Name ____________________________ Date ____________________ Class ___________________

15 REACTIVITY OF METALS

Text Reference
Section 11.2

Time Required
40 minutes

Objectives
- Observe the reaction of metallic elements with metallic ions of other metals.
- Based on data, rank the metals according to their relative reactivities.

Advance Preparation
solutions, 5% w/v, in dropper bottles
Prepare each of the seven solutions by dissolving 5 g of the given substance in 100 mL of distilled water.

PURPOSE

To measure the relative reactivities of selected metallic elements.

BACKGROUND

The chemical reactivity of a metal determines how the metal is used. For example, gold, which is commonly used in jewelry, is highly resistant to chemical reactions. Sodium, however, is not used in jewelry because it is so reactive it will explode if it contacts water. The chemistry of the metals is based on their ability to lose electrons. Differences in chemical reactivity among metals depend on the relative ease with which they give up electrons.

You can measure the relative reactivity of two metals by placing a small pure sample of one metal in a solution containing the ions of the other metal. If the small metal sample is more reactive than the metal whose ions are in solution, electrons will move from the solid metal sample into the solution. For example, a piece of iron placed in a solution containing copper(II) ions will corrode, while fine copper particles deposit on the iron. However, no reaction occurs when a strip of copper metal is placed in a solution of iron(II) ions.

In this experiment, you will test the reactivities of a variety of metals with different metal ions. You will then use the results of your tests to construct a scale of relative reactivities of the metals.

MATERIALS (PER PAIR)

safety goggles and apron
gloves
glass-marking pencil
8 medium test tubes
steel wool
test-tube rack
3 dropper pipets
tweezers
thin metal strips, 0.25 mm thick, approximately 2.00 cm × 0.50 cm:
- 8 strips copper, Cu
- 8 strips zinc, Zn
- 8 strips magnesium, Mg F

solutions, 5% w/v, in dropper bottles:
- lead(II) nitrate, $Pb(NO_3)_2$ T
- silver nitrate, $AgNO_3$ T I
- copper(II) sulfate, $CuSO_4$ T I
- magnesium chloride, $MgCl_2$
- zinc chloride, $ZnCl_2$ T
- sodium chloride, NaCl
- potassium chloride, KCl

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SAFETY FIRST!

In this lab, observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the Procedure, refer to the list below for its meaning.

Caution: Wear your safety goggles. (All steps.)

Caution: Wear your lab apron. (All steps.)

Caution: Wear plastic gloves. (All steps.)

Caution: Magnesium metal is flammable. Keep this material away from open flames. (Step 5.)

Caution: Solutions of lead and copper ions are toxic. (Steps 3–6.)

Caution: Silver nitrate is toxic and will leave dark brown stains on skin and clothing. (Steps 3–6.)

If $AgNO_3$ does get on the skin or clothing, staining can be prevented by dipping the affected area in "hypo" (0.5*M* sodium thiosulfate, $Na_2S_2O_3$), and then rinsing with water.

Note: Return or dispose of all materials according to the instructions of your teacher. (Step 6.)

PROCEDURE

As you perform this experiment, record your observations in Data Table 1.

1. Polish metal strips of copper, zinc, and magnesium with steel wool until they are clean and shiny.

Step 1.
The metals must be polished to remove any oxide coating.

2. Using a glass-marking pencil, label eight test tubes with the numbers 1–8. Place the tubes in a test-tube rack.
3. To tube 1, add 5 drops of $Pb(NO_3)_2$ solution. To tube 2, add 5 drops of $AgNO_3$ solution. Using tweezers, add one strip of copper metal to each tube. Record your observations.
4. Add 5 drops of solution to each tube as follows: tube 3, $CuSO_4$; tube 4, $Pb(NO_3)_2$; tube 5, $MgCl_2$. Add a strip of zinc metal to each tube. Record your observations.
5. Add 5 drops of solution to each tube, as follows: tube 6, $ZnCl_2$; tube 7, NaCl; tube 8, KCl. Add a strip of polished magnesium metal to each tube. Record your observations.
6. Follow your teacher's instructions for proper disposal of the materials.

Use the following disposal methods for chemical waste.

Disposal 1: Cu(*s*), Zn(*s*), and Mg(*s*).

Disposal 2: All reaction solutions except those containing $Pb(NO_3)_2$ or $AgNO_3$.

Disposal 7: All reaction solutions containing $Pb(NO_3)_2$.

Disposal 8: All reaction solutions containing $AgNO_3$.

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OBSERVATIONS

DATA TABLE 1: OBSERVATIONS OF METAL ACTIVITY			
Tube	Metal Ion	Metal	Observations
1	Pb^{2+}	Cu	no reaction
2	Ag^{+}	Cu	dark gray deposit on copper; solution turns blue
3	Cu^{2+}	Zn	dark copper-colored deposit on Zn, which corrodes
4	Pb^{2+}	Zn	black deposit on Zn, which corrodes
5	Mg^{2+}	Zn	no reaction
6	Zn^{2+}	Mg	dark gray deposit on Mg, which corrodes; may be evolution of gas
7	Na^{+}	Mg	no reaction
8	K^{+}	Mg	no reaction

ANALYSES AND CONCLUSIONS

1. Why is it necessary to polish the metal strips before doing the experiment?

Polishing will remove any oxide coat that may be present.

2. Write balanced chemical equations for those reactions that actually occurred.

$$Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

$$Zn(s) + Pb(NO_3)_2(aq) \rightarrow Zn(NO_3)_2(aq) + Pb(s)$$

$$Mg(s) + ZnCl_2(aq) \rightarrow MgCl_2(aq) + Zn(s)$$

3. In which of the five general classifications of chemical reactions do the reactions in your answer for question 2 belong?

single-replacement reactions

4. Using your experimental data, list the metals in order of increasing activity. Explain how you arrived at your list.

For each of the reactions tried, the activities are as follows.

1. Pb $>$ Cu [$Pb(NO_3)_2$ + Cu produce no reaction]

2. Cu $>$ Ag ($AgNO_3$ + Cu produce a reaction)

3. Zn $>$ Cu ($CuSO_4$ + Zn produce a reaction)

4. Zn $>$ Pb [$Pb(NO_3)_2$ + Zn produce a reaction]

5. Mg $>$ Zn ($MgCl_2$ + Zn produce no reaction)

6. Mg $>$ Zn ($ZnCl_2$ + Mg produce a reaction)

7. Na $>$ Mg (NaCl + Mg produce no reaction)

8. K $>$ Mg (KCl + Mg produce no reaction)

From 1 and 2, the relative activities are Pb $>$ Cu $>$ Ag.

From 3 and 4, Zn $>$ Cu and Pb. Therefore, the order is Zn $>$ Pb $>$ Cu $>$ Ag.

From 5–8, Na and K $>$ Mg $>$ Zn.

The final activity rankings are Na and K $>$ Mg $>$ Zn $>$ Pb $>$ Cu $>$ Ag.

The experiment does not enable ranking of Na relative to K.

5. Using the results of problem 4, do you think there would be a reaction if strips of copper or zinc were placed in solutions of KCl or NaCl? Explain.

No, sodium and potassium are more active than zinc or copper.

GOING FURTHER

Develop a Hypothesis

Based on the results of this lab, develop a hypothesis about how the relative activities of the metals correspond to their arrangement in the periodic table.

Design an Experiment

Propose an experiment to test your hypothesis. If resources are available and you have your teacher's permission, perform the experiment.