Cents-ible Chemistry - Analysis of the Metal in a Penny

DISCUSSION:

While a penny may have a trivial monetary value, it provides a useful source of materials for studying physical and chemical properties of matter. The design and composition of US Pennies has changed periodically since the Lincoln Penny was first introduced in 1909.

D = Denver

S = San Francisco

P = Philadelphia

W = West Point

(Note: Mint marks appear just under the date the penny was minted.)

Over 300 billion one-cent coins, with 11 different designs, have been minted since the first penny was struck in 1787. The current penny shown above is 97.5% zinc and 2.5 % copper

PURPOSE: This series of 4 laboratory exercises will illustrate some chemistry of common materials including some physical and chemical changes. You will gain experience in beginning laboratory procedures and at group presentation based on the evidence your small group gains to support a claim about the changes observed . **Learning Target: I am learning to use density measurements, acid types and observations to identify the metals present in pennies. I am learning how to create a CER (claim, evidence, reasoning) argument to present to my peers.**

WARNING: Several of the chemicals that you will use for this experiment are potentially very dangerous. Follow all safety precautions. Move very carefully around the lab! Don't alter the procedures and be sure to wear your safety goggles at all times!

You may use any of the following materials during your investigations.

Consumables	Equipment (1mL = 1cm^3)
Pennies 5 per group HNO_3 (Nitric Acid Concentrated 6M) HCl (Hydrochloric Acid Concentrated 6M) NaOH (Sodium Hydroxide Concentrated 6M)	Analytic Balance (+/- 0.01g) Graduated Cylinder 50 cm^3 or 100 cm^3 Pipettes 10 cm^3 for acids in fume hood 50 cm^3 Beaker 600 cm^3 Beaker 3 small (50 to 150 cm^3) Beakers Metal tongs Bunsen burner Wet paper towels Metal file

TASKS (TESTS) CAN BE DONE OUT OF ORDER…

Part 1: Analysis of base metals in a penny (Guiding Question; Can the property of density be used to identify a substance?)

TEST #1

1. Obtain five pennies from your instructor. Record the date and mint mark for each of the five pennies in chronological order in a table.

2. Take the mass of each penny separately. Record the masses next to the dates of your five pennies. These will go into this class database (spreadsheet) so that you can compare your data with those of other students in the class. Record the mass per penny. Compare your results with those of the rest of the class after all data is recorded on the spreadsheet. Do you see any significant differences in the masses of the pennies?

3. Determine the volume of your five pennies by water displacement in the graduated cylinder. Use this to find the average volume of a single penny. (Put in all the pennies, divide that volume by five.) Write these calculations down in your laboratory notebook.

4. Calculate and record **the density of each separate penny** in your notes. ***Does the density vary? Are all pennies alike?*** Remember density is mass divided by volume. **Discuss the guiding question for part 1 with your partner/group. What is your evidence to show an answer to the question?**

Part 2: Analysis of the surface metal in a penny (Guiding Question; Can acid type be used to determine the type(s) of metal(s) in a penny?)

TEST #2

WARNING: You will be using Hydrochloric Acid for the next part of the experiment. HCl is corrosive and dangerous. Use caution whenever working with it!

5. Record the date of a penny and put it in a 100 or 150 cm^3 beaker. Record the date of a second penny. Use a file to make several nicks around the edge of a second penny and place this penny next to the other penny in the 150 cm^3 beaker. Measure out 10 cm^3 of 6 M hydrochloric acid (HCl). Pour the acid over the pennies. Record your observations . Label the beaker containing the acid and the pennies with your period and group number and set it aside in the designated area overnight. The next day remove the pennies and rinse them off. Describe the pennies again. Be sure to point out any differences. Record your observations in your laboratory notebook. ***What happens to copper penny in hydrochloric acid? Why does notching make a difference?***

TEST #3

WARNING: You will be using nitric acid, HNO_3 for this part of the experiment. In its concentrated form, HNO_3, can cause deterioration of protein in your skin. Be careful in handling it. If you get any acid on your fingers for any reason, wash them thoroughly and inform your instructor.

6. Record the date and place another penny into a 50 cm^3 beaker. Measure out 8 cm^3 of 6.0 M nitric acid in ANOTHER beaker for transfer of the acid to your lab bench. Place several layers of wet paper towels on the laboratory bench. Put the 50 cm^3 beaker with the penny in the middle. Carefully pour the acid over the penny in the small beaker. Cover the beaker with a dampened larger, inverted 600 cm^3 beaker. Describe what happens and record your observations

7. Wait until the atmosphere in the large beaker is essentially clear.

8. Turn on the water tap. Remove the large beaker and carefully place the small beaker in the sink. Allow a slow but steady stream of water to flow from the tap . Carefully slide the beaker containing the Nitric acid and the penny under the stream of water and let it wash for a couple of minutes, Do not splatter the acid, and be careful when adding the water! When the beaker in the sink has been substantially washed, empty the beaker. Use the forceps to remove the penny and rinse it with tap water. ***Examine the penny and describe any changes in your lab notebook.***

Part 3: Alchemy (Guiding Question; Are the observed changes in the penny during this task chemical or physical?)

TEST #4

WARNING: For this part of the experiment you will be using Sodium Hydroxide, NaOH, also known as lye or caustic soda. It is another skin wrecker. Handle it with care! Wear safety glasses and use tongs. If any of the solution splatters on to your hand, flush continually until your instructor tells you to stop!

In the fume hood you will find a beaker set on a hot plate. It contains 6 M NaOH with some granular zinc at the bottom. It is boiling hot. .

9. Using tongs carefully drop your remaining pennies into the boiling hot sodium hydroxide. Be very careful. Splashing NaOH can cause severe burns. Leave them in the bath for 2-3 minutes.

10. Return to the hood with a 100 ml beaker half full of clean water. Your instructor will help you retrieve your pennies. With tongs or forceps carefully lift out the two pennies. Drop them into a beaker of clean water then return to your lab station. Describe the appearance of the two pennies now. Record your observations in your laboratory notebook.

11. Hold one of the pennies by the edge with the tongs. Heat it in the Bunsen burner flame for 15- 20 seconds. **Do not overheat your penny.** Describe the penny now. Place the penny on the stone lab counter to cool. Do not put it on or in a plastic container.

12. Clean up all of your equipment and dry it with paper towels and place your equipment back in the lab kit

How do you explain the changes in the penny that occur when it is heated in NaOH? Why does the color change when you heat it in a Bunsen Burner flame?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- the importance of patterns within science,
- the flow of energy and matter within a system,
- the difference between observations and inferences in science, and
- the difference between data and evidence in science.

Group 1 Penny Mass, Volume and Density

Group 2 Penny in Hydrochloric Acid

Group 3 Penny in Nitric Acid

Group 4 Penny in Sodium Hydroxide and Heat (Alchemy!!!?)

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a claim, which is your answer to the guiding question. Your argument must also include evidence in support of your claim. The evidence is your analysis of the data and your interpretation of what the analysis means. Finally, you must include a justification of the evidence in your argument. You will therefore need to use a scientific concept or principle to explain why the evidence that you decided to use is relevant and important. You will create your initial argument on a whiteboard. Your whiteboard must include all the information shown in the *figure L9.1*.

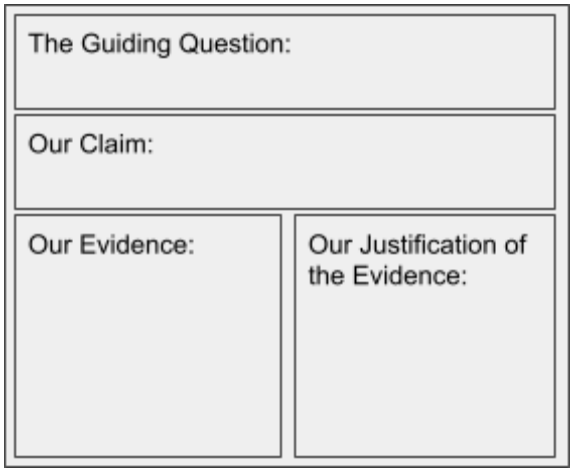

Figure L9.1 **Argument presentation on a whiteboard**

Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group stays at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the initial arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. To critique an argument, you might need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

• What did your group do to analyze the data, and why did you decide to do it that way?
• Is that the only way to interpret the results of your group's analysis? How do you know that your interpretation of the analysis is appropriate?
• Why did your group decide to present your evidence in that manner?
• What other claims did your group discuss before deciding on that one? Why did you abandon those alternative ideas?
• How confident are you that your group's claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Video Resouces:

Copper Cycle (Blue spider blood)

History of the Penny

Dissolving Gold in Acids...

Copper to Gold Penny (Brass) IB Chem

Copper Cycle Reactions

Reaction of Copper with Nitric Acid

Reaction of Zinc in Hydrochloric Acid

Hiding a Nobel Prize From the Nazis

Crash Course HISTORY of MONEY and DEBT

About the mints (where the money is made and stored)

GROUP PRESENTATION TASKS

Group 1: Analysis of base metals in a penny. Guiding Question; **Can the property of density be used to identify what a penny is made of?**

Discuss the guiding question for **test 1** with your partners/group. **Density = Mass/Volume**

1) ***Make a claim*** that answers the question.
2) What is your ***evidence*** to show an answer to the question? ***Present your data*** on dates the pennies were minted, the mass, the volume and the density. Search for **Penny (United States coin)** on **wikipedia**. Make notes on the following… During what years did the cent weigh 13.48g? During what years did the cent weigh 3.11g? What is the current mass of a cent? Since what year? MAKE SURE to show on your board the material pennies were made of during these different times… what elements, what percentage? History of Pennies VIDEO.
3) What is your ***scientific justification***? Present on your board and be ready to explain why your evidence supports your claim about the question. Search for Density on Wikipedia. Explain what Density is. Can Density be used to determine the composition of a substance? What is the Density of copper? Of zinc? Of brass? Are pennies pure copper, zinc, brass or an alloy? Does this make it easier or more difficult to use density to identify what a penny is made of?
4) Work together to ***NEATLY create/write your whiteboard or presentation SLIDE***. You will have 30 minutes to get this ready.
5) Select someone to ***present your whiteboard or SLIDE***, or a person for each section. Everyone must be prepared to answer questions about the claim, evidence, and scientific justification.
6) Make sure to ***take pictures of all*** the whiteboards (if you did this instead of making a slide) before they are cleaned, so you can complete the write up questions later.
7) Select who will ***clean the whiteboard*** at the end of the presentations.

Group 2: Analysis of the surface metal in a penny. Guiding Question: **Can acid type be used to determine the type(s) of metal(s) in a penny?** Discuss the guiding question for **test 2** with your partners/group. **Hydrochloric Acid + Penny**

1) ***Make a claim*** that answers the question.
2) What is your ***evidence*** to show an answer to the question? ***Present your data*** on dissolving a notched penny vs a non-notched penny in hydrochloric acid. Google search 'copper in hydrochloric acid' Does copper dissolve in hydrochloric acid? **Google search 'zinc in hydrochloric acid'** Does zinc dissolve in hydrochloric acid? Make a drawing on your whiteboard of what happened to the two pennies in the HCl(aq). Label the drawing. Make sure to label the types of metal in the penny. What metal is likely inside the penny? What metal is likely on the surface of the penny? How does this relate to your claim?
3) What is your ***scientific justification***? Present on your board and be ready to explain why your evidence supports your claim about the question. Google search for the chemical equation for zinc

in hydrochloric acid. Write this down on the whiteboard as a word equation AND a balanced chemical equation with correct subscripts and symbols (such as (aq) or (s)). Google search for the chemical equation for copper and hydrochloric acid. Write down both the word and balanced chemical equation for this (if there's no reaction you can still write the reactants and just say no reaction on the product side).

4) Work together to ***NEATLY create/write your whiteboard or presentation SLIDE***. You will have 30 minutes to get this ready.
5) Select someone to ***present your whiteboard or SLIDE***, or a person for each section. Everyone must be prepared to answer questions about the claim, evidence, and scientific justification.
6) Make sure to ***take pictures of all*** the whiteboards (if you did this instead of making a slide) before they are cleaned, so you can complete the write up questions later.
7) Select who will ***clean the whiteboard*** at the end of the presentations.

Group 3: Analysis of the surface metal in a penny. **Guiding Question; Can acid type be used to determine the type(s) of metal(s) in a penny?** Discuss the guiding question for **test 3** with your partners/group. **Nitric Acid + Penny**

1) ***Make a claim*** that answers the question.
2) What is your ***evidence*** to show an answer to the question? ***Present your data*** on dissolving a penny in nitric acid. Google search 'copper in nitric acid' Does copper dissolve in nitric acid? Google search 'zinc in nitric acid' Does zinc dissolve in nitric acid? Make a drawing on your whiteboard of what happened to the penny in the HNO3(aq). Label the drawing. Make sure to label the types of metal in the penny. What metal is likely inside the penny? What metal is likely on the surface of the penny? How does this relate to your claim?
3) What is your ***scientific justification***? Present on your board and be ready to explain why your evidence supports your claim about the question. **Google search for the chemical equation for copper in nitric acid.** Write this down on the whiteboard as a word equation AND a balanced chemical equation with correct subscripts and symbols (such as (aq) or (s)). Google search for the chemical equation for zinc and nitric acid. Write down both the word and balanced chemical equation for this (if it's no reaction you can still write the reactants and just say no reaction on the product side).
4) Work together to ***NEATLY create/write your whiteboard or presentation SLIDE***. You will have 30 minutes to get this ready.
5) Select someone to ***present your whiteboard or SLIDE***, or a person for each section. Everyone must be prepared to answer questions about the claim, evidence, and scientific justification.
6) Make sure to ***take pictures of all*** the whiteboards (if you did this instead of making a slide) before they are cleaned, so you can complete the write up questions later.
7) Select who will ***clean the whiteboard*** at the end of the presentations.

Group 4: Alchemy!!!? Guiding Question; Is the golden penny really gold or something else? Discuss the guiding question for **test 4** with your partners/group. **Gold vs 'Golden' vs Alloy type**

Are the observed changes in the penny during this task chemical or physical? How do you explain the changes in the penny that occur when it is heated in NaOH? Why does the color change when you heat it in a Bunsen Burner flame? Everyone in your group watches the following video while thinking about the previous questions. **Making gold pennies.**

1) ***Make a claim*** that answers the question.
2) What is your ***evidence*** to show an answer to the question? ***Present your data*** on making a 'golden' penny. Is this a chemical change (can it be written as a chemical equation?) Is this a physical change (can what happened be presented as a drawing or sketch?) What happens in the hot sodium hydroxide solution with zinc on the bottom in the first step? What happens when you heat the silvery looking penny in the bunsen burner flame in the second step? Make a drawing or sketch of what is going on. Label all the parts, making sure to include the copper, the zinc, and

what alloy is being formed. How does this relate to your claim? Decide who will present this part of the whiteboard.

3) What is your ***scientific justification***? Present on your board and be ready to explain why your evidence supports your claim about the question. Search wikipedia for 'brass' What is brass? Search wikipedia for 'list of copper alloys' What is an alloy? What is the percent composition of brass? Is it always the same? Search wikipedia for 'alchemy.' What did alchemists want to do? Did we do this during this lab?
4) Work together to ***NEATLY create/write your whiteboard or presentation SLIDE***. You will have 30 minutes to get this ready.
5) Select someone to ***present your whiteboard or SLIDE***, or a person for each section. Everyone must be prepared to answer questions about the claim, evidence, and scientific justification.
6) Make sure to ***take pictures of all*** the whiteboards (if you did this instead of making a slide) before they are cleaned, so you can complete the write up questions later.
7) Select who will ***clean the whiteboard*** at the end of the presentations.

CONCLUSION

Short Written Report

Once you have completed your research, you will need to prepare a short investigation report that provides answers to the following questions:

1) **Can the property of density be used to identify what a penny is made of?**
2) **Can acid type be used to determine the type(s) of metal(s) in a penny? Discuss effects of hydrochloric and nitric acid on the pennies.**
3) **Is the golden penny really gold or something else?**

Use this format *for each question*. Use the class slides to help if you get stuck.

1) What is the **guiding question**?
2) What is your **claim**?
3) What is the **evidence**? This means the data collected. **The data can be written** (also called narrative or qualitative) **and/or the data can be numeric with units.** Tables created in the lab *or from other sources* can be used. (This type of data is also called quantitative.)
4) What is the **justification**? In this section provide either **the balanced chemical equation WITH the word equation under it (use this for tests 2 and 3), and/or clear drawings/diagrams labeled that show what happened.** Write an explanation of the equation and/or drawings that shows you understand the scientific concepts that support your claim.

Your report should answer these questions in ***two pages or less***. The report should be neatly written or can be typed and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a *persuasive style*; you are trying to convince others that your claim is acceptable or valid!

Claim Evidence Reasoning (CER)

x

Claim

A statement or claim about an observed phenomena or investigation results. Answers a question based on phenomena or lab experience.

Evidence

Data that has been gathered or analyzed, resulting from observations or research. It is data that supports the claim.

Reasoning

An explanation that describes scientific knowledge or principles and accounts for claim and evidence. Provides the why and how evidence.

Sentences Stems

Claim

- According to data, _____
- The data supports (or does not) that _____
- If [this] then [that]....
- Evidence indicates that...

Evidence

- According to the text...
- Data gathered indicates...
- Observed phenomena shows...

Reasoning

- ___ has/have caused ___. This results/resulted in....
- This evidence leads to the conclusion that....
- The evidence supports the claim....

Conclusion *Scientific Explanation*		**0**	**1**	**2**
	Claim *Statement or conclusion that answers the original question/problem*	Does not make a claim, or makes an inaccurate claim	Makes an accurate but vague or incomplete claim	Makes an accurate and complete claim
		0	**1**	**2**
	Evidence *Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.*	Does not provide evidence, or only provides inappropriate evidence (evidence that does not support the claim)	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
		0	**2**	**4**
	Reasoning *Justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence*	Does not provide reasoning, or only provides reasoning that does not link evidence to claim.	Repeats evidence and links it to some scientific principles, but not sufficient.	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.