Electrochemistry in Action: Building A Battery Challenge

TEACHER ANSWER KEY

Lab Safety 101: You should NEVER smell or eat/drink anything in a Lab because it can be very dangerous. For this lab we are working with electrical currents so make sure you follow all directions and ask your teacher if you have any questions.

Important Vocabulary:

Anode: **The NEGATIVELY charged side of a battery**

Cathode: **The POSITIVELY charged side of a battery**

Ions: **an atom that has lost at least 1 electron (negative - anion) or has gained at least 1 electron (positive - cation)**

Which type of atom(s) make a good cathode or good anode?

Anode	Cathode
Atoms that have an affinity for taking electron(s) which will create a negative ion (anion). **Copper (Cu)** **Iron (Fe)**	**Atoms that have an affinity for giving away electron(s) which will create a positive ion (cation).** **Zinc (Zn)** **Aluminum (Al)**

Electrolyte: **the substance that allows ions (atoms that have LOST or GAINED electrons) to flow between the anode and the cathode.**

Separator: **prevents physical contact between the anode and cathode, while facilitating ion transport in the cell.**

Answer the following questions while watching the Video: How do Lithium-ion Batteries Work?

1. Why does lithium prefer to give up its outermost electron at the anode?

Lithium has 1 electron in its outer shell and the inner shell has 2 electrons, therefore to gain a full outer shell it needs 7 more electrons but it is easier for it to lose an electron and become a 1+ ion and have a full outer shell of 2.

2. Discuss the importance of the electrolyte in allowing lithium ions to migrate between the anode and cathode of a lithium-ion battery while preventing the flow of electrons.

The electrolyte allows lithium ions (Li+) to move between anode and cathode which stabilizes the cathode and anode surfaces. This also extends battery lifespan and improves cell performances. We do not want the electrons to travel from one side to the other inside the battery because a dangerous chemical reaction will occur as a result. We want electrons to flow outside the battery through an electrical conductor which generates electricity which we can use.

3. What happens to lithium ions during the battery charging process?

When your phone dies you need to recharge it. When you plug it in the electrons are sent back to the anode (negative side) and the lithium ions re-intercalate themselves in the cathode. Once the battery is charged you can unplug it and the cycle starts all over again until the battery discharges again.

4. Why do electrons flow from the anode (negative) side to the cathode (positive) side instead of staying on the negative side?

Electrons have a negative charge. Opposite charges attract each other and similar charges repel each other, thus electrons move from negative electrode to positive electrode inside a cell.

5. What happens if the cathode and the anode accidentally touch?

In a Lithium Ion Battery, if the electrolytes leak and the anode & cathode touch this creates a chemical reaction that releases heat. This heat can then damage other battery cells, creating a chain reaction of damage which leads to a fire. This was seen when the Galaxy Note 7 cell phones batteries continued to get punctured so they would catch fire leading to the large recall back in 2016.

Materials:

Voltmeter	Iron Nails	Aluminum Nails
Galvanized (Zinc) Nails	Copper Nails	Alligator Clips
Periodic Table of Elements	Potato or Yam	Lemon or Lime
Gatorade or Powerade	Apple or Orange	Water
Paper Towels-optional	Cups to hold liquid	1 tablespoon Salt

Procedure:

1) Make sure you have all of your materials before you start the experiment. Completely read this procedure and make sure to ask if you have any questions after reading it.
2) Roll the lemon gently on a table to soften it without breaking the skin. This will help release the juice inside, improving conductivity.
3) Insert the Electrodes by iInserting the copper nail into the lemon about 1 inch deep. Then Insert the zinc nail into the lemon about 1-2 inches away from the copper nail. Make sure the nails do not touch each other inside the lemon.
4) Connect the Voltmeter by attaching the positive (red) probe of the voltmeter to the copper nail. Then attach the negative (black) probe of the voltmeter to the zinc nail.
5) Measure the Voltage by turning on the voltmeter and set it to measure DC voltage (if not already set).
6) Observe the reading on the voltmeter. It should show a small voltage, typically around 0.3 to 1 volt. Record the voltage on your data table.
7) Repeat steps 3-6 with the zinc nail and iron nail.
8) Repeat steps 3-6 with the aluminum and copper nail.
9) Repeat steps 3-6 with the aluminum and iron nail.
10) After finishing the experiment with the lemon, complete the experiment (steps 3-9) with each of the following electrolytes: apple, yam, gatorade, water, salt water.

Data Table I - LEMON:

Cathode	Anode	Voltage Trials 1	Voltage Trial 2	Voltage Trial 3	Average
Zinc (Zn)	Copper (Cu)	0.99 V	1.0	1.0	1.0
Zinc (Zn)	Iron (Fe)	0.41V	0.46	0.44	0.44
Aluminum (Al)	Copper (Cu)	0.93 V	0.83	0.84	0.86
Aluminum (Al)	Iron (Fe)	0.17V	0.36	0.35	0.29

Data Table II - APPLE:

Cathode	Anode	Voltage Trial 1	Voltage Trial 2	Voltage Trial 3	Average
Zinc (Zn)	Copper (Cu)	1.01 V	1.00	1.01	1.01 V
Zinc (Zn)	Iron (Fe)	0.45 V	0.45	0.43	0.44 V
Aluminum (Al)	Copper (Cu)	0.98 V	0.80	0.74	0.84 V
Aluminum (Al)	Iron (Fe)	0.33 V	0.40	0.38	0.37 V

Data Table III - YAM:

Cathode	Anode	Voltage Trial 1	Voltage Trial 2	Voltage Trial 3	Average
Zinc (Zn)	Copper (Cu)	**0.91 V**	**0.84 V**	**0.87 V**	**0.87 V**
Zinc (Zn)	Iron (Fe)	**0.78 V**	**0.75 V**	**0.83 V**	**0.79 V**
Aluminum (Al)	Copper (Cu)	**0.84 V**	**0.85 V**	**0.84 V**	**0.84 V**
Aluminum (Al)	Iron (Fe)	**0.60 V**	**0.61 V**	**0.60 V**	**0.60 V**

Data Table IV - GATORADE:

Cathode	Anode	Voltage Trial 1	Voltage Trial 2	Voltage Trial 3	Average
Zinc (Zn)	Copper (Cu)	**1.03 V**	**1.03 V**	**1.02 V**	**1.03 V**
Zinc (Zn)	Iron (Fe)	**0.41 V**	**0.40 V**	**0.41 V**	**0.41 V**
Aluminum (Al)	Copper (Cu)	**0.69 V**	**0.70 V**	**0.79 V**	**0.73 V**
Aluminum (Al)	Iron (Fe)	**0.23 V**	**0.28 V**	**0.26 V**	**0.26 V**

Data Table V- WARM WATER:

Cathode	Anode	Voltage Trial 1	Voltage Trial 2	Voltage Trial 3	Average
Zinc (Zn)	Copper (Cu)	**0.82 V**	**0.90 V**	**0.94 V**	**0.89 V**
Zinc (Zn)	Iron (Fe)	**0.65 V**	**0.62 V**	**0.64 V**	**0.64 V**
Aluminum (Al)	Copper (Cu)	**0.77 V**	**1.01 V**	**0.98 V**	**0.92 V**
Aluminum (Al)	Iron (Fe)	**0.72 V**	**0.83 V**	**0.81 V**	**0.79 V**

Data Table VI: WARM SALT WATER

Cathode	Anode	Voltage Trial 1	Voltage Trial 2	Voltage Trial 3	Average
Zinc (Zn)	Copper (Cu)	**0.74 V**	**.80 V**	**0.82 V**	**0.79 V**
Zinc (Zn)	Iron (Fe)	**0.62 V**	**.64 V**	**0.63 V**	**0.63 V**
Aluminum (Al)	Copper (Cu)	**0.62 V**	**0.77 V**	**0.82 V**	**0.74 V**
Aluminum (Al)	Iron (Fe)	**0.44 V**	**0.31 V**	**0.54 V**	**0.43 V**

Answer the following questions.

1) Which cathode gave you the highest voltage between Zinc and Aluminum? **Zinc**

2) Which anode gave you the highest voltage between Copper and Iron? **Copper**

3) What are the characteristics of an atom that would make a good anode? **Atoms that have an affinity for losing electrons. Since electrons have a negative charge when an atom loses electrons it will have a positive charge.**

4) What are the characteristics of an atom that would make a good cathode? **Atoms that have an affinity for gaining electrons. Since electrons have a negative charge when an atom gains electrons it will have a negative charge.**

5) What is the function of the anode in a battery?
The anode is the negative electrode, where oxidation (loss of electrons) takes place.

6) What is the function of the cathode in a battery?
The cathode is the positive electrode, where reduction (gain of electrons) occurs.

7) How does the electrolyte facilitate the movement of lithium ions within the battery?
The electrolyte is in contact with electrodes and the separator, so it electronically interacts with all the components in the battery. The electrolyte facilitates the transfer of the Li+ ions from cathode to anode during charging and from the anode to cathode in the discharging process.

8) Label the batteries with each of your vocabulary words and draw lines to indicate which direction the electrons are flowing.

