

Chemistry Project

Investigate and compare the quantitative effects of changing (a) metal types and (b) fruit/vegetable type on the emf (voltage) produced across two different metals, when the electrolytes take the form of fruits and/or vegetables.



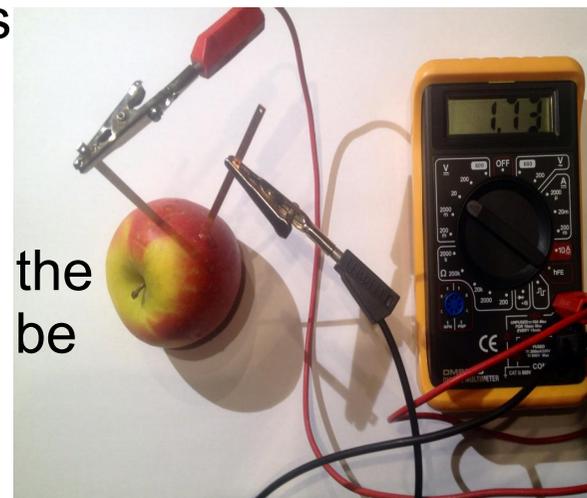
Background -

The fruit battery is a simple battery.

The metals (e.g. zinc and copper) are called the **electrodes**, and the juice inside the lemon is called the **electrolyte**.

When connected by a wire (voltmeter), the electrons in the Zinc (- or anode) flow to the Copper (+ or Cathode). This movement can be seen on the Voltmeter. The electricity isn't coming from the fruit, it's coming from the metals. The fruit and voltmeter wires just allow the electrons to move.

Different metals will have different amounts of electrons that they can lose or gain. This is called the **electrochemical series**.



electro-chemical series

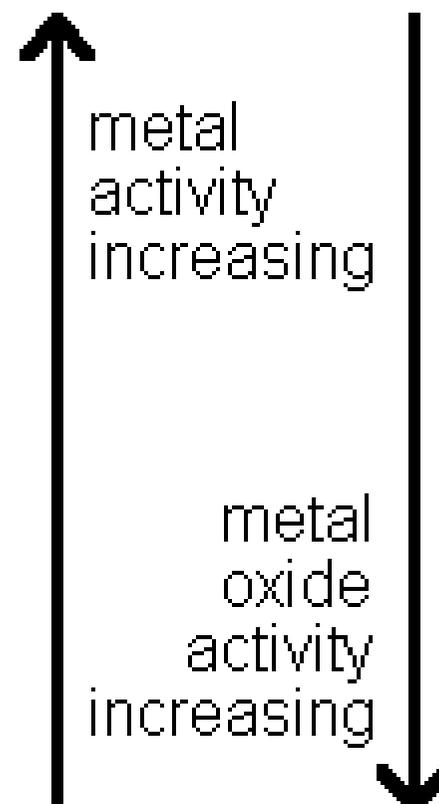
Potassium	-2.92
Calcium	-2.87
Sodium	-2.71
Magnesium	-2.37
Aluminium	-1.66
Zinc	-0.76
Iron	-0.44
Tin	-0.14
Lead	-0.13
Hydrogen	0.00
Copper	+0.34
Silver	+0.80
Mercury	+0.85
Gold	+1.00

↑ metal activity increasing

metal oxide activity increasing ↓

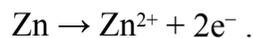
electro-chemical series

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Mercury	+0.85
Gold	+1.68



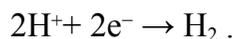
More Detailed Background

When the cell is providing an electrical current through an external circuit, the metallic zinc at the surface of the zinc electrode is dissolving into the solution. Zinc atoms dissolve into the liquid electrolyte as electrically charged [ions](#) (Zn^{2+}) leaving 2 negatively charged [electrons](#) (e^-) behind in the metal:



This reaction is called [oxidation](#).

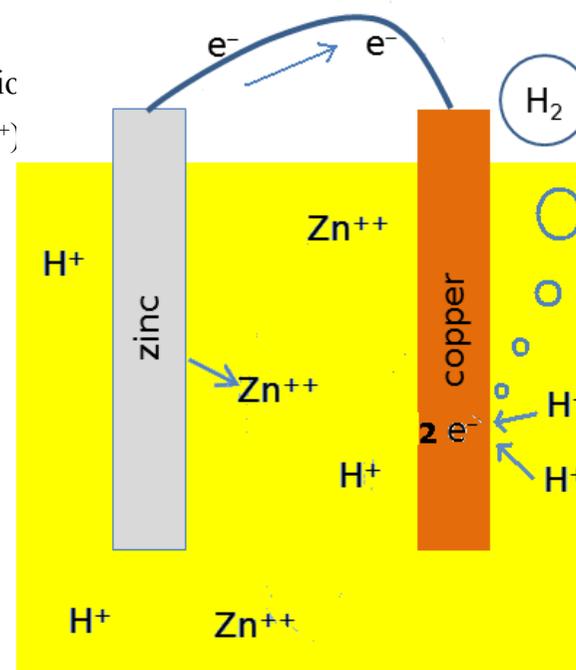
While zinc is entering the electrolyte, two positively charged [hydrogen](#) ions (H^+) from the electrolyte combine with two electrons at the copper electrode's surface and form an uncharged hydrogen molecule (H_2):



This reaction is called reduction.

The electrons used from the copper to form the molecules of hydrogen are transferred by an external wire from the zinc.

The hydrogen molecules formed on the surface of the copper by the reduction reaction ultimately bubble away as hydrogen gas.



Part 1 (Introduction)

(i) Statement or problem to be investigated - What you are going to do **in your own words**

(ii) Background research undertaken - You will have to look up a few websites and books to find information for your investigation.

You may even have to ask your teacher or someone at home for information.

This is your background research you will need to give **at least 2 pieces** of background research and make sure for these that you mention where you got the piece of information and what you used it for.

e.g. <https://www.youtube.com/watch?v=GhbuhT1GDpI>

Internet
(Give full link!)



Books
(Author and Publisher
Page and Details)



Part 2 (Preparation and Planning)

(i) Variables

1. **Independent Variables** (what I will change - **Metal Type/Fruit or Vegetable**)
2. **Dependent Variable** (what I measure - **Voltage - How much it changes**)
3. **Controls** (what I will keep the same -
 - **Test Copper with Copper to show that there is no voltage**
 - **Use same piece of Fruit/Vegetable for each test**
 - **Same Voltage meter as they can differ**
 - **Same distance between electrodes and same depth in fruit**

(ii) Equipment: List every piece of equipment you use, leave nothing out!
e.g. **Safety glasses, notebook and pencil, 3 pieces of fruit and /or vegetable, (e.g. lemon, apple and potato), electrodes of 4 different metal types, (e.g. Magnesium, Copper, Zinc and Aluminium), wires with crocodile clips, Multimeter (set to Voltage).**

(iii) Tasks: *This is the list of jobs (to do list) that need to be done in order.*

e.g. We will insert all possible combinations (6) of metals into a lemon, an apple and a potato. We will record the voltage of each combination in each fruit/vegetable and then arrange them in order of highest voltage to lowest voltage. We will then compare the results for the different metals in the different fruits/vegetables.

Part 3 (Procedures, apparatus etc.)

(i) Safety - Safety goggles to stop fruit juices from spraying into eyes.
Use Care when cutting or inserting electrodes as the metal edges are quite sharp.

(ii + iii) Procedure with diagram - Write it like a recipe.

1. Carefully cut 4 pieces of the metals to be used to the same size

We used **Copper, Zinc, Magnesium and Aluminium.**

2. Take two metals and insert them into the lemon. Connect each metal (electrode) to a wire and insert the other end into a multimeter set to measure Voltage. Wait 10 seconds before recording the voltage to allow reading to settle.

Repeat **3 times** for each combination & work out **average**.

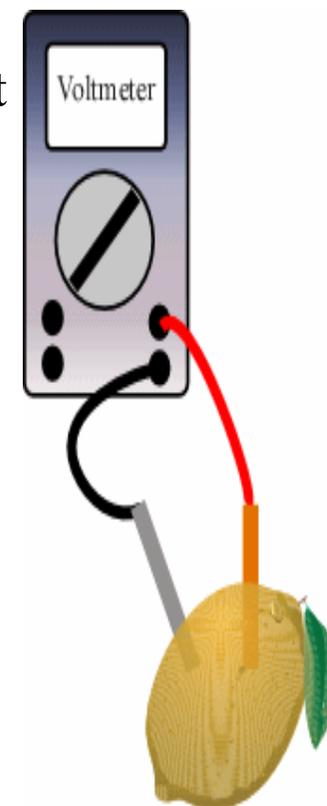
3. Draw a two-way table to put your results into and compare every metal with every other metal, e.g.

Copper with Copper (our control), Copper with Zinc, Copper with Magnesium and Copper with Aluminium).

4. Repeat for all metals so that all combinations are tried.

5. Record all your results for the lemon and then wipe the electrodes clean and **repeat the procedure** for the apple and then again for the potato.

6. Draw **tables** and **graphs** to represent the data.



(iv) Data and observations - Decide what results you are going to take and when you are going to take them before starting the test.
 e.g. All the metal combinations in one table for the lemon. Then repeat all the combinations for the apple and then the potato. We can do the control (Copper with Copper) in each fruit/vegetable also to show that the current doesn't flow.

Make a data table before you start your experiment so you can record your measurements as soon as you observe them. This will ensure that you are consistent in the way that you record your results and it will also make it easier to analyse. Make sure to give your tables and graphs a name or number.

e.g.

Table No. 1 - Voltage in Lemon (V)

	Zinc	Copper	Aluminium	Magnesium
Zinc	0.01			
Copper	1.54	0.05		
Aluminium	0.64	0.64	0.08	
Magnesium	0.30	1.80	1.13	0.00

Do another table like this for the Apple and Potato

Example Answers only**Table No. 2 - Voltage in Apple (V)**

	Zinc	Copper	Aluminium	Magnesium
Zinc	0.00			
Copper	1.58	0.00		
Aluminium	0.68	0.54	0.02	
Magnesium	0.15	1.81	0.97	0.05

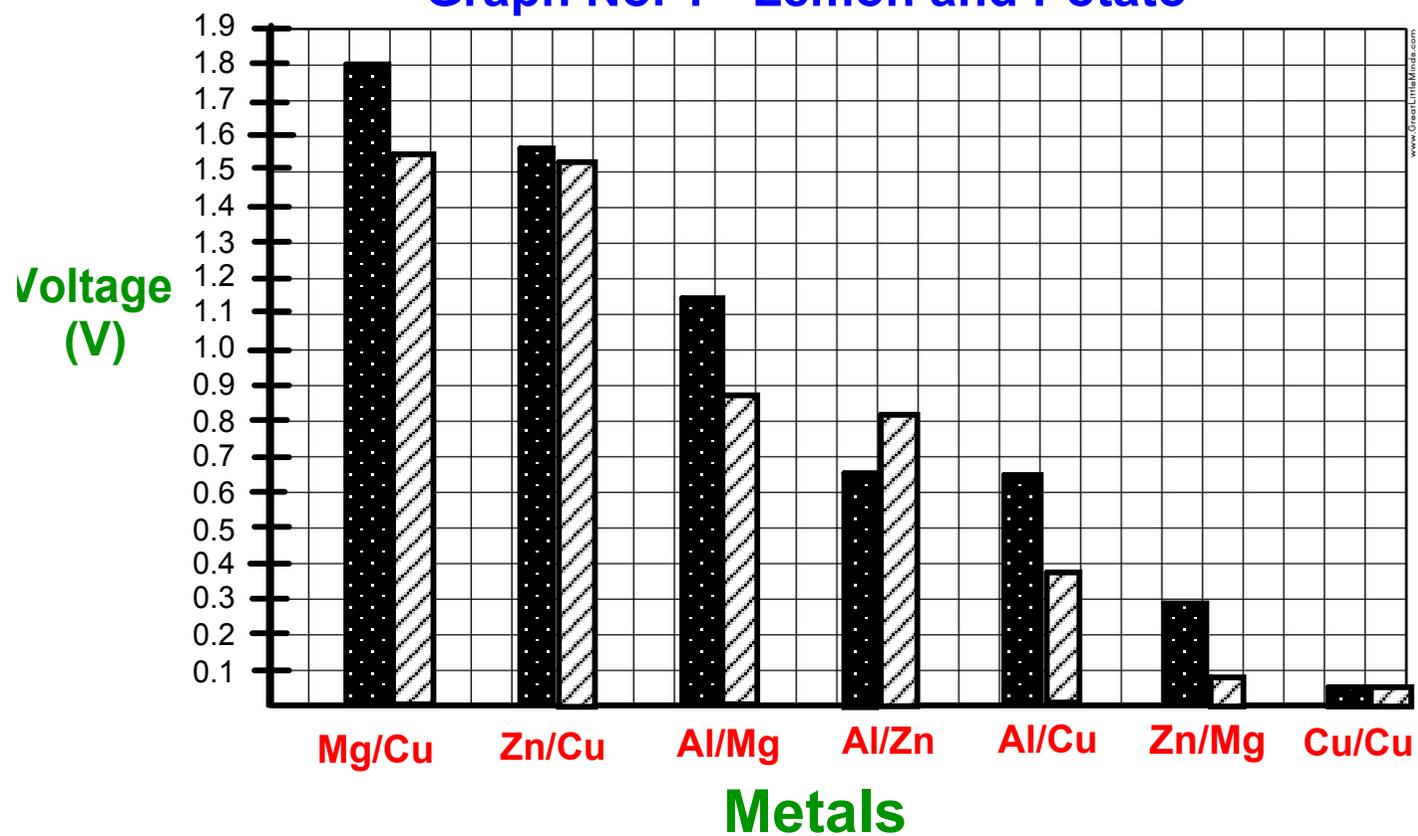
Table No. 3 - Voltage in Potato (V)

	Zinc	Copper	Aluminium	Magnesium
Zinc	0.03			
Copper	1.54	0.05		
Aluminium	0.81	0.37	0.06	
Magnesium	0.09	1.56	0.88	0.00

Key -

Zn = Zinc Al = Aluminium
Cu = Copper Mg = Magnesium

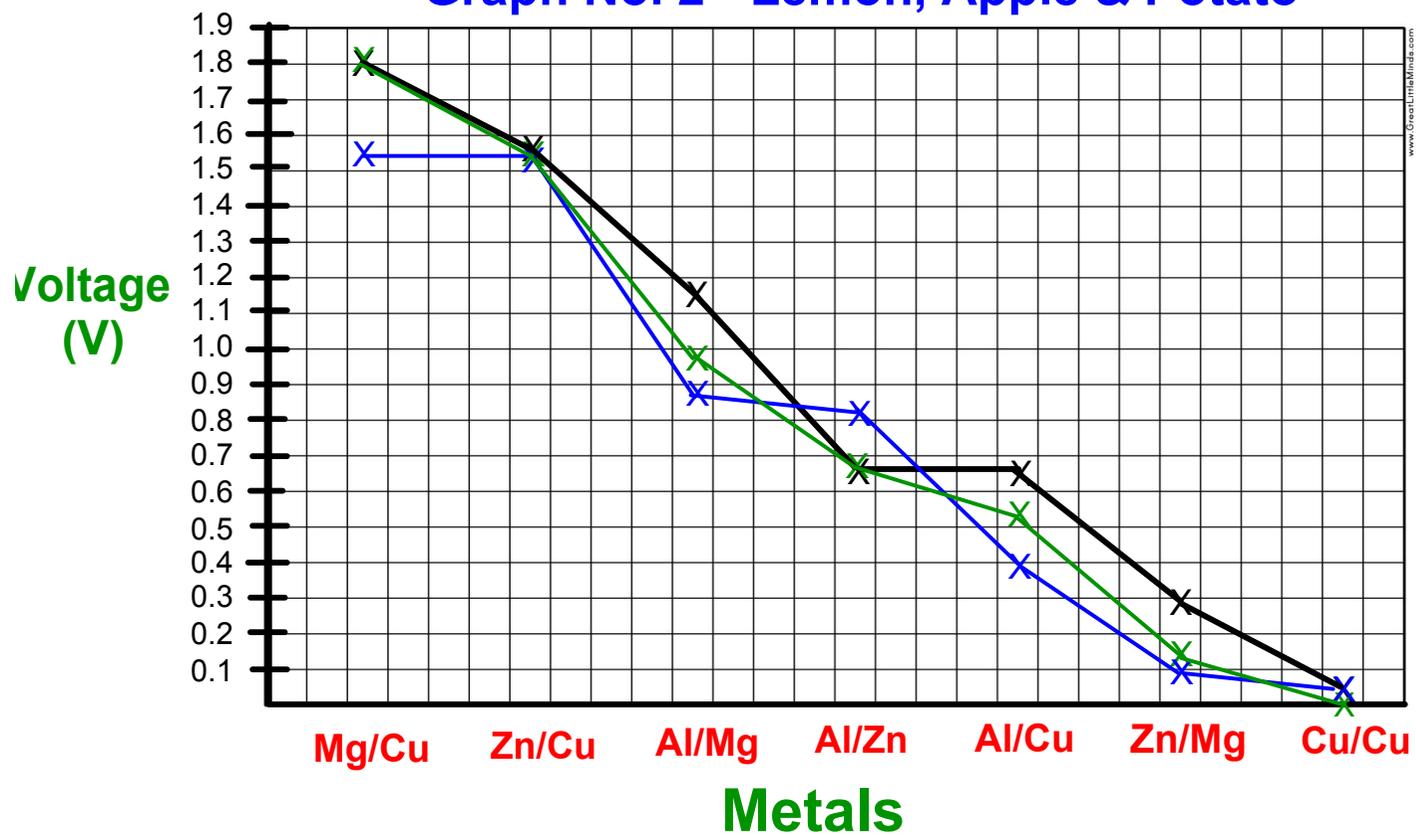
 = Lemon
 = Potato

Graph No. 1 - Lemon and Potato

Key -
 Zn = Zinc Al = Aluminium
 Cu = Copper Mg = Magnesium

X = Lemon
 X = Apple
 X = Potato

Graph No. 2 - Lemon, Apple & Potato



Analysis

Now, analyze your data, and see if you can figure out the best two metals to use and the best fruit/vegetable to use. Make sure to compare the best and worst metals and the best and worst Fruit/Vegetable.

Questions to think about...

Which metals give the biggest Voltage?

Does the **Table** here give you any clues as to why you got the results you got?

Can you explain your results?

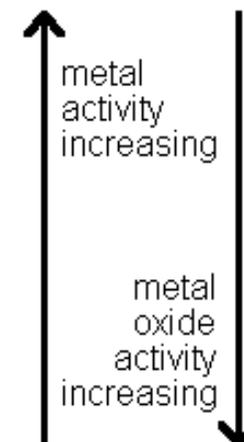
Does Voltage differ from fruit to fruit?

Does the liquid content of the fruit/vegetable seem to affect the result?

Can you think of any other questions?

electro-chemical series

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Mercury	+0.85
Gold	+1.60



Part 4 (Analysis)

(i) Calculations and Data Analysis -

Make sure you outline any calculations (e.g. finding averages)

To find the average for each metal combination we did the experiment 3 times and took the average result for the table and graph. We did the same for each of the fruits/vegetables.



(ii) Conclusion and Evaluation of result

Some useful sentence starters in this section are:

- I can see from my results that
- When I changed, changed by
- From the graph I can see that

Answer some of the following questions in your written report.

- Do your results answer the question you were asking at the start?
- Were the results what you were expecting?
- Is there a trend in your results or did anything unusual happen?
- If you got an unusual result why do you think this happened?



Conclusions

In general my results show that **Magnesium and Copper** combination gave the greatest Voltage in all of the fruits/vegetables tested.

They are also the furthest apart on the electrochemical series and this may be why they gave such a good result.

The worst result was when we used the same metal for both electrodes. This was expected as there is no chemical difference between them.

Metals closer on the electrochemical series had lower voltages in general.

The different fruits/vegetables gave slightly different results but there was not a large difference in any of them. Lemon had the highest voltages and potato had the lowest. The Zn and Cu combination in the potato gave higher results than the lemon. This maybe to do with the amount or **types of electrolytes** in the fruit or vegetable. The lemon would have a lot of citric acid and the potato may have more salts but also has phosphoric acid.

Part 5 (Comments)

(i) Refinements, extensions and sources of error

- Do your results answer the what you were trying to find out?
- Were you surprised by these results?
- Was there anything that might have affected your results.
Use a better voltmeter to get more accurate results
- Are there any changes you would make if you did the experiment again?
Use more fruits and vegetables to see if there are any better/worse results.
- Possible errors - we may have confused some of the metals, label them?
- Is there any way of making it more accurate - do more repetitions
- Could you develop your experiment further, how?
Use more of the metals, e.g. tin and iron on the electrochemical series and use more fruit and vegetables with various electrolytes.

