

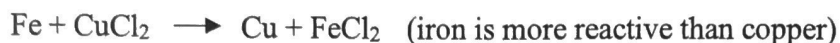
Name(s) _____

Determining the Activity Series of Metals

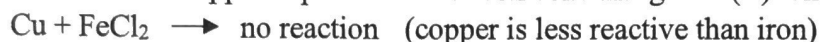
Background Information

When an iron nail is placed in a solution of copper II chloride, copper metal soon appears in the surface of the nail. If the reaction is allowed to continue, eventually all of the iron in the nail will be replaced with copper.

Chemical reactions in which one element of a compound is replaced with another are called single-replacement reactions. In general, the ease with which atoms of metals lose electrons determines the activity of the metal. A metal will replace a metal in a metal salt if it is more active. From the reaction between the iron nail and copper II chloride, we conclude the iron is more active than copper. The iron replaced the copper in the copper chloride.



However, **no reaction** occurs when copper is put into a solution containing iron (II) ions.



In this experiment you will conduct a series of single-replacement reactions by placing a metal in an acid or solution of a metal salt. By observing the reactions to see if the metal replaced the metal in the metal salt, you will be able to develop an activity pattern (activity series) for several of the metal elements. You will rank the metals in order of decreasing activity.

Objectives and Outcomes

1. You will be able to determine which metals lose their electrons more easily.
2. You will develop an activity series for some of the metal elements.
3. Using the activity series, you will be able to predict single-replacement reactions.
4. You will be able to write chemical equations for single-replacement reactions.

Pre-Lab Activity

1. You put a piece of lead into a copper (II) chloride solution. There is a color change.
 - a. Write an equation for this reaction _____
 - b. What type of chemical reaction is this? _____
 - c. Based on these results, which metal (Pb or Cu) is more reactive? _____
2. Suppose we have metals H, M, J, and W. you add them to chloride solutions of these same metals. Using the following lab results, determine the relative reactivity of the metals. The first one was done for you as an example.

TABLE 1.

Metal	Solution	Observations	Relative Reactivity
H	JCl	Color change	H > J
H	MCl	Bubbles	
H	WCl	Bubbles	
J	MCl	Color change	
J	WCl	No reaction	
M	WCl	No reaction	

- a. Based on the reactions, rank the 4 metals from most reactive to least reactive:

_____ > _____ > _____ > _____

Materials

Lab Equipment: Well plate, plastic droppers

Metal Samples: copper, magnesium, zinc, and iron

Solutions: 1M HCl, $\text{Cu}(\text{NO}_3)_2$, $\text{Zn}(\text{NO}_3)_2$, $\text{Fe}(\text{NO}_3)_2$, AgNO_3

Safety Precautions

Wear goggles at all times. Handle all solutions in this lab carefully and avoid contact as they can be irritating to the skin. Since silver nitrate may stain skin and clothing, avoid contact. Dispose of all solids in the trash and put all liquids in the appropriate container, **do not pour liquids down the sink!**

Experimental Procedures

A. COMPARING THE ACTIVITY OF SEVERAL METALS IN HYDROCHLORIC ACID

1. Add 1 M Hydrochloric Acid to 3 of the wells in the well plate (about 1/3 full).
2. Add a small sample of solid zinc (Zn) to the first well, a small sample of magnesium (Mg) to the 2nd well, and a small sample of iron (Fe) (the nail) to the 3rd well.
3. Observe the reactions carefully for 3-5 minutes to determine how rapidly each metal reacts with the acid. The more reactive the metal, the faster the gas bubbles are formed.
4. Carefully feel the outside of the wells to observe the temperature of the reaction.
5. Record your observations in TABLE 2 below and use them to answer part A of the data and analysis report.

TABLE 2

Metal	Observation
Zinc (Zn)	Some bubbles
Magnesium (Mg)	lots of bubbles immediately
Iron (Fe)	a few bubbles after about 5 minutes

B. DETERMINING THE ACTIVITY OF ZINC

NOTE: You can tell when a metal has been replaced because the replaced metal appears on the surface of the first metal

1. In 3 of the wells in your well plate, add the following solutions (fill 1/3 full):
 - i. Copper II Chloride to well #1
 - ii. Iron III Nitrate to well #2
 - iii. Silver Nitrate to well #3
2. Add a small piece of solid zinc metal to each of the 3 wells.
3. Allow the reactions to proceed for 5-10 minutes while you prepare part C.

C. DETERMINING THE ACTIVITY OF COPPER

1. To 3 more wells add the following solutions (fill 1/3 full)
 - i. Zinc Nitrate to well #4
 - ii. Iron III Nitrate to well #5
 - iii. Silver Nitrate to well #6
2. Add a small piece of solid copper metal to each of the wells.
3. Allow these reactions to proceed 5-10 minutes.
4. Record your observations for parts B and C in TABLE 3 on the next page, then complete the Data and Analysis Report and Follow Up Questions.

TABLE 3

Well	Solution Metallic Compound	Solid Metal	Did a reaction occur?	Symbol of more reactive metal	Symbol of less reactive metal
1	Copper (II) Chloride	Zn	yes		
2	Iron (III) Nitrate	Zn	yes		
3	Silver Nitrate	Zn	yes		
4	Zinc Nitrate	Cu	no		
5	Iron (III) Nitrate	Cu	no		
6	Silver Nitrate	Cu	yes		

DATA AND ANALYSIS REPORT:

PART A: ACTIVITY OF METALS IN HCL ACID

Use your observations listed in TABLE 2 to answer the following questions.

- List the 3 metals (Zinc, Magnesium, and Iron) in order of decreasing activity.
 - _____
 - _____
 - _____
- What was the makeup of the gas bubbles produced by the reaction?
- Write a chemical equation for the reaction observed between zinc and hydrochloric acid (HCl).



- Decide if each is more or less reactive than hydrogen:
 - Zn is **more/less** reactive than hydrogen
 - Mg is **more/less** reactive than hydrogen
 - Fe is **more/less** reactive than hydrogen

PARTS B AND C: ACTIVITY OF ZINC AND COPPER

Use your results listed in TABLE 3 to answer the following questions:

- Which metal in the table above is the most reactive? Explain your choice.
- According to the observations you have made in Parts A, B, and C, prepare a list in which the metals copper, zinc, iron, magnesium, and silver are arranged according to their reactivity. List the most reactive metal first.
 - _____
 - _____
 - _____
 - _____
 - _____

FOLLOW UP QUESTIONS:

Look up the Activity Series Table on page 361 of the white Chemistry textbooks.

1. How do your results compare with those given in the table?
2. Which elements are more active than magnesium?
3. Which elements are less active than silver?
4. Use the Activity Series Table to predict if the following reactions will occur. For each, say if the reaction will occur. Then, **if it will**, write a chemical equation to show the reactants and products of the reaction.

a. Cu added to H_2SO_4 to give H_2

Will the reaction happen?

Reaction equation:

b. Al added to $AgNO_3$ to give Ag

Will the reaction happen?

Reaction equation:

c. Zn added to $CuSO_4$ to give Cu

Will the reaction happen?

Reaction equation: