

# Penny Sandwiches

From 1864 until 1983, the usual composition of a penny (its actual name is “cent”) was 95% copper and 5% zinc and tin. Because of the increasing costs of copper, pennies are now composed of a zinc interior with a thin copper coating comprising only 2.4% of the penny. This activity allows you to remove the inside of the penny, leaving only the thin copper coating.

## Materials

- 2 pennies (dated 1983 or later)
- file or coarse sandpaper
- 2 cups lemon juice
- 2 cups vinegar
- 2 clear wide-mouthed containers (greater than 2-cup capacity)
- cup measure

## Safety

Do not seal the bottles. The pressure of the hydrogen gas may be sufficient to shatter the bottles.

## Exploration

Step 1 Using the file or coarse sandpaper, completely remove the copper coating from the edge of both pennies. Pour the lemon juice into one container. Position one penny in the container so that it is standing on its edge against the side of the container. Pour the vinegar into the second container and similarly position the second penny. Observe the pennies for 4 or 5 minutes. What do you see? What is occurring? What is the identity of the observed substance?

Step 2 Observe the pennies over the course of 1 week and describe any difference(s) in their behavior. What accounts for the difference(s)? What specific process is occurring in each container? How do you know when the processes are complete? Write an appropriate equation representing the processes. Use your observations to rank the three elements hydrogen, copper, and zinc from most to least reactive.

## Challenge

What is the chemistry-based reason for this peculiar construction of a penny?

# Penny Sandwiches

This activity extends over a much longer time period than the usual challenge.

## Concepts

oxidation-reduction reaction (redox), single replacement reaction

## Expected Student Responses to Exploration

- Step 1
- (a) Bubbles should be visible in both containers.
  - (b) The formation of bubbles indicates a chemical process (reaction).
  - (c) The bubbles are of hydrogen gas.
- Step 2
- (a) Bubbles should be visible while the reaction continues. The zinc interior dissolves and the copper coating on each side of the pennies remains and will float to the surface if gas adheres to them. Bubbles will stop forming in the lemon juice first; the bubbles may still be forming in the vinegar after one week.
  - (b) There is a greater concentration of acid in the lemon juice than in the vinegar.
  - (c) The reaction of zinc with an acid is occurring.
  - (d) The reactions are complete when bubbles stop forming.
  - (e)  $\text{Zn(s)} + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2(\text{g})$
  - (f) Order of reactivity:  $\text{Zn} > \text{H} > \text{Cu}$

## Expected Student Answer to Challenge

Zinc by itself is too reactive to be made into a coin; the copper is necessary as a protective coating.

## Reference

R.S. Yoeman, *A Guide Book of United States Coins*, 24th Ed., Western Publishing Company, Inc., Racine, Wisc. 1970.

## Acknowledgment

This activity was developed as a part of the NSF-funded “General Chemistry: Discovery-Based Advances for the Two-Year College Chemistry Curriculum” project, grant #DUE-9354378.