Single Replacement Reactions

This procedure will allow the student to develop a basic activity series through an exploration of single replacement reactions.

Materials
- Zinc
- Copper
- Aluminum foil
- 0.1 M CuSO₄
- 0.1 M AgNO₃
- 0.1 M ZnSO₄
- 1 M HCl
- 8 watch glasses
- 8 pipettes

Substitutions
- galvanized nail
- copper wire
- spot plate

Procedure
1. After numbering a spot plate or 8 watch glasses, arrange the solids (using the tip of a spatula) in the respective wells as shown on the diagram below:

   I. Zn(s) CuSO₄ (aq)
   II. Al(s) CuSO₄ (aq)
   III. Zn(s) AgNO₃ (aq)
   IV. Cu(s) AgNO₃ (aq)
   V. Pb(NO₃)₂ (aq)
   VI. Cu(s) Pb(NO₃)₂ (aq)
   VII. Zn(s) HCl (aq)
   VIII. Al(s) HCl (aq)
2. Add approximately 10 drops of each required solution.

3. Record any color changes or gas production in the Data section.

4. Write a balanced equation for any reactions that occur. Include physical state symbols for the reactants and products.

5. Construct an activity series by listing the elements in decreasing order of reactivity. [e.g. Zn (s) + Cu²⁺(aq) ----> Cu (s) + Zn²⁺(aq) implies that zinc is above copper in the activity series.]

Data and Observations

I. ________________________________________________
   ______________________________________________
II. ______________________________________________
   ______________________________________________
III. ______________________________________________
    ______________________________________________
IV. ______________________________________________
    ______________________________________________
V. ______________________________________________
   ______________________________________________
VI. ______________________________________________
    ______________________________________________
VII. ______________________________________________
    ______________________________________________
VIII. ______________________________________________
     ______________________________________________
Teacher’s Notes
Anticipated reactions are:

I. \[ \text{Zn (s)} + \text{CuSO}_4 (aq) \rightarrow \text{Cu (s)} + \text{ZnSO}_4 (aq) \]
   Copper forms on zinc; solution color becomes less blue

II. \[ 2\text{Al (s)} + 3\text{CuSO}_4 (aq) \rightarrow 3\text{Cu (s)} + \text{Al}_2(\text{SO}_4)_3 (aq) \]
    Copper forms onto aluminum.

III. \[ \text{Zn (s)} + 2\text{AgNO}_3 (aq) \rightarrow 2\text{Ag (s)} + \text{ZnSO}_4 (aq) \]
     Silver crystals form on zinc solid.

IV. \[ \text{Cu (s)} + 2\text{AgNO}_3 (aq) \rightarrow 2\text{Ag (s)} + \text{Cu(NO}_3)_2 (aq) \]
    Silver crystals grow on copper solid.

V. \[ \text{Zn (s)} + \text{Pb(NO}_3)_2 (aq) \rightarrow \text{Pb (s)} + \text{Zn(NO}_3)_2 (aq) \]
   Dull gray lead forms on pieces of zinc.

VI. \[ \text{Cu (s)} + \text{Pb(NO}_3)_2 (aq) \rightarrow \text{No Reaction.} \]
    Copper will not replace lead.

VII. \[ \text{Zn (s)} + 2\text{HCl (aq)} \rightarrow \text{ZnCl}_2 (aq) + \text{H}_2 (g) \]
    Zinc reacts with acid and hydrogen gas is released.

VIII. \[ 2\text{Al (s)} + 6\text{HCl (aq)} \rightarrow 2\text{AlCl}_3 (aq) + 3\text{H}_2 (g) \]
    Aluminum reacts with acid and hydrogen gas is released.

Activity series that is achievable by the reactions in THIS experiment:


Note that the position of aluminum in this series cannot be determined exactly. It is MORE ACTIVE than Hydrogen.

Disposal
Aqueous solutions of HCl, Zn(NO₃)₂, AgNO₃, and Cu(SO₄)₂ may be flushed down the sink. Solutions of Pb(NO₃)₂ should be evaporated and the solid residue placed in a solid waste disposal container. Solid metals should also be placed in a solid waste container.