Developing an Activity Series

While metals share common properties, they do not all behave the same way in single displacement reactions. For example, zinc displaces many metal cations from their aqueous ionic compounds. Gold, on the other hand, is extremely unreactive. Potassium reacts violently with water. Zinc does not react with water, but it reacts with acids. How can metals be ranked in order of their reactivity?

Question
What is the order of reactivity if the metals copper, iron, magnesium, and zinc in single displacement reactions?

Materials
- well plates
- six small pieces each of copper, iron, zinc, and magnesium.
- dropper bottles of dilute solution of ZnSO₄, MgSO₄, FeSO₄, HCl, and CuSO₄.
- test tubes and rack
- wash bottle with distilled water

Procedure
1. Design a procedure to react each metal with each of the given solutions, as well as with water. In your procedure, identify amounts of the materials that you will need to combine and observe. Prepare a data table to record your observations.
2. Have your teacher approve your procedure before you begin.
3. Carry out your procedure. If any of the metals you are given appear dull (rather than shiny) remove this oxide with stainless steel wool.
4. Record any changes in the appearance of each metal or solution. Look for colour changes on the surface of the metal or in the solution. If you have difficulty determining whether a reaction has occurred, repeat the test using a test tube to better observe the reaction. Remember that some reactions are slow so plan to re-examine any combinations that do not react immediately.
5. At the end of the investigation, dispose of the solutions in the waste beaker provided. Do not pour anything down the drain.

Analysis
1. For any reactions that occurred, write the corresponding balanced single displacement reaction.
2. Lithium metal reacts with water.
   a) Is lithium more or less reactive than magnesium?
   b) Write a balanced equation to represent the reaction of lithium with water.
3. Given that lithium reacts with water and magnesium does not, do you expect lithium to react with hydrochloric acid? Explain your answer.
4. Why do you think that solutions containing only sulfate ions were used?

Conclusion
1. Write the activity series corresponding to your observations. Include hydrogen as an ion (H⁺).
2. How do you think an activity series for metal would help you predict whether or not a single displacement reaction will occur? Use examples to help you explain your answer.