Lab:
What's In Your Water?

(How do different water qualities affect different types of metal pipes?)

Created By:
Doug Balmer
Barb Doyle
Eli Graf
Kate Sundeen

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- Student Lab Manual (Black-Line Masters)
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  - Pre-Lab Assignment: Pre-Lab Research and Discussion Questions
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Teacher Note
If paper is at a premium, copy only the procedure and articles and show the other parts on an overhead or projector for students to copy into their lab books.

Instructor's Manual

Lab:
What's In Your Water?
(How do different water qualities affect different types of metal pipes?)

Background:

This lab can be used in a number of different units in general chemistry, or in environmental chemistry. It can even be used as a lab for getting students to think about how to create lab procedures by removing the lab procedure from the student manual and having them create their own lab procedures. See the success criteria below for specific topics:

Success Criteria:

- Students will be able to develop an activity series for iron, copper, and lead using nitrate solutions.
- Students will be able to measure the change in conductivity when iron, copper, and lead scales are placed in water with different water conditions.
- Students will be able to determine the risks associated with iron, copper, and lead water pipes.
- Students will be able to determine which metal pipe would be best suited to carry drinking water.

Suggested Time:

- If the provided procedure is used, the suggested class time is two days. Day one is for the activity; day two is for the discussion.
- If the procedure is condensed (i.e. by having half the groups perform and discuss the reactivity portion, and half the groups perform and discuss the solubility portion, and/or by measuring out he materials for the students) then this can be completed in one day.
- If the instructor would like the students to create their own procedures then the recommended time is three days.

Materials:

The materials list provided is enough for 10 groups of 3 or 4 students, each. Scale accordingly, given class size.

The additional materials listed are for the given procedure. If students are developing their own procedures, make sure that the students are specific about the additional materials that are required.

Part A: Reactivity

Reagent Solutions ***Pour into 50 mL dropper bottles after mixing.***		
Reagent	**Components**	**Molecular Wt**
iron (III) nitrate (0.2M)	27.80g $Fe(NO_3)_3$/500mL solution	277.94g/mol
copper (II) nitrate (0.2M)	18.76g $Cu(NO_3)_2$/500mL solution	187.57g/mol
lead (II) nitrate (0.2M)	33.12g $Pb(NO_3)_2$/500mL solution	331.21g/mol

Metal Samples

- Store in separate containers after rinsing with HCl and drying.
- Be sure to seal the containers tightly for storage before lab.
- Each group will be using three pieces of each type of metal.

Metal	Instructions
30 iron nails	washed in 6M HCl, rinsed, dried
30 pcs. copper shot	washed in 6M HCl, rinsed, dried
30 pcs. lead shot	washed in 6M HCl, rinsed, dried

Additional materials: 10 well-plates
10 distilled water bottles

Materials, cont.

Part B: Solubility

Solvent Solutions	
Solvent	**Components**
2L distilled water	N/A
2L hard water	130ppm $CaCO_3$ = 0.72g/L
2L soft water	100mgNa/L = 0.254g NaCl/L
2L fluorinated water	1ppm F^- = 1mgF/L = .08g F/L (H_2SIF_6)
2L chlorinated water	2ppm NaClO = $1.1x10^{-4}$M NaClO/L Dilute 0.3mL of 6% bleach (commercial) to 2L
SPECIAL NOTE: If fluorine is not available, fluorinated water can often be purchased in bottles at supermarkets. **SPECIAL NOTE**: Since chloramine can be difficult to acquire, it is not included as a specific component of this lab. However, if there is access to chloramine, chloraminated water can be an interesting addition to the solubility tests.	

Solute Materials		
Type and Total Amount of Scale	**Group Amounts**	**Mol Wt**
40g iron scale (Fe_2O_3)	4g of 0.01mol Fe scale (Fe_2O_3) * for division into (5) .8g parts*	159.69g/mole
40g copper scale (CuO)	4 g of 0.01mol Cu scale (CuO) * for division into (5) .8g parts	79.55g/mol
135g lead scale ($PbCO_3$)	13.5 g of 0.01 mol Pb scale ($PbCO_3$) * for division into (5) 2.7g parts	267.21g/mol
SPECIAL NOTE: If chloraminated water is included in the solubility tests, there should be an additional portion given of each type of scale.		

Additional materials:
150 50 mL beakers (15 per group)
10 Conductivity probes and related equipment (1 per group)
Distilled water bottles
Paper towels/cleaning rags

Pre-Lab Articles inserted here. (see pdf documents)

Teacher Note
The students are not required to have a "correct" answer in their predictions. Just look for thoroughness and quality of writing in their answers.

Lab:
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Pre-Lab:
Research and Predictions

Teacher Note
See next page for an extension for higher-level students.

Read the following articles:

"Iron in Drinking Water" (Colter and Mahler)
"Copper in Drinking Water: Health Effects and How to Reduce Exposure" (Minnesota Dept. of Health)
"Lead in Water: Questions and Answers" -(United States Environmental Protection Agency)

Read the following article:
"Corrosion" (Non-Destructive Techniques Resource Center)

Read through the first part of the article on corrosion, paying special attention to electromotive force series table. You do not need to be concerned about the different types of corrosion.

Questions: Answer each question carefully. Be sure to use evidence from each of the articles to support your answers.

1. What are the human health effects associated with consuming iron, copper and lead? Write at least one paragraph for each metal.
2. Which metal would you expect to be most reactive? Why?
3. Which metal would you expect to be least reactive? Why?
4. Which metal scale would you expect to dissolve most in water? Why?
5. Write 1-2 sentences that explain why you are completing this experiment.
6. Make your prediction: What metal would you choose? Why?

Type your answers to these questions and turn in with your other pre-lab work at the start of class, before the lab work begins.

Make a note of your predictions for use in your post-lab.

Teacher Note
This Pre-Lab Extension is not included in the student manual.

Lab:
What's In Your Water?

Pre-Lab: Extension

Part One:

Read the definitions below for Ionization Energy, Effective Nuclear Charge, and Electromotive Force (the EF definition should look familiar if you've read the "Corrosion" article!)

Term	Definition
Electromotive Force (E^o)	A measure of the driving force or electrical potential for the completion of an electrochemical reaction. The more negative the electromotive force, the more reactive the metal.
Ionization Energy (IE)	The energy required to remove an electron from a gaseous atom when an atom is in its ground state.
Effective Nuclear Charge (Z*)	The net positive charge experienced by an electron in a many-electron atom. This charge is not the full nuclear charge, because there is some shielding of the nucleus by other electrons in the atom.

Part Two:

Look at the table of data below.

Reactivity Trends

Electromotive Force	Ionization Energy	Effective Nuclear Charge
$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$ $\varepsilon^o = -0.41V$	$Fe_{(g)} \rightarrow Fe^+_{(g)} + 1e-$ $I.E._1 = 759.3kJ/mole$	$Z^* = 3.75$
$Pb_{(s)} \rightarrow Pb^{2+}_{(aq)} + 2e^-$ $\varepsilon^o = -0.13V$	$Pb_{(g)} \rightarrow Pb^+_{(g)} + 1e-$ $I.E._1 = 715.5J/mole$	$Z^* = 5.65$
$Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$ $\varepsilon^o = 0.34V$	$Cu_{(g)} \rightarrow Cu^+_{(g)} + 1e-$ $I.E._1 = 745.5kJ/mole$	$Z^* = 3.70$

Discussion Questions:

- These three properties deal with energy, charge and the removal of electrons from an atom, which is necessary for a metal to react. Based on the definitions and values, which of these three properties do you think will most determine the order of reactivity in the reactivity series? Explain your reasoning.

Teacher Note
Sample answers are from JTBaker, not Flinn. However, answers should be similar. The primary purpose of this exercise is to make sure students are aware of the fact that they must use safety in using these compounds.

Lab:
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Pre-Lab:
Hazards Table

Go to the Flinn website (http://www.flinnsci.com/search_MSDS.asp) to find the information. Complete the Hazards Table and turn in with your other pre-lab work at the start of class, before the lab work begins. **Be sure to review this table before you hand it in**!

Compound	Mol Wt, melting pt, boiling pt	Hazards
iron (III) nitrate (0.2M)	*MW: 404* *MP: 47.2C* *BP: <100C*	*Contact with other materials may cause fire. Harmful if swallowed/inhaled. Affects liver. Irritates skin, eyes, respiratory tract.*
copper (II) nitrate (0.2M)	*MW: 232.6* *MP: 115C* *BP: 170C*	*Contact with other materials may cause fire. Harmful if swallowed. Affects liver. Irritates skin, eyes, respiratory tract.*
lead (II) nitrate (0.2M)	*MW: 331.23* *MP: 470C* *BP: N/A*	*POISON! Contact with other materials may cause fire. May be fatal if swallowed. Affects many systems, including nervous system.*
iron nails	*MW: 55.85* *MP: 1535C* *BP: 2750C*	*May be harmful if swallowed. May cause omiting, irritation.*
copper shot	*MW: 63.5* *MP: 1083C* *BP: 2595C*	*Harmful if swallowed or inhaled. May cause irritation to skin and eyes.*
lead shot	*MW: 207.19* *MP: 327.5C* *BP: 1740C*	*POISON! May be fatal if swallowed. Affects many systems, including nervous system. Possibly causes cancer.*
hard water (water with $CaCO_3$)	*MW: 100.09 + water* *MP: N/A* *BP: N/A*	*May cause irritation.*
soft water (water with NaCl)	*MW: 58.44 + water* *MP: N/A* *BP: N/A*	*Causes eye irritation.*
fluorinated water (water with fluorine)	*MW:* *MP: N/A* *BP: N/A*	
chlorinated water (water with NaClO)	*MW: 74.44 + water* *MP: N/A* *BP: N/A*	*Harmful if swallowed or inhaled. Causes irritation to respiratory tract.*
iron scale (Fe_2O_3)	*MW: 159.69* *MP: 1565C* *BP: N/A*	*Harmful if inhaled. Causes irritation.*
copper scale (CuO)	*MW: 79.55* *MP: 1026C* *BP: N/A*	*Harmful if swallowed. Affects liver and kidneys.*
lead scale ($PbCO_3$)	*MW: 775.62* *MP: >400C* *BP: N/A*	*POISON! May be fatal if swallowed. Affects many systems, including nervous system. Possibly causes cancer.*

Pre-Lab:
Procedures Chart

Draw a chart that depicts your lab procedure. Be specific about each of your steps, and be sure to include drawings of your lab equipment. Turn in with your other pre-lab work at the start of class, before the lab work begins.

Teacher Note
The instructor should allow some flexibility with this exercise, as some students will prefer to do a flow chart and others a more visual, art-based approach. The idea is to make sure that students are familiar with the procedure before lab day.

Teacher Notes:
Remember that you can have students create their own lab procedures. If you are going to do this, have them create them the day before so that they can give you a list of equipment.

Lab
What's In Your Water?

Lab Procedure

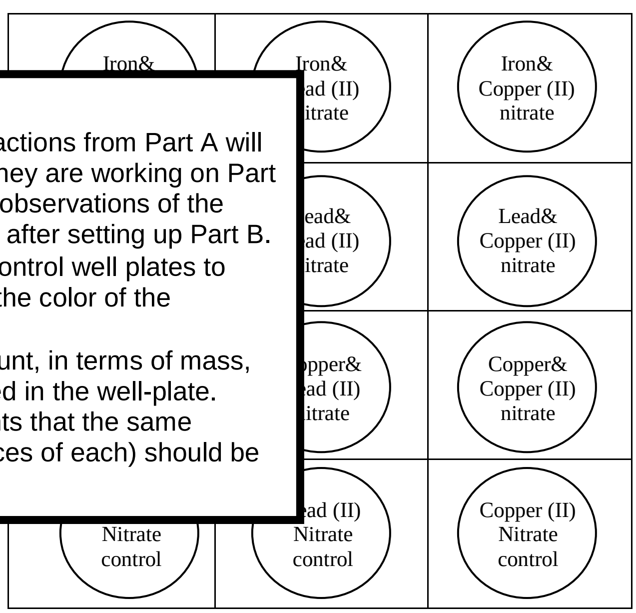
***** Safety Reminders *****

- **Make sure you have your safety goggles and gloves on.**
- **Review your MSDS table and be careful when handling your materials.**
- **Clean up carefully and thoroughly when you are finished.**

Part A

1. Obtain a spot well-plate. In one column, fill four wells with iron (III) nitrate solution. The second column fill four wells with lead (II) nitrate solution. The column will contain four wells holding copper (II) nitrate solution.
2. Obtain samples (9 pieces of each) of iron, lead and copper. Note the appearance of each metal. All of your observations will be recorded on the Metal Reactivity Data table.
3. Place three piece of iron into an iron (III) nitrate well, three piece of iron into the lead (II) nitrate well and three pieces of iron into a copper (II) nitrate well.
4. Follow step # 3 for the lead and copper (see diagram below).
5. The wells that contain the solutions but no metal will be used as a control.
6. Make an initial set of observations.
7. Place the well-plate aside. Wait approximately 15 minutes. Set up Part B of your lab while you are waiting.
8. Record your observations made at 15 minutes.
9. Set your well-plate aside and complete Part B.
10. You will make and record a final set of observations after you have completed Part B.

Diagram of well-plate



Teacher Notes:
- Emphasize that the reactions from Part A will be taking place while they are working on Part B. Their second set of observations of the well-plate will be taken after setting up Part B.
- Students will use the control well plates to note any difference in the color of the solutions.
- There is no exact amount, in terms of mass, for the metals be placed in the well-plate. Just remind the students that the same amount (approx. 3 pieces of each) should be used in each solution.

Lab – What's In Your Water?
Procedure, cont. (page 2 of 2)

Teacher Notes:

- Emphasize that students should test every control beaker for conductivity. There can be variations within each of the samples.
- Students will clean-up Part B before their final observation of Part A. The last step of the lab will be to clean their well-plates.
- Students can be given the option of bringing in a water sample from home to test for conductivity.
- Remember that if chloramine is available, this should be added into the procedure for Part B.

<u>Part B:</u>

1. Measure out four samples of 8.0g iron (III) oxide, four samples of 2.7g lead (II) carbonate and four samples 0.8g of copper (II) oxide.
2. Collect 15 50 ml beakers. Fill them as follows:
   a. (3) beakers with 40ml of distilled water in each;
   b. (3) beakers with 40ml of hard water in each;
   c. (3) beakers with 40ml of soft water in each;
   d. (3) beakers with 40ml of chlorinated water in each;
   e. (3) beakers with 40ml of fluorinated water in each;
3. You will begin using a conductivity probe. Be sure to place the probe into conductivity solution and calibrate to 1000 μs/cm (microSiemen/cm).
4. Use the conductivity probe to test **all** samples by placing probe into **each** beaker. This will be your control. Place all readings on Scale Solubility data table. **Between each test, dip probe into separate sample of distilled water so there is no cross contamination. You may need to wipe the probe to remove any residues. Re-rinse in distilled water after wiping the probe.**
5. Pour one sample of iron (III) oxide into a beaker of distilled water, another sample into a beaker containing hard water, a third sample into the beaker containing soft water, a fourth sample into the beaker containing chlorinated water, and the final sample into the beaker containing fluorinated water.
6. Follow step # 5 for the lead (II) carbonate, and the copper (II) oxide.
7. Wait approximately five minutes to test each mixture for conductivity. DO NOT ALLOW PROBE TO TOUCH THE BOTTOM OF THE BEAKER. Record initial conductivity reading. Wait for 10 minutes.
8. This would be a good point to make your next observations for Part B.
9. Take a final reading after 10 minutes. Calculate a percent difference between the initial and final readings.
10. While you are waiting to take additional conductivity readings look at your well-plate and note the appearance of the metals and solutions. Your final observation will be made after Part B clean-up.

Clean-up:

- **Begin with Part B. Place all of the contents from Part B into the beaker labeled WASTE B.**
- **Place all of the contents of your well-plate into the beaker labeled WASTE A.**
- **Clean up your lab area, wash your labware and return all of your equipment to the designated areas.**

Discussion:

- Discuss the results with your group. Discuss what seems most reactive and most soluble. Try to come to a consensus on which metal would make the best drinking water pipes.
- We will come together as a class to discuss. Designate a reporter that will report the data points and three key points in your group's discussion.

Lab
What's In Your Water?

Teacher Note:
Recorded data in italics is from a trial run. The instructor should conduct a trial run him/herself to confirm data.

Lab Data

Use the tables to record your data. You will be recording qualitative data for Part A: Metal Reactivity. You will be recording quantitative data for Part B: Solubility. All of your quantitative data should be labeled and must include correct units.

Part A: Metal Reactivity

	$Fe(NO_3)_{3\ (aq)}$	$Pb(NO_3)_{2\ (aq)}$	$Cu(NO_3)_{2\ (aq)}$
Control: only solution	**Initial:** *yellow* **15min:** *yellow* **50min:** *still yellow*	**Initial:** *clear, colorless* **15min:** *clear* **50min:** *still clear*	**Initial:** *aqua blue* **15min:** *blue* **50min:** *still blue*
$Fe_{(s)}$	**Initial:** *yellow; metal is dark silvery gray* **15min:** *no Rxn on metal, solution still yellow* **50min:** *rusty brown solution*	**Initial:** *clear, colorless;metal is dark silvery gray* **15min:** *No Rxn on metal, solution has yellow tint* **50min:** *solution has yellow tint*	**Initial:** *aqua blue; metal is dark silvery gray* **15min:** *Reddish-brown substance on nail, solution now greenish tint* **50min:** *Solution olive green in color*
$Pb_{(s)}$	**Initial:** *yellow; metal is silvery with some whiteness* **15min:** *no Rxn on metal, orange solution* **50min:** *orange solution*	**Initial:** *clear; metal is silvery with some whiteness* **15min:** *No Rxn on metal, solution still clear* **50min:** *solution has slight tint*	**Initial:** *blue; metal is silvery with some whiteness* **15min:** *blackish tint on lead, solution is now lighter blue* **50min:** *solution now has greenish tint*
$Cu_{(s)}$	**Initial:** *yellow; metal is orangeish* **15min:** *No Rxn on metal, solution still yellow* **50min:** *slightly orange solution*	**Initial:** *clear; metal is orangeish* **15min:** *No Rxn on metal, solution still clear* **50min:** *Solution still clear*	**Initial:** *aqua; metal is orangeish* **15min:** *No Rxn on metal, solution still blue* **50min:** *Solution still blue*

Teacher Note:

- There is no sample data for the fluorinated water, as it was not available for the trial run.
- See Next page for conclusions & % change.

Lab: What's In Your Water?
Data, cont.

Part B: Scale Solubility

	hard water conductivity (µS/cm)	soft water conductivity (µS/cm)	fluorinated water conductivity (µS/cm)	chlorinated water conductivity (µS/cm)	distilled water conductivity (µS/cm)
0.8g $Fe_2O_{3\ (s)}$	**Control:** *741.8* **5min:** *776.9* **% change:** **10min:** *780.5* **% change:**	**Control:** *988.9* **5min:** *990.4* **% change:** **10min:** *991.1* **% change:**	**Control:** *N/A* **5min:** *N/A* **% change:** **10min:** *N/A* **% change:**	**Control:** *728.4* **5min:** *744.7* **% change:** **10min:** *750.3* **% change:**	**Control:** *709.5* **5min:** *741.5* **% change:** **10min:** *742.1* **% change:**
2.7g $PbCO_{3\ (s)}$	**Control:** *741.8* **5min:** *743.9* **% change:** **10min:** *744.8* **% change:**	**Control:** *988.0* **5min:** *989.0* **% change:** **10min:** *989.2* **% change:**	**Control:** *N/A* **5min:** *N/A* **% change:** **10min:** *N/A* **% change:**	**Control:** *730.8* **5min:** *735.8* **% change:** **10min:** *737.1* **% change:**	**Control:** *710.0* **5min:** *719.9* **% change:** **10min:** *714.1* **% change:**
0.8g $CuO_{\ (s)}$	**Control:** *741.8* **5min:** *745.5* **% change:** **10min:** *747.0* **% change:**	**Control:** *994.9* **5min:** *995.0* **% change:** **10min:** *995.1* **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** *729.9* **5min:** *733.1* **% change:** **10min:** *734.7* **% change:**	**Control:** *709.9* **5min:** *711.7* **% change:** **10min:** **% change:**

Control: conductivity of the solution with no solid scale added

	hard water conductivity (μS/cm)	soft water conductivity (μS/cm)	chlorinated water conductivity (μS/cm)	distilled water conductivity (μS/cm)	Average	
Fe_2O_3						Iron scale had the greatest increase by percentage in conductivity in hard water and the least in soft water.
control: no scale	741.8	988.9	728.4	709.5		
after 10 min	780.5	991.1	750.3	742.1		
change	38.7	2.2	21.9	32.6		
% increase	5.2%	0.2%	3.0%	4.6%	3.3%	
$PbCO_3$						Lead scale had the greatest increase by percentage in conductivity in chlorinated water and the least in soft water.
control: no scale	741.8	988.0	730.8	710.0		
after 10 min	744.8	989.2	737.1	714.1		
change	3.0	1.2	6.3	4.1		
% increase	0.4%	0.1%	0.9%	0.6%	0.5%	
CuO						Copper scale had the greatest increase by percentage in conductivity in hard and chlorinated water and the least in soft water.
control: no scale	741.8	994.9	729.9	709.9		
after 10 min	747.0	995.0	734.7	713.7		
change	5.2	0.1	4.8	3.8		
% increase	0.7%	0.0%	0.7%	0.5%	0.5%	
For the first run-though of a brand-new experiment, it was a success. For future experiments, our group would recommend using PbO instead of PbCO3. This would allow the integrity of comparisons between the scales to be more firm. Our group wanted to use a fluorinated water sample and a chloraminated water sample, but the samples could not be obtained in time for the first run-through. We would hypothesize that the chloraminated water sample would dissolve more lead scale than regular chlorinated water because of the Washington, D.C. drinking water problem.					Overall, iron scale saw the greatest increase in conductivity. Lead and copper scales were tied for the least increase in conductivity.	

Teacher Notes:

- Iron should be the most reactive based on its placement on the electromotive force series table. Copper should be the least reactive.
- An activity series will support the electromotive force series table.

Lab:
What's In Your Water?

Post-Lab:
Analysis and Further Research

This Post-Lab assignment should be typed. Be sure to include a list of your sources for Part Three, and don't forget to properly cite your information using ACS format!

Part One: Analysis

Answer the following questions carefully and thoroughly. Be sure to use specific examples from your data **and post-lab discussion** to support your answers.

1. Write a brief description of what happened during your lab. Be sure to include any difficulties or possible procedural errors that might have led to bad data. Also be sure to include a discussion of any surprises or interesting highlights.

2. Based on the data, which metal appeared to be the most reactive? How did this compare to what you expected?

3. Was there a difference between your prediction and your result? If so, what do you think could be the cause? If not, what information led you to your prediction in the first place?

4. Look at the activity series of metals in your textbook. Does the table support your answers to question #1? Explain.

5. Based on your conductivity results, which metal was most soluble? How do you know?

6. Was there a difference between your prediction and your result? If so, what do you think could be the cause? If not, what information led you to your prediction in the first place?

Part Two: Conclusion

So, which metal would you use? What are you going to tell your contractor to do?

In 2 paragraphs, explain which metal you want for your plumbing pipes, and why you want that metal. Be sure to include information from your pre-lab research and from your lab data to explain your reasoning. Be sure to discuss health risks, metal reactivity and scale solubility.

Part Three: Further Research

Choose one of the following topics and complete research on the topic. Write a 1-2 page mini-essay discussing your findings. Incorporate what you learned during the lab into your discussion.

- What alternatives are there to metal pipes? What are the pros and cons of these alternatives?
- If you have plumbing with metal pipes, how can you test the level of heavy metals in your water? What can be done to take out the heavy metals in your water?
- If you drop a penny into a fish tank, some of the organisms die and some survive. Why?

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Post-Lab:
Extension Question

After seeing the order of reactivity from your lab data, which property (Electromotive Force, Ionization Energy, Effective Nuclear Charge) proved to be the most responsible for the reactivity of the metals? Compare your answer to your prediction from your Pre-Lab Extension.

Write your discussion below.

Teacher Note

- This Pre-Lab Extension is not included in the student manual. Just white-out this Teacher Note to copy.
- Students should note that the Electromotive Force is the only trend that follows the experimental data.

Lab:
What's In Your Water?

Student Lab Manual

You are completing renovations on a house, and the contractor tells you that the pipes in the house are currently made out of lead, but if you wanted, she could replace them with iron or copper pipes. You have a decision to make. Should you keep the lead? Or should you swap them out with iron pipes or copper pipes?

What do you do?

Lab
What’s In Your Water?

Pre-Lab
Research and Predictions

Read the following articles:

“Iron in Drinking Water” (Colter and Mahler)
“Copper in Drinking Water: Health Effects and How to Reduce Exposure” (Minnesota Dept. of Health)
“Lead in Water: Questions and Answers” -(United States Environmental Protection Agency)

Read the following article:
“Corrosion” (Non-Destructive Techniques Resource Center)

Read through the first part of the article on corrosion, paying special attention to electromotive force series table. You do not need to be concerned about the different types of corrosion.

Questions:

1. What are the human health effects associated with consuming iron, copper and lead? Write at least one paragraph for each metal.
2. Which metal would you expect to be most reactive? Why?
3. Which metal would you expect to be least reactive? Why?
4. Which metal scale would you expect to dissolve most in water? Why?
5. Write 1-2 sentences that explain why you are completing this experiment.
6. Make your prediction: What metal would you choose? Why?

Type your answers to these questions and turn in with your other pre-lab work at the start of class, before the lab work begins.

Make a note of your predictions for use in your post-lab.

Lab:
What's In Your Water?

Pre-Lab:
Hazards Table

Go to the Flinn website (http://www.flinnsci.com/search_MSDS.asp) to find the information. Complete the Hazards Table and turn in with your other pre-lab work at the start of class, before the lab work begins. **<u>Be sure to review this table before you hand it in</u>**!

Compound	Mol Wt, melting pt, boiling pt	Hazards
iron (III) nitrate (0.2M)		
copper (II) nitrate (0.2M)		
lead (II) nitrate (0.2M)		
iron nails		
copper shot		
lead shot		
hard water (water with $CaCO_3$)		
soft water (water with NaCl)		
fluorinated water (water with fluorine)		
chlorinated water (water with NaClO)		
iron scale (Fe_2O_3)		
copper scale (CuO)		
lead scale ($PbCO_3$)		

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Pre-Lab:
Procedures Chart

Draw a chart that depicts your lab procedure. Be specific about each of your steps, and be sure to include drawings of your lab equipment. Turn in with your other pre-lab work at the start of class, before the lab work begins.

Lab:
What's In Your Water?

Lab Procedure

***** Safety Reminders *****

- **Make sure you have your safety goggles and gloves on.**
- **Review your MSDS table and be careful when handling your materials.**
- **Clean up carefully and thoroughly when you are finished.**

Part A

1. Obtain a spot well-plate. In one column, fill four wells with iron (III) nitrate solution. The second column fill four wells with lead (II) nitrate solution. The last column will contain four wells holding copper (II) nitrate solution.
2. Obtain samples (9 pieces of each) of iron, lead and copper. Note the appearance of each metal. All of your observations will be recorded on the Metal Reactivity Data table.
3. Place three piece of iron into an iron (III) nitrate well, three piece of iron into the lead (II) nitrate well and three pieces of iron into a copper (II) nitrate well.
4. Follow step # 3 for the lead and copper (see diagram below).
5. The wells that contain the solutions but no metal will be used as a control.
6. Make an initial set of observations.
7. Place the well-plate aside. Wait approximately 15 minutes. Set up Part B of your lab while you are waiting.
8. Record your observations made at 15 minutes.
9. Set your well-plate aside and complete Part B.
10. You will make and record a final set of observations after you have completed Part B.

Diagram of well-plate

Iron& Iron (III) nitrate	Iron& Lead (II) nitrate	Iron& Copper (II) nitrate
Lead& Iron (III) nitrate	Lead& Lead (II) nitrate	Lead& Copper (II) nitrate
Copper& Iron (III) nitrate	Copper& Lead (II) nitrate	Copper& Copper (II) nitrate
Iron (III) Nitrate control	Lead (II) Nitrate control	Copper (II) Nitrate control

Lab – What's In Your Water?
Procedure, cont. (page 2 of 2)

Part B:

1. Measure out four samples of 8.0g iron (III) oxide, four samples of 2.7g lead (II) carbonate and four samples 0.8g of copper (II) oxide.
2. Collect 15 50 ml beakers. Fill them as follows:
    a. (3) beakers with 40ml of distilled water in each;
    b. (3) beakers with 40ml of hard water in each;
    c. (3) beakers with 40ml of soft water in each;
    d. (3) beakers with 40ml of chlorinated water in each;
    e. (3) beakers with 40ml of fluorinated water in each;
3. You will begin using a conductivity probe. Be sure to place the probe into conductivity solution and calibrate to 1000 μs/cm (microSiemens/cm).
4. Use the conductivity probe to test **all** samples by placing probe into **each** beaker. This will be your control. Place all readings on Scale Solubility data table. **Between each test, dip probe into separate sample of distilled water so there is no cross contamination. You may need to wipe the probe to remove any residues. Re-rinse in distilled water after wiping the probe.**
5. Pour one sample of iron (III) oxide into a beaker of distilled water, another sample into a beaker containing hard water, a third sample into the beaker containing soft water, a fourth sample into the beaker containing chlorinated water, and the final sample into the beaker containing fluorinated water.
6. Follow step # 5 for the lead (II) carbonate, and the copper (II) oxide.
7. Wait approximately five minutes to test each mixture for conductivity. DO NOT ALLOW PROBE TO TOUCH THE BOTTOM OF THE BEAKER. Record initial conductivity reading. Wait for 10 minutes.
8. This would be a good point to make your next observations for Part B.
9. Take a final reading after 10 minutes. Calculate a percent difference between the initial and final readings.
10. While you are waiting to take additional conductivity readings look at your well-plate and note the appearance of the metals and solutions. Your final observation will be made after Part B clean-up.

Clean-up:

- **Begin with Part B. Place all of the contents from Part B into the beaker labeled WASTE B.**
- **Place all of the contents of your well-plate into the beaker labeled WASTE A.**
- **Clean up your lab area, wash your labware and return all of your equipment to the designated areas.**

Discussion:

- Discuss the results with your group. Discuss what seems most reactive and most soluble. Try to come to a consensus on which metal would make the best drinking water pipes.
- We will come together as a class to discuss. Designate a reporter that will report the data points and three key points in your group's discussion.

Lab
What's In Your Water?

Lab Data

Use the tables to record your data. You will be recording qualitative data for Part A: Metal Reactivity. You will be recording quantitative data for Part B: Solubility. All of your quantitative data should be labeled and must include correct units.

Part A: Metal Reactivity

	$Fe(NO_3)_{3\,(aq)}$	$Pb(NO_3)_{2\,(aq)}$	$Cu(NO_3)_{2\,(aq)}$
Control: only solution	**Initial:** **15min:** **50min:**	**Initial:** **15min:** **50min:**	**Initial:** **15min:** **50min:**
$Fe_{(s)}$	**Initial:** **15min:** **50min:**	**Initial:** **15min:** **50min:**	**Initial:** **15min:** **50min:**
$Pb_{(s)}$	**Initial:** **15min:** **50min:**	**Initial:** **15min:** **50min:**	**Initial:** **15min:** **50min:**
$Cu_{(s)}$	**Initial:** **15min:** **50min:**	**Initial:** **15min:** **50min:**	**Initial:** **15min:** **50min:**

Lab: What's In Your Water?
Data, cont.

Part B: Scale Solubility

	hard water conductivity (µS/cm)	soft water conductivity (µS/cm)	fluorinated water conductivity (µS/cm)	chlorinated water conductivity (µS/cm)	distilled water conductivity (µS/cm)
0.8g $Fe_2O_{3\ (s)}$	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**
2.7g $PbCO_{3\ (s)}$	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**
0.8g $CuO_{\ (s)}$	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**	**Control:** **5min:** **% change:** **10min:** **% change:**

Control: conductivity of the solution with no solid scale added

Lab:
What's In Your Water?

Post-Lab:
Analysis and Further Research

This Post-Lab assignment should be typed. Be sure to include a list of your sources for Part Three, and don't forget to properly cite your information using ACS format!

Part One: Analysis

Answer the following questions carefully and thoroughly. Be sure to use specific examples from your data **and post-lab discussion** to support your answers.

1. Write a brief description of what happened during your lab. Be sure to include any difficulties or possible procedural errors that might have led to bad data. Also be sure to include a discussion of any surprises or interesting highlights.

2. Based on the data, which metal appeared to be the most reactive? How did this compare to what you expected?

3. Was there a difference between your prediction and your result? If so, what do you think could be the cause? If not, what information led you to your prediction in the first place?

4. Look at the activity series of metals in your textbook. Does the table support your answers to question #1? Explain.

5. Based on your conductivity results, which metal was most soluble? How do you know?

6. Was there a difference between your prediction and your result? If so, what do you think could be the cause? If not, what information led you to your prediction in the first place?

Part Two: Conclusion

So, which metal would you use? What are you going to tell your contractor to do?

In 2 paragraphs, explain which metal you want for your plumbing pipes, and why you want that metal. Be sure to include information from your pre-lab research and from your lab data to explain your reasoning.

Part Three: Further Research

Choose one of the following topics and complete research on the topic. Write a 1-2 page mini-essay discussing your findings. Incorporate what you learned during the lab into your discussion.

- What alternatives are there to metal pipes? What are the pros and cons of these alternatives?
- If you have plumbing with metal pipes, how can you test the level of heavy metals in your water? What can be done to take out the heavy metals in your water?
- If you drop a penny into a fish tank, some of the organisms die and some survive. Why?