Experimental Determination of an Activity Series

In this experiment you will determine the relative activities of six metals and hydrogen, and thus an empirical activity series for these elements.

STOCKROOM

You will need enough two well plates. You will need a transfer pipet with each solution and a pair of tweezers for each metal.

CHEMICALS

You will need about 1 mL each of 0.1 M $CuSO_4$, 0.1 M $ZnSO_4$, 0.1 M $Pb(NO_3)_2$, 0.1 M $Fe(NO_3)_2$, 0.1 M $AgNO_3$, $Mg(NO_3)_2$, and 6 M HCl. You will also need a small piece of Cu wire, Pb metal, Fe metal, Zn metal, Ag metal, and Mg ribbon.

WASTE DISPOSAL

All solutions go in the waste container. The solids waste (metals) go in the garbage can.

SAFETY

Wear your goggles the entire time. 6 M HCl is a strong acid; avoid contact with body tissue. Use it in a hood. Hydrogen gas is generated upon reaction of some metals with acid. Hydrogen is flammable; keep all heat and flames away from your well plate.

INTRODUCTION

All of the reactions that you will perform in this experiment are oxidation – reduction reactions. Specifically, these are a type of oxidation reduction reaction called single – replacement reactions.

In single – replacement reaction an element (a metal or a halogen normally) reacts with an ionic compound or acid that contains a like element. That is, if the single element is a metal, the ionic compound or acid will contain a metal. If the single element is a halogen the ionic compound or acid will contain a halogen.

For example:

$$3\mathrm{Na}(s) + \mathrm{Au(NO_3)_3}(aq) \rightarrow \mathrm{Au}(s) + 3\mathrm{NaNO_3}(aq)$$

or

$$\mathrm{Cl_2}(g) + 2\mathrm{NaBr}(aq) \rightarrow \mathrm{Br_2}(l) + 2\mathrm{NaCl}(aq)$$

In the first equation the sodium has a zero charge on the left side of the arrow, and a +1 charge on the right side of the arrow. The only way this can be is if the sodium atom lost an electron. When a species loses electrons we say that species is **oxidized**. Thus sodium is oxidized here.

In the same equation the gold atom has a +3 charge on the left side of the arrow and a zero charge on the right side of the arrow. The only way this can happen is if each gold atom gains 3 electrons. When a species gains electrons we say that species is **reduced**. Thus gold is reduced in this reaction.

In the second equation the chlorine is reduced and the bromide ion is oxidized. Make sure you understand why this is.

Different elements are easier or harder to oxidize than others. For example, the following reaction does not occur because gold is harder to oxidize (remove electrons from) than sodium.

$$\mathrm{Au}(s) + \mathrm{NaNO_3}(aq) \rightarrow \text{No Reaction}$$

We say that an element is more active than another element if it is easier to oxidize than that element.

In this experiment you will determine the relative activities of 5 metals plus H_2.

PROCEDURE

In your data section, set up a table like the following. Each cell represents a different potential chemical reaction. The possible combinations are given in the following tables.

Well Plate #1

	1	2	3	4	5	6
A	Zn/Cu^{2+}__	Cu/Zn^{2+}__	Cu/Pb^{2+}___	Cu/H^{+}___	Zn/Fe^{2+}_	Zn/Ag^{+}_
B	Pb/Cu^{2+}__	Pb/Zn^{2+}__	Zn/Pb^{2+}___	Zn/H^{+}___	Pb/Fe^{2+}_	Pb/Ag^{+}_
C	Fe/Cu^{2+}__	Fe/Zn^{2+}__	Fe/Pb^{2+}___	Pb/H^{+}___	Cu/Fe^{2+}_	Fe/Ag^{+}_
D	Mg/Cu^{2+}__	Mg/Zn^{2+}__	Mg/Pb^{2+}___	Fe/H^{+}___	Mg/Fe^{2+}_	Mg/Ag^{+}_

Well Plate #2

	1	2	3	4	5	6
A	Ag/Cu^{2+}__	Ag/Zn^{2+}__	Ag/Pb^{2+}___	Mg/H^{+}___	Ag/Fe^{2+}___	Cu/Ag^{+}___
B	Zn/Mg^{2+}___	Pb/Mg^{2+}___	Cu/Mg^{2+}___	Ag/H^{+}___	Ag/Mg^{2+}___	Fe/Mg^{2+}___
C						
D						

Each symbol to the left of the slash represents the solid metal. The symbol to the right of each slash represents the solution containing that ion.

For example, well **A1** in the table above would contain solid zinc and $CuSO_4$(aq).

Place 1 small piece of each metal into each well as set up in the table above.

Transfer a small amount of each solution into each well as marked. Add enough solution to cover the piece of metal in the well.

That is, to each well that is labeled with Cu^{2+} you add $CuSO_4$(aq), for Zn^{2+} add $ZnSO_4$(aq), For Pb^{2+} add $Pb(NO_3)_2$(aq) etc.

Record all observations for each well after 15 minutes in your data table. You will need sufficient space for each well in your data table.

You are looking for an indication that a chemical reaction has occurred. These are:

1.) Formation of a precipitate (solid).

2.) Color change.

3.) Thermal energy absorbed or emitted (it gets colder or warmer).

4.) Evolution of a gas (bubbles).

5.) Emission of light.

CALCULATIONS

Based on your observations, rank the six elements in order of decreasing activity (from most active at the top to least active on the bottom). The most active metal is the one that releases electrons most easily. The least active metal is the one that holds onto electrons most strongly. Your list will look like this:

Most Active (put the symbol for the element here)

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Least Active (put the symbol for the element here)

CONCLUSION

Explain your reasoning for your order of activity. Make sure to explain in detail the placement of each element.