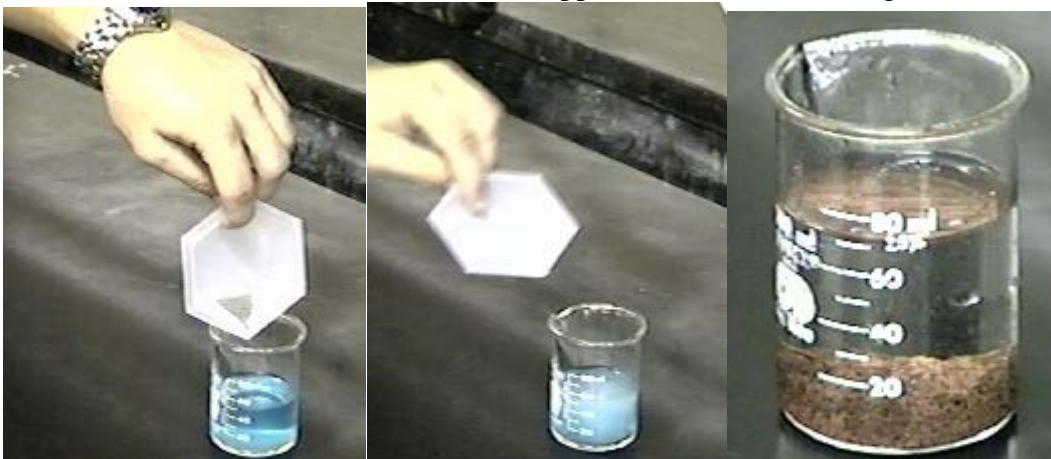
2. Is the reaction pictured above an oxidation or a reduction? How do you know?
3. What happens to the copper as its charge changes? Describe the appearance of the  $\text{Cu}^{+2}$  ions.
4. The images below show the Statue of Liberty as it appeared when cast and as it looks now in New York Harbor. Explain the underlying chemistry.

<http://images.search.yahoo.com/images/view?back=http%3A%2F%2Fimages.search.yahoo.com%2Fsearch%2Fimages%3Fp%3Dstatue%2Bof%2Blib>



<http://www.flickr.com/photos/g-fhunk/1254018365/>

5. In the reaction of zinc metal with copper sulfate, the following is observed:



<http://ch185.semo.edu/copper/partIIstepA.html>

This equation can be written as  $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$ . The sulfate ( $\text{SO}_4$ ) is a spectator. If it is eliminated, the “net ionic” equation is  $\text{Zn} + \text{Cu}^{+2} \rightarrow \text{Zn}^{+2} + \text{Cu}$ . Notice that electrons do not appear in a complete reaction as opposed to the half reaction.

a. What is reduced in this reaction? What is oxidized?

b. What happened to the blue copper ions? What happened to the zinc metal?

6. In many important reactions, oxygen from the atmosphere is a participant. When iron “rusts” through a series of redox reactions involving water and oxygen, the ultimate reaction is  $\text{Fe}$  (iron) +  $\text{O}_2$  (molecular, elemental oxygen)  $\rightarrow$   $\text{Fe}_2\text{O}_3$  (red rust). The charge of iron in rust is +3; the charge of oxygen in rust is -2.

a. What is the charge of metallic iron? Atmospheric oxygen? How do you know?

b. What is oxidized in this reaction? What is reduced?

7. In raku firing of ceramics, a piece of clay is formed, then glazed, often with some type of copper, iron, cobalt, or other metallic compound. The product is removed hot from the kiln and placed in a container of sawdust, leaves, or other combustible materials. The burning quickly consumes all the oxygen, and produces a “reductive” environment. You know that the half reaction:
- $$\text{Cu} \rightarrow \text{Cu}^{+2} + 2 \text{e}^{-}$$
- is an oxidation.
- Write this in reverse to show what happens to the copper ions in glazes in a reductive environment. Explain, then, why raku firing yields interesting effects.



## Jewelry

<http://www.grandinetti.org/Teaching/Chem121/Lectures/ActivitySeries/assets/ActivitySeries.png>

### Model The activity series:

An activity series is a table that shows the relative ease of oxidation of metals, with the most easily oxidized, most reactive metals at the top of the chart.

### Critical Thinking Questions:

- What metals are used most commonly to make expensive jewelry? Where are they found on the activity series? Why are these metals preferred for precious jewelry?

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Metal	Oxidation Reaction
Lithium	$\text{Li} \rightleftharpoons \text{Li}^{+} + \text{e}^{-}$
Rubidium	$\text{Rb} \rightleftharpoons \text{Rb}^{+} + \text{e}^{-}$
Potassium	$\text{K} \rightleftharpoons \text{K}^{+} + \text{e}^{-}$
Barium	$\text{Ba} \rightleftharpoons \text{Ba}^{2+} + 2\text{e}^{-}$
Calcium	$\text{Ca} \rightleftharpoons \text{Ca}^{2+} + 2\text{e}^{-}$
Sodium	$\text{Na} \rightleftharpoons \text{Na}^{+} + \text{e}^{-}$
Magnesium	$\text{Mg} \rightleftharpoons \text{Mg}^{2+} + 2\text{e}^{-}$
Aluminum	$\text{Al} \rightleftharpoons \text{Al}^{3+} + 3\text{e}^{-}$
Manganese	$\text{Mn} \rightleftharpoons \text{Mn}^{2+} + 2\text{e}^{-}$
Zinc	$\text{Zn} \rightleftharpoons \text{Zn}^{2+} + 2\text{e}^{-}$
Chromium	$\text{Cr} \rightleftharpoons \text{Cr}^{3+} + 3\text{e}^{-}$
Iron	$\text{Fe} \rightleftharpoons \text{Fe}^{2+} + 2\text{e}^{-}$
Cobalt	$\text{Co} \rightleftharpoons \text{Co}^{2+} + 2\text{e}^{-}$
Nickel	$\text{Ni} \rightleftharpoons \text{Ni}^{2+} + 2\text{e}^{-}$
Tin	$\text{Sn} \rightleftharpoons \text{Sn}^{2+} + 2\text{e}^{-}$
Lead	$\text{Pb} \rightleftharpoons \text{Pb}^{2+} + 2\text{e}^{-}$
Hydrogen	$\text{H}_2 \rightleftharpoons 2 \text{H}^{+} + 2\text{e}^{-}$
Copper	$\text{Cu} \rightleftharpoons \text{Cu}^{2+} + 2\text{e}^{-}$
Silver	$\text{Ag} \rightleftharpoons \text{Ag}^{+} + \text{e}^{-}$
Mercury	$\text{Hg} \rightleftharpoons \text{Hg}^{2+} + 2\text{e}^{-}$
Platinum	$\text{Pt} \rightleftharpoons \text{Pt}^{2+} + 2\text{e}^{-}$
Gold	$\text{Au} \rightleftharpoons \text{Au}^{3+} + 3\text{e}^{-}$

2. Less expensive costume jewelry is often fashioned from nickel or copper. Many people have adverse reactions to these metals or may notice bands of color on their skin where it contacts copper jewelry. Explain, in light of the activity series.

3. One of the more interesting metals in jewelry applications is niobium, shown "anodized" and bent into ear wires to the right. Anodizing is an electrochemical process that converts metallic niobium into its ionic oxides. For niobium, the different oxides have a high refractive index, and, depending on thickness, produce a wonderful array of colors:



The underlying reaction is  $\text{Nb (s)} + \text{H}_2\text{O (l)} \rightarrow \text{NbO (s)} + \text{H}_2 \text{(g)}$ . (Nb has a charge of +2 in the oxide).

Is anodizing an oxidation or a reduction from the perspective of the niobium?

Which element is reduced? How do you know?