Zinc Layers

Catherine Chen
New Zealand

If a copper coin and small granules of zinc are immersed into a solution of zinc sulphate and then heated, a layer of zinc appears on the coin. What is the thickness of the zinc layer? What other metals can be covered with zinc in such an experiment? Investigate and explain the effect.

Interpreting the problem

Coin
A flat disc of metal that is used as money.

New Zealand Currency

Thickness
How far opposite sides or surfaces are.

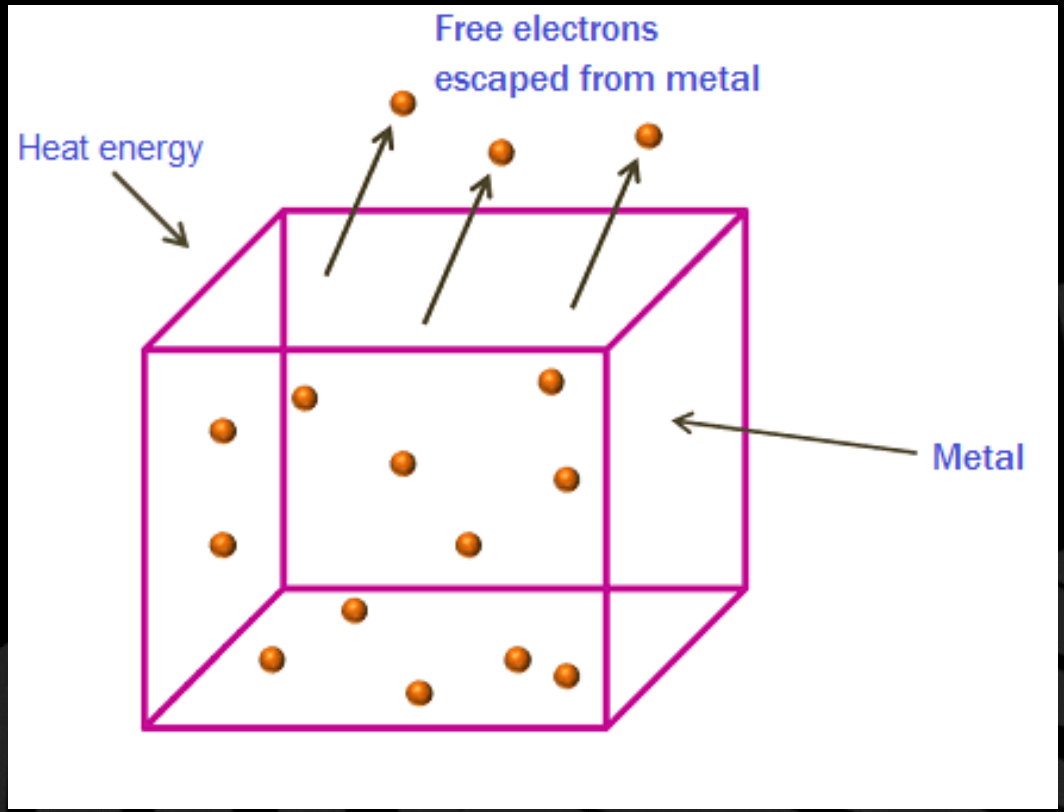
(Calculate average thickness)

Granules
A small particle of a substance (zinc granules)

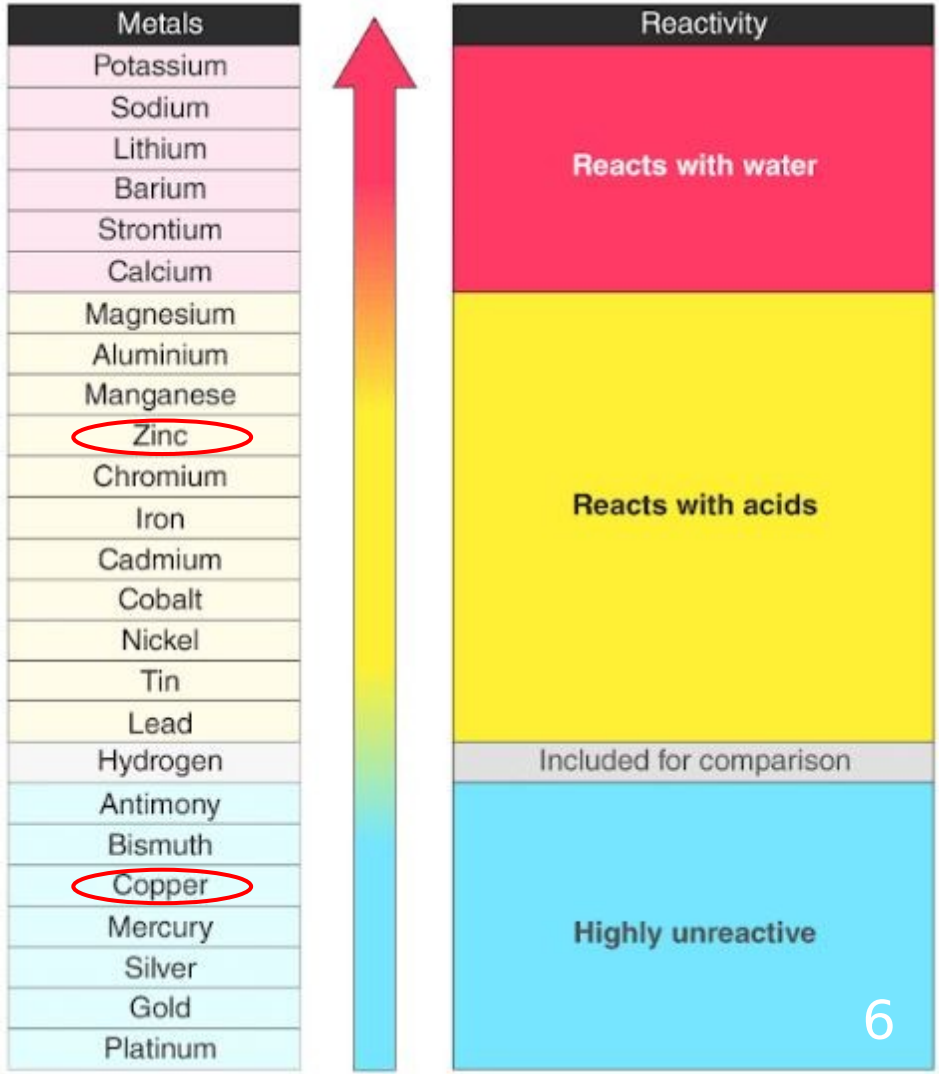
Such an Experiment
Used same successful process consistently

Theory

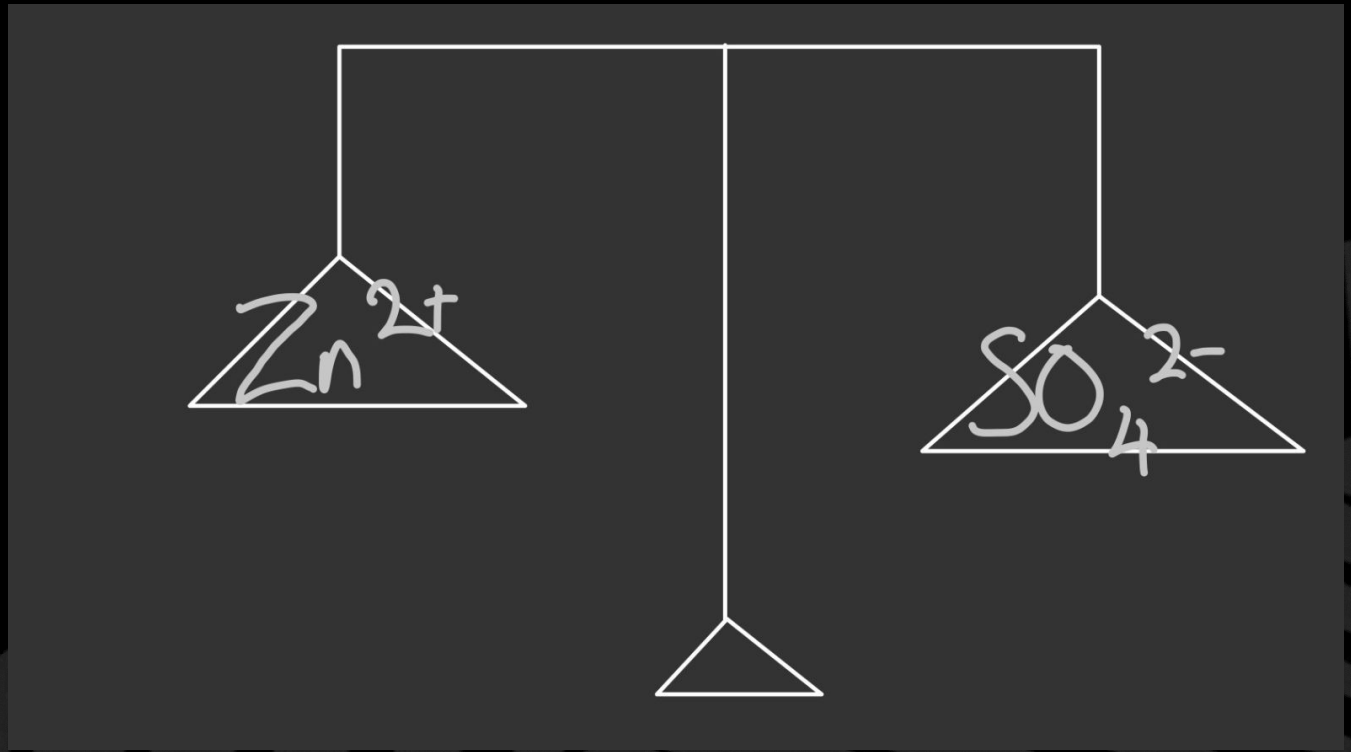
Electron Emission



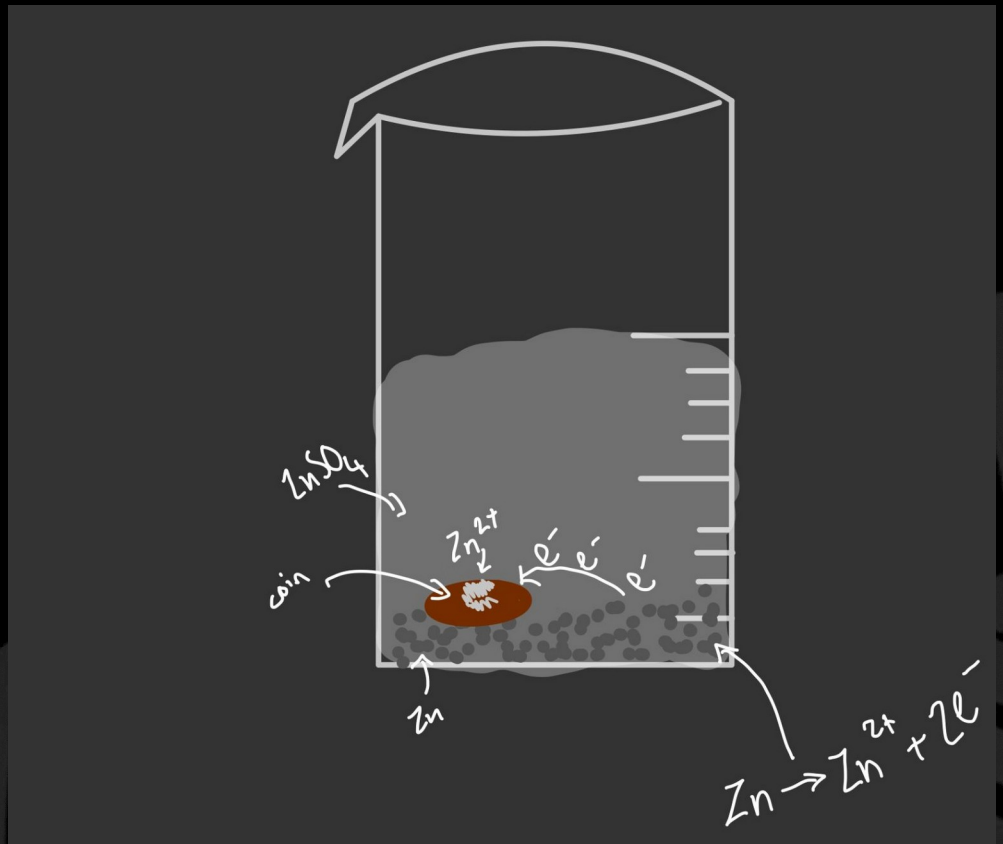
Metal Reactivity Series



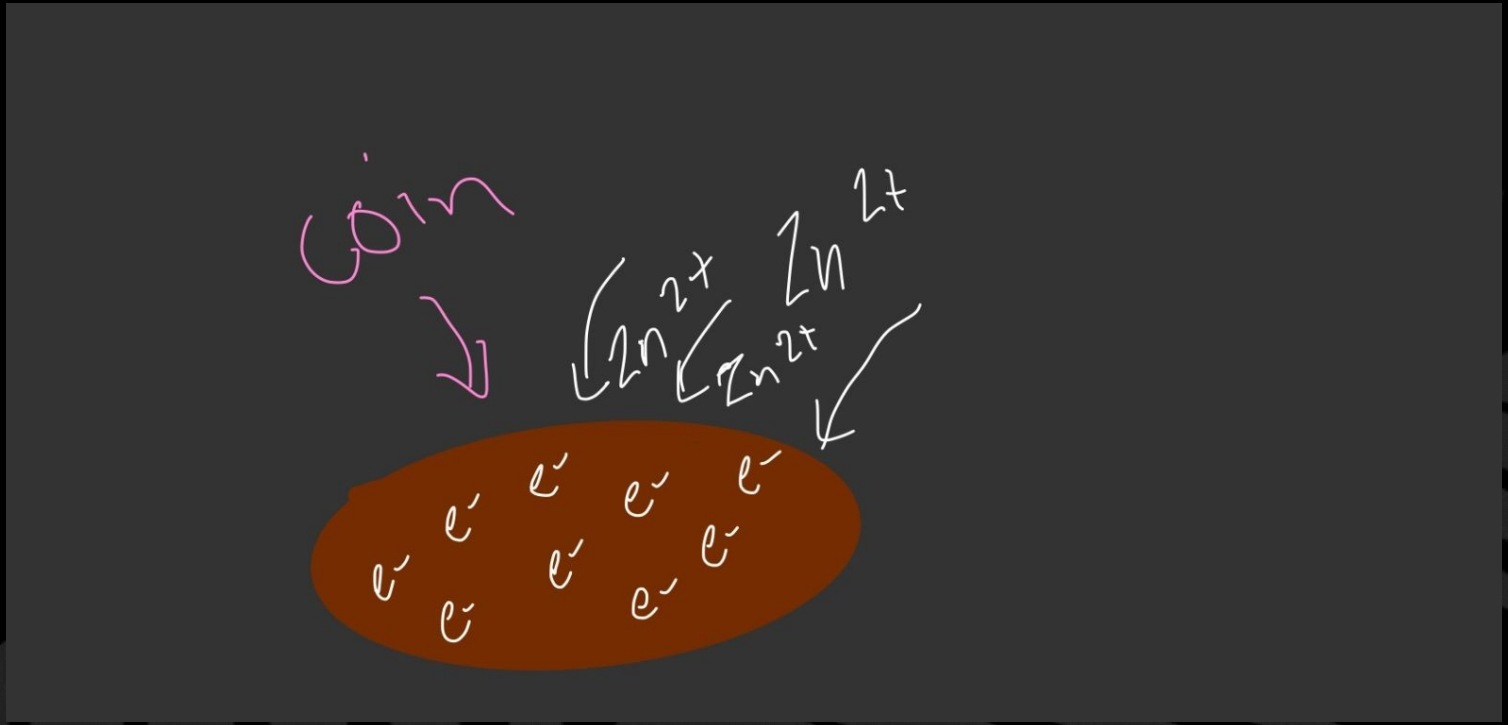
Theory



Theory



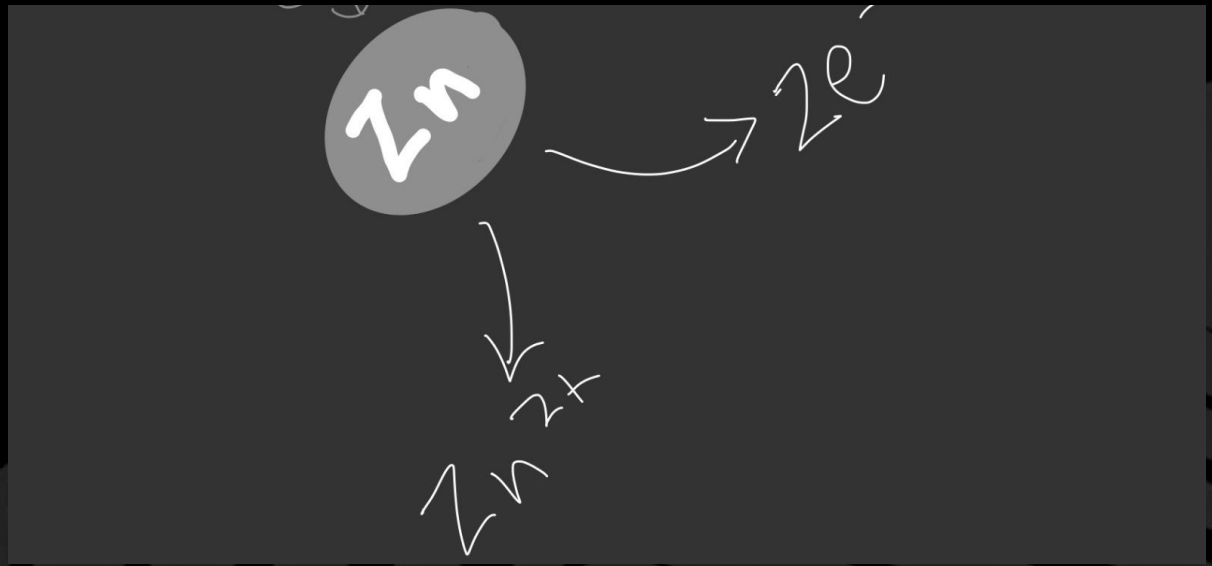
Theory



Zinc oxidation

$Zn \leftrightharpoons Zn^{2+} + 2e^-$

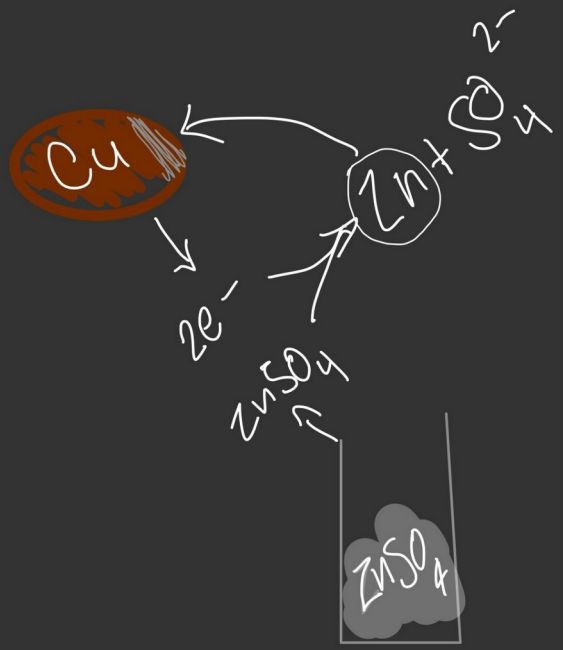
Zinc Gets oxidised to Ions



Zinc Ion Reduction

$ZnSO_4 + 2e^- \leftrightharpoons Zn + SO_4^{2-}$

Zinc Sulfate gets reduced to Zinc on the surface of the copper



Combination

$SO_4^{2-} + Zn^{2+} \leftrightharpoons ZnSO_4$

The Zinc and Sulfate Ions (Byproducts) get combined back into the starting

Before

After

Independent and Dependent Variables

- Metals Used (independent variable)
  - 10c (Cu plated), 20c (Ni plated), 1 dollar (92% Cu, 6% Al, 2% Ni)
- Average Thickness of Zinc Layer (Dependent Variable)

Controlled Variables

- Initial Temperature of Solution
  - Boiling (thermometer)
- Concentration of Solution
  - 1:4 ratio of Zinc Sulfate to Water (state mass)
- Amount of Zinc
  - 10g Zinc Granules
- Heat Application time
  - 15 minutes over a bunsen with a open airhole

My Experiment

1) Record Mass of Coin
2) 20g of Zinc Sulfate, 80ml of Water
   10g Zinc Granules, 250ml Beaker
3) Boil with a bunsen
4) Place 10c coin, contact with Zinc
5) Wait 15 minutes
6) Remove coin
7) Weigh coin
8) Record Results

Predictions of Theory

Which ones will work?

- All 3 will work
- 1 dollar thickest
- 10 cent middle
- 20 cent thinnest

Thickness

Surface Area- 761.88mm^2

Zinc (4050nm)

Surface Area- 849.68mm^2

Zinc (330nm)

Surface Area- 1038mm^2

Zinc (5950nm)

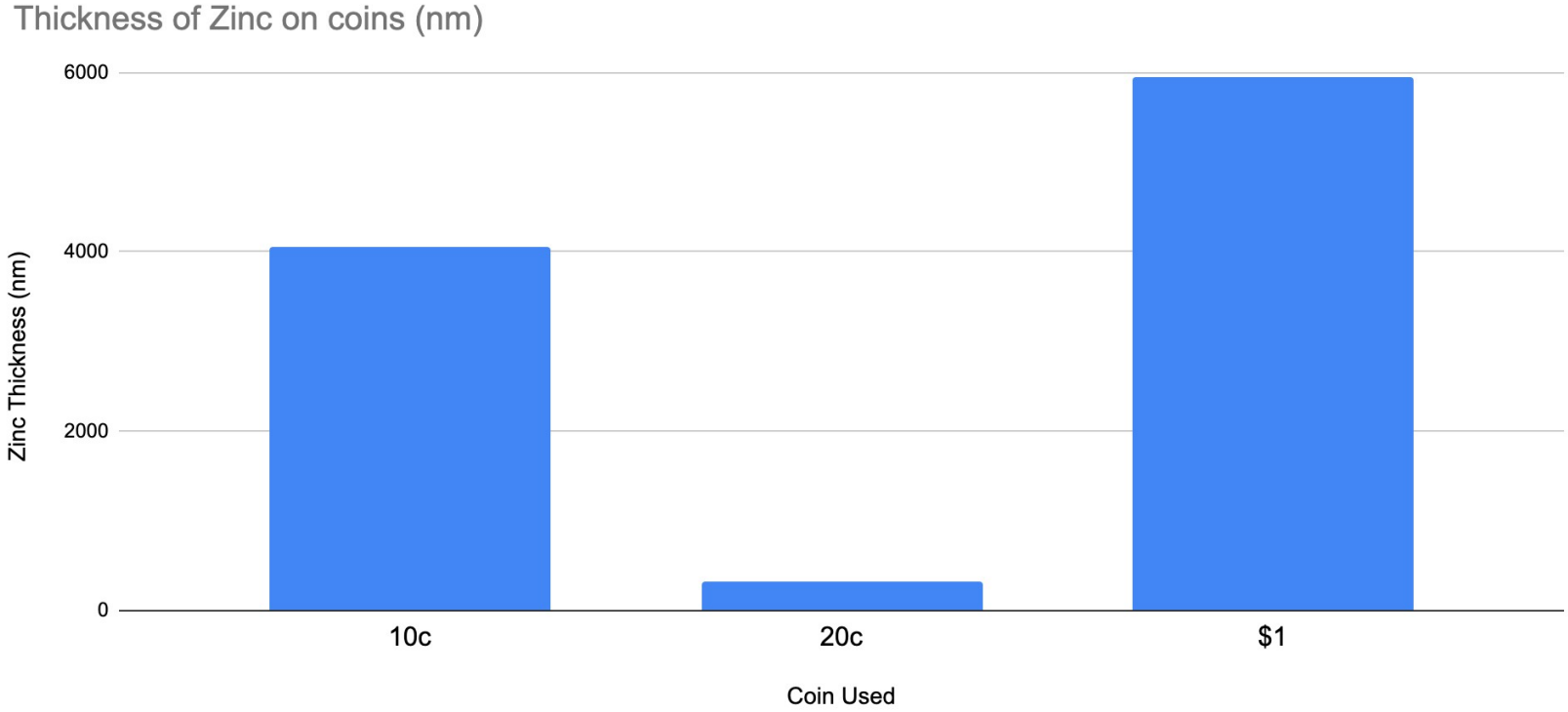
How to Calculate Surface Area

- (Diameter * Pi * Thickness) + (Radius^2 * Pi * 2)

How to Calculate Thickness

- (Increase / 0.00713)/ Surface Area

Which Was Thickest



Conclusion

- Predictions of Theory were correct
- Metal’s conductivity influenced thickness
- 1 dollar had thickest
- 10c second thickest
- 20c thinnest

Appendixes

https://www.sciencecompany.com/Turn-Copper-Pennies-Into-Silver-and-Gold-Pennies

https://sites.google.com/a/gapps.smc.edu/timdong/blog/turningcopperpenniesintosilverandgoldpennies

https://en.wikipedia.org/wiki/Metallic_bonding

https://en.wikipedia.org/wiki/Electronegativities_of_the_elements_(data_page)

https://en.wikipedia.org/wiki/Electronegativity

https://image.shutterstock.com/image-vector/electronegativity-infographic-diagram-example-sodium-260nw-1084385915.jpg

https://www.flinnsci.com/api/library/Download/674479ccda964683ac6201381ffbdb89

https://sites.google.com/a/gapps.smc.edu/timdong/blog/turningcopperpenniesintosilverandgoldpennies

https://en.wikipedia.org/wiki/New_Zealand_ten-cent_coin

https://en.wikipedia.org/wiki/New_Zealand_twenty-cent_coin

Coin Size Calculations

10 cent	20.5 (diameter) * pi = 64.402….. ANS * 1.58 (thickness) = 101.756… (x) 20.5 (diameter)/ 2 = 10.25 (radius) 10.25^2 * pi * 2 = 660.13… (y) x+y=762mm^2 or 7.62cm^2 (3 s.f)
20 cent	21.75 (diameter) * pi = 68.33… ANS * 1.56 = 106.59…. (x) 21.75/2 = 10.875 (radius) 10.875^2 * pi * 2 = 743.08… (y) x+y=849.68mm^2 (2.dp) or 8.49cm^2
1 dollar	23.00 (diameter) * pi = 72.26…. ANS * 2.74 (thickness) = 197.98…. (x) 23.00/2 = 11.5mm (radius) 11.50^2 * pi * 2 = 831… (y) x+y=1038mm^2 (2.dp) or 10.38cm^2

Zinc Thickness Calculations (0.00713g/mm³)

10c coin (0.02g increase)	(0.022/0.00713)/761.88 = 4.05 x 10^-3 Thickness of Zinc is 4.05*10^-3mm (or 4050nm)
20c coin (0g increase)	(0.002/0.00713)/849.68 Thickness of Zinc is 3.30*10^-4mm (or 330nm)
$1 coin (0.04g increase)	(0.044/0.00713)/1038 Thickness of Zinc is 5.95*10^-3mm (or 5950nm)

Raw Data

10c coin (0.02g increase)

Trial 1 - 3.30g -> 3.31g Trial 2 - 3.32g -> 3.34g Trial 3 - 3.28 -> 3.31g
Trial 4 - 3.30g -> 3.33g Trial 5 - 3.31g -> 3.33g

20c coin (0g increase)

Trial 1 - 3.98 -> 3.98g Trial 2 - 3.97 -> 3.97g Trial 3 - 4.00 -> 4.00g
Trial 4 - 4.00 -> 4.01g Trial 5 - 3.97 -> 3.97g

$1 coin (0.04g Increase)

Trial 1 - 7.98 -> 8.03g Trial 2 - 7.96 -> 8.02g Trial 3 - 7.99 -> 8.03g
Trial 4 - 8.02 -> 8.05g Trial 5 - 8.01 -> 8.05g

Table with information

Coin Type	Surface Area (mm^2)	Avg. Initial Mass (g)	Avg. Final mass (g)	Zinc Thickness (nm)
10c	761.88	3.302	3.324	4050
20c	849.68	3.984	3.986	330
$1	1038	7.992	8.036	5950