

## Part 1: Battery

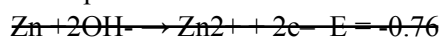
In this experiment we created two cells, one copper-zinc galvanic cell and another dry carbon-zinc cell. By using scientific principles learned in AP chemistry we were able to design and run an experiment in which we used chemicals to create voltage.

### Carbon-Zinc Battery

A carbon-zinc battery is a dry cell primary battery which siphones an electrochemical from a reaction between Zinc and magnesium (IV) oxide. Conventionally, Ammonium chloride is used as an electrolyte to stimulate the current throughout the cell. Yet, due to the lack of this chemical, Our team decided to use Potassium hydroxide, which works equally as well as Ammonium chloride.

<b>Materials: Carbon-zinc cell</b>	Magnesium (IV) Oxide	Sodium hydroxide	Graphite
Water	Zinc (anode lead)	Graphite (cathode lead)	

By calculating the reduction potential of the copper-zinc battery we were able to determine the maximum amount of voltage our battery was able to produce.

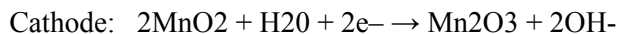


$$E^0 = 1.35 \text{ volts}$$



From this math we know that the maximum amount of voltage which can be produced from this cell is approximately 1.35 volts.

### Part A1: Assembling the Battery

To create the cathode paste used to create an electrical current from a reaction between zinc and Magnesium (IV) Oxide. The paste is made by combining Magnesium (IV) Oxide, Graphite, Sodium hydroxide, and water into a paste in order to produce electricity. There is a 2:1 ratio between the Magnesium (IV) Oxide and Sodium, because of the cathode and anode reaction equations.




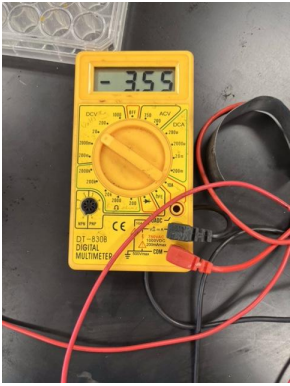
1. Measure out at 2:1 ratio of Magnesium (IV) Oxide and Sodium hydroxide
2. Grind up graphite - this will increase conductivity of the cell.
3. Combine Magnesium (IV) Oxide and Sodium hydroxide and graphite to make a heterogeneous dry mixture - make sure it is finely grounded.
4. Add water to dry mixture to make the paste - water will increase conductivity of the cell
5. Place mixture in small beaker or container - this will serve as the "shell" of the battery
6. Insert the cathode and anode lead - this will allow us to create a full circuit
7. Attach leads to a meter to see how much voltage/ amperage battery is making

	
Zinc coiled around the inner part of the cell	Graphite and zinc leads sticking out of mixture

As shown above, our team created two versions of this battery: one with zinc wrapped around the inner edge of our beaker, and the second with the electrodes sticking out of the beaker. We noticed an extreme improvement in voltage and current with the second design.

## Part A2: Testing Batteries

To test our carbon-zinc battery we first measured the voltage of one battery to get a baseline voltage. This voltage came out around 1 volt and had a current of around 20 amps. We then proceeded to create two more batteries, hopefully, tripling our voltage and current. By putting our batteries in parallel we were able to exceed our prediction and increase our voltage to 3.5 volts and almost doubled our current.

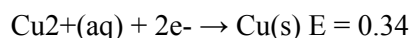
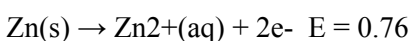
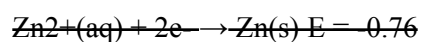
	
Batteries connected in parallel	Voltage produced by linking batteries in parallel

## Copper-Zinc Battery

A copper-zinc galvanic cell is a common battery which uses copper and zinc electrodes submerged in an electrolytic solution. A salt bridge allows ions to flow between the solutions to create an electrochemical reaction. By siphoning of the electricity using copper and zinc leaders which are able to create a battery.

Copper-Zinc Materials	Copper	Zinc
Copper sulfate	Zinc Sulfate	Sodium Nitrate (1M)
2 Beakers	Salt bridge	Cotton

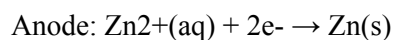
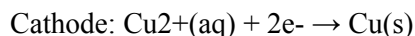
By calculating the reduction potential of this battery we are able to determine the maximum amount of voltage that this battery is able to produce.



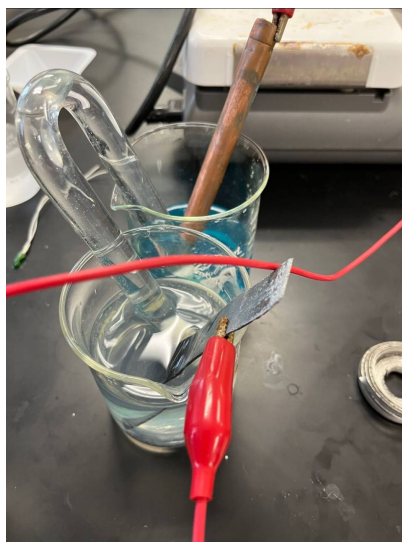
$$E^0 = 1.1 \text{ volts}$$

### Part B1: Assembling the battery

The copper-zinc galvanic cell we built utilizes a zinc anode and a copper cathode placed in zinc sulfate and copper sulfate, respectively.



1. Obtain 1.0 molar zinc sulfate and 1.0 molar copper sulfate solution. Fill two beakers with sufficient solution to cover a portion of the electrodes.
2. Place the zinc and copper electrodes into their respective solutions.
3. Obtain a 1.0 molar sodium nitrate solution. Fill the salt bridge with this solution and plug each end with cotton.
4. Place the salt bridge into the zinc sulfate and copper sulfate solutions such that each end of the salt bridge is immersed in each solution.
5. Attach a wire to each electrode. Attach these wires to a multimeter or other measuring device.
6. The galvanic cell is now complete. Use a multimeter to measure its voltage.

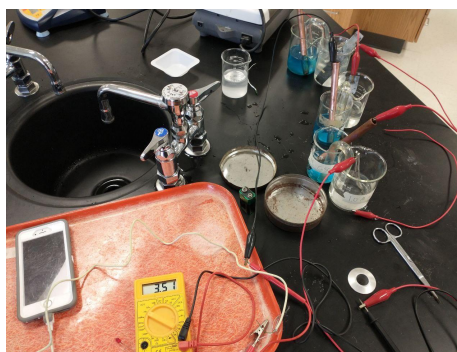


Completed copper-zinc galvanic cell

As shown above, we used zinc and copper leads, in conjunction with copper sulfate and zinc sulfate solution. To connect the batteries together we used a salt bridge with sodium nitrate. This allows ions to travel through to the other side and conduct electricity.

## Part B2: Testing the Battery

To test our galvanic cell, we attached the electrodes to a multimeter. We found that our copper-zinc cell produced approximately 0.8 volts. However, this was inconsistent, and could produce between 0.35 and 0.9 volts depending on the position of the electrodes. Additionally, cleaning the zinc anode with steel wool improved the cell's performance.



Collaboration with other lab groups - linking batteries in parallel and series to maximize voltage and current

We also combined our batteries with other lab groups to try and see if we could power a clock. With these batteries we were able to produce a voltage of 3.51 volts yet a relatively low current. Sadly, we were not able to power the clock because of the low current produced by the battery. If we had combined the battery we made in the previous experiment with this copper-zinc battery set up, we could have possibly made enough current and voltage to power a clock.

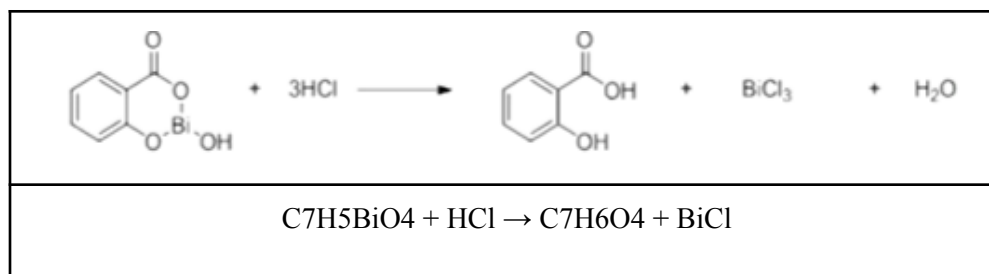
## Part 2: Electroplating

In this experiment we attempted to electroplate Bismuth derived from pepto bismol onto copper penny. Electroplating is the process of coating the surface of a conducting material with a metal. This is typically done by applying a current between the anode and cathode metal through an electrolyte. This allows for the transfer of ions onto a metal surface, coating the surface

<b>Materials:</b>	Pepto-Bismol (Bismuth Subsalicylate )	3M Hydrochloric acid
Whatman Filters	Funnel	Beakers (4)
Vacuum Pump	Crucible / Ring stand	Butane torch
Concentrated Nitric Acid ~ 18M	Water	Electrodes
Pennies	Battery	

### Part C1: Extracting Bismuth

To get the materials for electroplating we first have to extract bismuth from pepto-bismol. This is done by creating a reaction with pepto-bismol and Hydrochloric acid. By separating doing this reaction we are able to separate bismuth for subsalicylate allowing for bismuth ions to be produced.



1. To begin the extracting process we have to prepare the correct molarity of hydrochloric acid - we do this by diluting the molarity of muriatic acid

We first confirmed this using the dilution formula

$$MV = M_2V_2$$

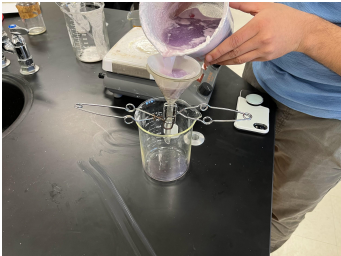

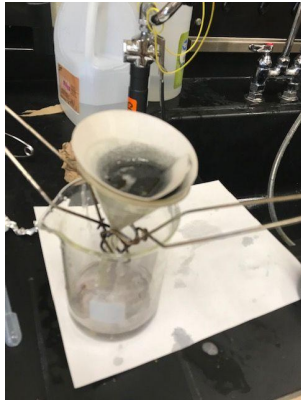
$$1(12.1) = (4)x$$

$$x = 3 \text{ M}$$

2. By mixing three parts water and one part hydrochloric acid and slowly add pepto-bismol into the solution. Add a stir bar and heat up the beaker to speed up the reaction. Salicylic acid will begin to bubble up due to the reaction and should be done in a large beaker
3. Using strong stirring, we react to the active ingredient of pepto bismol, bismuth subsalicylate with hydrochloric acid to produce bismuth chloride and salicylic acid.
4. To remove Salicylic acid from the solution, we have to filter it out from the solution, allowing us to isolate bismuth chloride
5. We then reduced bismuth ion in our bismuth chloride solution by adding aluminum foil. This pulled out the bismuth ions while 'eating' the aluminum foil. The Aluminum also reacts with the acid, making it difficult to determine when to stop adding more foil. We tested this by adding

some of the solution onto a piece of aluminum foil and checking if there was any bismuth precipitate.

6. Once the aluminum was completely gone, we filtered out water which was left in the solution. This left us with bismuth in its non-metallic form!


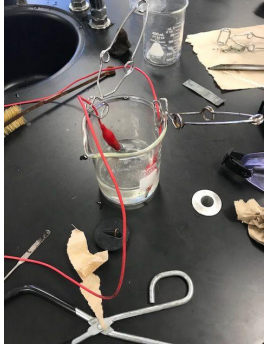
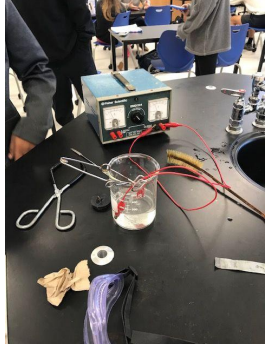
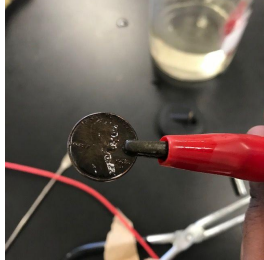
		
Filtering process for removal of salicylic acid.		Filtering process to remove excess water from Bismuth

## Part C1: Electroplating

To begin electroplating we first have to determine our anode and cathode materials; in our case the cathode is our copper penny while the anode is the bismuth. By running a voltage through a solution of nitric acid and water we were able to electroplate.


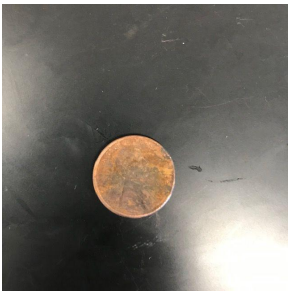

1. Use a Vacuum pump to drain out any remaining water in bismuth - this allows us to convert bismuth into its metallic form
2. Place bismuth into a crucible and use a butane torch to melt the play-do like bismuth
  - a. Bismuth tends to oxidize while being melted so a significant amount of bismuth may be lost
3. After melting place bismuth place in a ceramic bowl to cool down - this will serve as our anode terminal
4. To make the electrolyte for electroplating use 200 ml water and approximately 20 ml concentrated Nitric acid - this will be enough to conduct electricity
5. Attach bismuth to the anode terminal of the battery through alligator clips and cathode terminal of the battery to the penny - when submerged in electrolyte solution, the circuit will be complete allowing for bismuth ions to plate the copper penny



			
Melting bismuth in crucible	Placing cathode and anode in electrolytic solution	Adding voltage to electroplate pennies with bismuth	Electroplated penny

### Part C1A: Effect of Electroplating on different pennies

Since pennies from different years tend to have different compositions of metals, we decided to try pennies from different years. This included pennies from 1998, 1960, 1979, and others. Pennies from 1944 to 1982 are composed of 95% copper and 5% zinc, while any penny which is 1998 and older is just copper plated zinc. While electroplating we noticed the penny from 1998 was stripped of its copper plating and was replaced with bismuth. In contrast, the older pennies (1982-1944) seemed to have a more bismuth plated on its surface.

		
1944 - 1982 pennies	1998- present penny	Penny after significant amount of time drying

## Observations:

Regarding the extraction of bismuth I believe we made some fatal mistakes that limited our time. Three main ideas come to mind to accelerate the process.

1. Crushing caplets into a fine powder using the mortar and pestle would allow reaction to occur quicker between bismuth subsalicylate and hydrochloric acid
2. Streamline filtering process to reduce losses - this will increase the amount of bismuth collected
3. Using higher concentration hydrochloric acid to take out break down pills

In future experiments we should create a more detailed plan when tackling the process of extracting and electroplating bismuth.