Purpose: To determine the order of reactivity of metals, i.e. to determine which metals are better at losing electrons by observing single displacement reactions of metals.

Introduction

In a single displacement reaction, a more reactive element will react with a compound of a less reactive metal to produce the less reactive metal.

Example: $Zn_{(s)} + CuSO_{4\,(aq)} \longrightarrow Cu_{(s)} + ZnSO_{4\,(aq)}$

$Y + MX_{(aq)} \longrightarrow M_{(s)} + YX_{(aq)}$

The more reactive metal, Y, has displaced the less reactive metal, M from the solution of its salt, $MX_{(aq)}$, forming the less reactive metal, M. Thus, we can devise a reactivity series for metals by combining metals and metal ion solutions. In this experiment you will combine metals and metal ion solutions to determine the reactivity series for metals.

Apparatus & Materials

Test tubes, Emery paper, Small strips of Zn, Cu, Mg, Fe, Pb, small pieces of each of these metals
0.20 mol L^{-1} solutions of: $Zn(NO_3)_2$, $Cu(NO_3)_2$, $Mg(NO_3)_2$, $FeSO_4$, Pb $(NO_3)_{2,}$ 3M $HCl_{(aq)}$

Safety

1. The metal nitrate solutions used in this experiment are poisonous. Avoid direct contact with them.
2. Silver nitrate is corrosive as well as poisonous and a strong oxidizing agent. If spilled on your skin, it will leave brown stains. If this occurs wash with sodium thiosulphate solution and rinse with plenty of water.

Procedure

1. Prepare a suitable table to record all your observations. (A table with the metals across the top and metal solutions down the side.)
2. Clean the strips of metal with emery paper. Avoid cross-contamination by using different pieces of emery paper, one for each metal.
3. Dip a piece of each metal into solutions of salts of each of the other metals. Leave for ~ 2 min.
4. Examine each test-tube, (observe the surface of each metal strip and the colour of each solution), and record your observations in a table.
5. Place ~ 2 cm^3 of HCl $_{(aq)}$ in five test tubes, add a small piece of each of the metal, and note the rate of reactivity (order of 1 - 5, where 1 represents very reactive, and 5 no observable reaction).
6. Dispose of each solution in the waste container provided.

Data Collection

Make a suitable table to record all the data.

Developing the Idea

1. Write balanced chemical equations for all the reactions that you have observed.
2. According to your observations, which metal reacted with the most solutions? Explain your reasoning.
3. Which metal reacted with the fewest solutions? Explain your reasoning.
4. Arrange the metals that were reacted in order of increasing reactivity.
4. Which metal was the most reactive with hydrochloric acid, $HCl_{(aq)}$, and which the slowest?
5. A metal can displace hydrogen ions, $H^{+1}_{(aq)}$, from acids to form hydrogen gas. Write equations to represent the reactions of the metals with $HCl_{(aq)}$.

Applying the Idea

1. Use the list constructed in question 4, in Developing the Idea above, to answer the following questions:

a. Would it be feasible to store a solution of copper sulphate in a container made of metallic zinc? Explain.

b. Would it be feasible to store a solution, $CuSO_{4(aq)}$, in a container made of metallic silver? Explain.

2. Some nuclear power plants have used sea water as a coolant. Choosing the correct type of piping to carry the sea water throughout the plant is very important because sea water contains trace amounts of gold and silver ions. Are copper pipes suitable for nuclear power plants that use sea water? Explain your answer.

3. Blocks of zinc or magnesium are attached to steel boat hulls, underground steel tanks, and steel pipelines to prevent the corrosion of the iron in the steel. Why does this anti-corrosion tactic work so well?

4. Arrange a similar table of reactivity for the halogens, explaining the order of reactivity stated by you.