


See the ChemLab worksheet in your FAST FILE.

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## Preparation

**Time Allotment** one class period

**Process Skills** observe and infer, sequence, compare and contrast, apply concepts, predict

**Safety Precautions** Approve lab safety forms before work begins. Be sure students wear an apron and goggles, and wash hands with soap after the lab. Review MSDS with students. Account for all Mg ribbon.

**Disposal** Unreacted metal can be reclaimed and reused. The contents of the well plate can be emptied into a waste container and evaporated to dryness in the fume hood. Dispose of the solid waste at an approved chemical disposal site.

**Preparation of Solutions** Use the following masses of nitrate salts to prepare 1.0 L of a 1.0M solution:  
 298 g  $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   
 375 g  $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$   
 242 g  $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$   
 256 g  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   
 See p. 47T for preparation of all solutions.

**Alternate Materials** Other metals and their nitrate salts can be substituted for the ones listed.

## Procedure

- A well in the reaction plate will be half filled by 2 mL of solution.
- The metal must be cleaned with emery cloth or sandpaper and have a luster.
- Troubleshooting Remind students that if a shiny piece of metal darkens, that is evidence of a chemical change.

## DEVELOP AN ACTIVITY SERIES

**Background:** Some metals are more reactive than others. By comparing how different metals react with the known ions in aqueous solutions, an activity series for the tested materials can be developed. The activity series will reflect the relative reactivity of the tested metals.

**Question:** How is an activity series developed?

### Materials

1.0M $\text{Zn}(\text{NO}_3)_2$	Al wire
1.0M $\text{Al}(\text{NO}_3)_3$	Mg ribbon
1.0M $\text{Cu}(\text{NO}_3)_2$	Zn metal strips (4)
1.0M $\text{Mg}(\text{NO}_3)_2$	Emery cloth or sandpaper
pipettes (4)	24-well microscale reaction plate
wire cutters	
Cu wire	

### Safety Precautions



### Procedure

1. Read and complete the lab safety form.
2. Create a table to record your data.
3. Use a pipette to fill each of the four wells in column 1 of the reaction plate with 2 mL of 1.0M  $\text{Al}(\text{NO}_3)_3$  solution.
4. Repeat the procedure in Step 3 to fill the four wells in column 2 with 2 mL of 1.0M  $\text{Mg}(\text{NO}_3)_2$ .
5. Repeat the procedure in Step 3 to fill the four wells in column 3 with 2 mL of 1.0M  $\text{Zn}(\text{NO}_3)_2$ .
6. Repeat the procedure in Step 3 to fill the four wells in column 4 with 2 mL of 1.0M  $\text{Cu}(\text{NO}_3)_2$ .
7. With the emery cloth or sandpaper, polish 10 cm of aluminum wire until it is shiny. Use wire cutters to carefully cut the aluminum wire into four 2.5-cm pieces. Place a piece of the aluminum wire in each well of row A containing solution.
8. Repeat the procedure in Step 7 using 10 cm of magnesium ribbon. Place a piece of Mg ribbon in each well of row B containing solution.
9. Use the emery cloth or sandpaper to polish each small strip of zinc metal. Place a piece of Zn metal in each well of row C containing solution.
10. Observe what happens in each well. After 5 minutes, record your observations in the data table you made.

## Analyze and Conclude

1. A3, A4, B1, B3, B4, C4  
 Mg – 3 reactions  
 Cu – 0 reactions  
 Magnesium is the most reactive.
2. Mg, Al, Zn, Cu
3. A3:  $2\text{Al} + 3\text{Zn}(\text{NO}_3)_2 \rightarrow 2\text{Al}(\text{NO}_3)_3 + 3\text{Zn}$   
 A4:  $2\text{Al} + 3\text{Cu}(\text{NO}_3)_2 \rightarrow 2\text{Al}(\text{NO}_3)_3 + 3\text{Cu}$   
 B1:  $3\text{Mg} + 2\text{Al}(\text{NO}_3)_3 \rightarrow 3\text{Mg}(\text{NO}_3)_2 + 2\text{Al}$   
 B3:  $\text{Mg} + \text{Zn}(\text{NO}_3)_2 \rightarrow \text{Mg}(\text{NO}_3)_2 + \text{Zn}$   
 B4:  $\text{Mg} + \text{Cu}(\text{NO}_3)_2 \rightarrow \text{Mg}(\text{NO}_3)_2 + \text{Cu}$   
 C4:  $\text{Zn} + \text{Cu}(\text{NO}_3)_2 \rightarrow \text{Zn}(\text{NO}_3)_2 + \text{Cu}$



11. **Cleanup and Disposal** Dispose of the chemicals, solutions, and pipettes as directed by your teacher. Wash and return all lab equipment to the designated location. Wash your hands thoroughly.

## Analyze and Conclude

1. **Observe and Infer** In which wells of the reaction plate did chemical reactions occur? Which metal reacted with the most solutions? Which metal reacted with the fewest solutions? Which metal is the most reactive?
2. **Sequence** The most-active metal reacted with the most solutions. The least-active metal reacted with the fewest solutions. Order the four metals from most active to least active.
3. **Apply** Write a chemical equation for each single-replacement reaction that occurred on your reaction plate.
4. **Real-World Chemistry** Under what circumstances might it be important to know the activity tendencies of a series of elements?
5. **Error Analysis** How does your answer from Question 2 above compare with the activity series in **Figure 9.13**? What could account for the differences?

## INQUIRY EXTENSION

**Design an Experiment** Think of three “what if” questions about this investigation that might affect your results. Design an experiment to test one of them.

4. Answers may vary. For example, industrial chemists could use the information to fine-tune a product or process.
5. Answers will vary. If the procedure was not followed or if the contents of two wells mixed due to over-filling, then the activity series would not agree.

## Inquiry Extension

Students might include checking the concentrations of the solutions, changing the temperature at which the reaction occurs, or conducting the experiment without polishing wires. Experiments should be designed to test only one variable at a time. See the Solutions Manual.

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