Citrus Battery Contest

Metal Activity and Cell Potentials

Introduction
Design a battery using metal strips and a lemon or an orange. The group who creates the battery with the highest voltage using the correct metals wins. Good luck!

Concepts
• Electrochemistry • Cell potential
• Metal activity • Anode vs. cathode

Materials

- Lemon, grapefruit or orange
- Metal strips (aluminum, copper, iron, magnesium, tin, and zinc), 1 cm × 4 cm, 2 each
- Ruler, metric
- Sandpaper or steel wool
- Scissors, heavy-duty
- Digital Multimeter

Safety Precautions

Magnesium metal is a flammable solid. Avoid contact with flames and heat. Any food-grade items that have been brought into the lab are considered laboratory chemicals and are for lab use only.

Do not taste or ingest any materials in the laboratory and do not remove any remaining food items after they have been used in the lab. Wear chemical splash goggles, chemical-resistant gloves, and chemical-resistant apron.

Procedure

1. Cut strips of metal sheet, about 1 cm wide by 4 cm long, using heavy-duty scissors. Place the metal strips on a labeled sheet of paper to keep track of their identity.

2. “Prime” the lemon or orange by pushing down slightly and rolling it briskly on a table or benchtop to soften the skin.

3. Insert two different metal strips about 1–2 cm apart into the lemon or orange. The metals should penetrate the fruit to a depth of at least 2–3 cm.
4. Attach a voltage lead (or connector cord with alligator clips) from the multimeter or voltage sensor to each metal electrode.

5. Measure the voltage. *If a positive voltage reading is obtained,* record the voltage and note which metal is attached to the positive lead and which is attached to the negative lead. *Note:* If a negative voltage reading is obtained, reverse the polarity (switch the positive and negative leads) of the metal electrodes to obtain a positive reading.

6. Observe any signs of a chemical reaction in or around each metal electrode.

7. Repeat steps 3–6 to measure the voltage for different combinations of metals. Remember to record the identity of the positive and negative electrodes when a positive voltage is obtained.

8. Set up a friendly competition among different student groups to design a battery that will give the highest voltage.

Trial	Anode (-)	Cathode (+)	(+) Voltage Reading
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Calculations

Write the reduction and oxidation half-reactions for the (3) trials that produced the largest potential difference. Determine which is oxidized and which is reduced and write the overall reaction and cell EMF for the reaction. Were your reading close to the predicted cell EMF?

Trial _____

Trial _____

Trial _____

9. Some questions to consider:
   (a) What combination of metals gives the highest voltage?

   (b) Does the voltage depend on the separation between the metals?

   (c) (d) Is the battery voltage stable over time?

   (d) (e) How long will the battery last?