

NAME _____

SECTION _____

PARTNER(S) _____

DATE _____

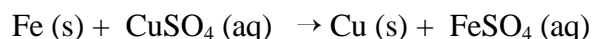
AN INVESTIGATION OF CHEMICAL REACTIONS II

This activity explores the reactivity of a number of metals using single replacement reactions and investigates the role of solubility in visualization of products of double replacement reactions. Careful observation is important in this activity.

PART I: RELATIVE REACTIVITIES

PRE-LAB QUERIES

1. In *Investigations of Chemical Reactions I* you had the experience of placing iron (steel wool) into a solution of copper (II) sulfate and observing the chemical reaction that took place. Refer to that reaction to answer the questions below.



What color is $\text{CuSO}_4 \text{ (aq)}$?

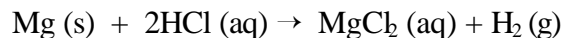
What color is Cu (s) ?

Where was the Cu formed?

Where was the FeSO_4 ?

Why do you think this reaction is called a **single replacement**?

2. You have also observed what happens when magnesium is placed in hydrochloric acid.



What was replaced in this reaction? _____

What did the replacing? _____

Name three pieces of evidence (visual or auditory) from observing this reaction that would indicate that the reaction actually occurred as shown in the equation above.

1. _____
2. _____
3. _____

PROCEDURE

1. For the six combinations of metals and compounds shown in Data Table 1 (on the following page) predict the possible outcome of each reaction by completing the equation and indicating something that you could expect **to see** in each case assuming the reaction took place.

Let's test your predictions.

2. Obtain a spot plate, clean it, and rinse with distilled water. Number six wells. Fill the six wells of the spot plate with the solutions (one per well) as shown in the table below.
NOTE: Do not use the FeSO₄ solution if there is brown precipitate in it when placed in a well. Ask the instructor for fresh solution.

Place the indicated metals in the numbered wells.

Well	1	2	3	4	5	6
Solution	HCl	HCl	FeSO ₄	KCl	CuSO ₄	FeSO ₄
Metal	Fe (steel wool)	Cu (filament)	Cu (filament)	Mg	Mg	Mg

3. Allow the reactions to sit **at least five minutes** before making observations. Record your observations in the data table and decide if your prediction was correct (that is, did a reaction occur). You may want to start Part II while you are waiting.
4. Dispose of all materials in the waste containers provided.
5. On the basis of your observations, what **general statement** can you make about the ability of one metal to replace another metal from a compound?

If a neutral metal can replace a metal ion from a compound it is said to be more reactive than the metal it replaced.

6. From your observations, rearrange the following list in order of REACTIVITY. Start with the most active metal first.
Cu Mg Fe K H

DATA TABLE 1

Predicted Chemical Equation (complete as though it took place)	What I expect to see if the reaction takes place	Well #	What I actually saw when the reactants were placed together	Prediction Correct? (Did a reaction occur?) (Yes or No)
$\text{Fe} + \text{HCl} \rightarrow$		1		
$\text{Cu} + \text{HCl} \rightarrow$		2		
$\text{Cu} + \text{FeSO}_4 \rightarrow$		3		
$\text{Mg} + \text{KCl} \rightarrow$		4		
$\text{Mg} + \text{CuSO}_4 \rightarrow$		5		
$\text{Mg} + \text{FeSO}_4 \rightarrow$		6		

PART II: AN INVESTIGATION OF SOLUBILITY AND PRODUCTS OF DOUBLE REPLACEMENT REACTIONS

PRE-LAB QUERIES

1. In *Investigations of Chemical Reactions I* you had the opportunity to complete several double replacement reactions. Write the chemical equations for those reactions here.

Which reaction(s) had visible products? Explain

Which reaction showed a visible precipitate (formation of a solid and/or cloudiness)? Why did this reaction have a precipitate while the reaction of NaOH and HCl did not?

The CoCl_2 and Na_3PO_4 reaction had one product with low solubility in water so as it formed it would not remain aqueous and precipitated out as a solid. A **precipitate** is an insoluble solid formed through a chemical reaction. The NaOH-HCl reaction had products that are water soluble. Below is a list of general rules for the solubility of ionic compounds in water.

Soluble Compounds	Exceptions
Compounds containing alkali metals (Li^+ , Na^+ , K^+ , Rb^+ , Cs^+) and the ammonium ion (NH_4^+)	
Nitrates (NO_3^-), bicarbonates (HCO_3^-), and chlorates (ClO_3^-)	
Halides (Cl , Br^- , I^-)	Halides of Ag^+ , Hg_2^{2+} , and Pb^{2+}
Sulfates (SO_4^{2-})	Sulfates of Ca^{2+} , Ba^{2+} , Pb^{2+} , and Hg_2^{2+}
Insoluble Compounds	Exceptions
Carbonates (CO_3^{2-}), phosphates (PO_4^{3-}), chromates (CrO_4^{2-}), sulfides (S^{2-})	Compounds containing alkali metals and the ammonium ion
Hydroxides (OH^-)	Compounds containing alkali metals, the ammonium ion, and the Ba^{2+} ion

PROCEDURE

1. Locate the six sets (of pairs) of water soluble compounds in Data Table 2. Your group will be assigned two of these sets by the instructor. For your assigned sets, write a balanced double replacement reaction for each pair. Using the solubility rules, predict if a precipitate will form and which product it will be. (Hint: write chemical formulas)
2. In a spot plate, combine each pair using a few drops of each reactant from dropper bottles.

What evidence will tell you that a precipitate formed? _____

If it is difficult to determine whether a precipitate formed, remove some of the material from the well with a glass medicine dropper and observe the material in the dropper.

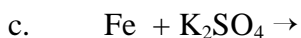
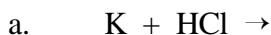
Record your observations in your data table and on the master table provided by the instructor. Be sure to copy the results from all the other groups in your data table so that you have the observations for all reactions. If you are part of a full class, each set of reactions will be done twice and results should agree. If they do not, ask the instructor which information is correct.

DATA TABLE 2

Set	Double Replacement Reaction	Will precipitate form?	Observations	Prediction Correct? (Did ppt form?)
1	$\text{Ni}(\text{NO}_3)_2 + \text{NaOH} \rightarrow$			
	$\text{Ni}(\text{NO}_3)_2 + \text{NaCl} \rightarrow$			
	$\text{Ni}(\text{NO}_3)_2 + \text{Na}_3\text{PO}_4 \rightarrow$			
	$\text{Ni}(\text{NO}_3)_2 + \text{Na}_2\text{CO}_3 \rightarrow$			
	$\text{Ni}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow$			
2	$\text{Fe}(\text{NO}_3)_2 + \text{NaOH} \rightarrow$			
	$\text{Fe}(\text{NO}_3)_2 + \text{NaCl} \rightarrow$			
	$\text{Fe}(\text{NO}_3)_2 + \text{Na}_3\text{PO}_4 \rightarrow$			
	$\text{Fe}(\text{NO}_3)_2 + \text{Na}_2\text{CO}_3 \rightarrow$			
	$\text{Fe}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow$			
3	$\text{Cu}(\text{NO}_3)_2 + \text{NaOH} \rightarrow$			
	$\text{Cu}(\text{NO}_3)_2 + \text{NaCl} \rightarrow$			
	$\text{Cu}(\text{NO}_3)_2 + \text{Na}_3\text{PO}_4 \rightarrow$			
	$\text{Cu}(\text{NO}_3)_2 + \text{Na}_2\text{CO}_3 \rightarrow$			
	$\text{Cu}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow$			
4	$\text{Co}(\text{NO}_3)_2 + \text{NaOH} \rightarrow$			
	$\text{Co}(\text{NO}_3)_2 + \text{NaCl} \rightarrow$			
	$\text{Co}(\text{NO}_3)_2 + \text{Na}_3\text{PO}_4 \rightarrow$			
	$\text{Co}(\text{NO}_3)_2 + \text{Na}_2\text{CO}_3 \rightarrow$			
	$\text{Co}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow$			
5	$\text{Ca}(\text{NO}_3)_2 + \text{NaOH} \rightarrow$			
	$\text{Ca}(\text{NO}_3)_2 + \text{NaCl} \rightarrow$			
	$\text{Ca}(\text{NO}_3)_2 + \text{Na}_3\text{PO}_4 \rightarrow$			
	$\text{Ca}(\text{NO}_3)_2 + \text{Na}_2\text{CO}_3 \rightarrow$			
	$\text{Ca}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow$			
6	$\text{KNO}_3 + \text{NaOH} \rightarrow$			
	$\text{KNO}_3 + \text{NaCl} \rightarrow$			
	$\text{KNO}_3 + \text{Na}_3\text{PO}_4 \rightarrow$			
	$\text{KNO}_3 + \text{Na}_2\text{CO}_3 \rightarrow$			
	$\text{KNO}_3 + \text{Na}_2\text{SO}_4 \rightarrow$			

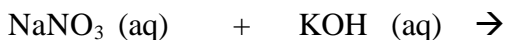
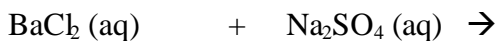
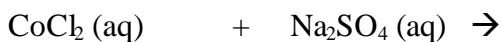
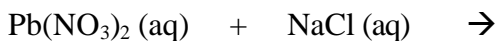
POST-LAB QUESTIONS

1. Based on the results of Part I of this experiment, predict the outcome of the following combinations of metals and compounds. If a reaction takes place, complete the equation. If no reaction is expected, write "no reaction" after the arrow.



2. Silver (Ag) and gold (Au) are both used as jewelry. From your experience, which of these two metals is more reactive than the other? State your reason(s)

3. Complete and balance the following double replacement reactions. Using your observations and the solubility rules, indicate the state of each product. If a reaction takes place, complete the equation. If no reaction is expected, write "no reaction" after the arrow.



4. Which of the cations you used in Data Table 2 tend to form colored products in double replacement reactions? How is this property related to their positions on the periodic table?

5. A student gets a beaker with the completed reaction of aqueous HCl and aqueous NaOH and evaporates the water. Is the resulting residue a precipitate? Explain.