

# Magnesium Metal Ribbon

## Limiting Reagents and Limiting Nutrients



### Introduction

The reaction of magnesium metal ribbon and hydrochloric acid is used to illustrate and clarify the related concepts of limiting reagents and limiting nutrients. Simple and inexpensive, this activity can be adapted as a teacher demonstration or class activity.

### Concepts

- Limiting reagents
- Limiting nutrients
- Stoichiometry

### Materials

Magnesium metal ribbon, Mg, approximately 65 cm  
Hydrochloric acid, HCl, 3 M, 42 mL  
Balloons, 4 to 7 inches in diameter, assorted colors, 8

Test tubes, Pyrex®, 16 × 150 mm, or 18 × 150 mm, 8  
Test tube rack to hold at least eight tubes  
Scissors and ruler

### Safety Precautions

*Hydrochloric acid is highly toxic by ingestion and inhalation and severely corrosive to skin and eyes. Highly flammable hydrogen gas is produced but is produced in very small volumes. Magnesium metal ribbon is a flammable solid, keep away from open flames. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.*

### Procedure

The setup for this activity is as follows:

	Tube #	3 M HCl (mL)	Mg Ribbon (cm)		Tube #	3 M HCl (mL)	Mg Ribbon (cm)
Group 1	1	5	4	Group 2	5	2	6
	2	5	8		6	4	6
	3	5	12		7	6	6
	4	5	16		8	10	6

1. Label eight test tubes numerically, 1 through 8, and arrange them in two groups of four in a test tube rack.
2. Fill the tubes with the indicated volumes of 3 M hydrochloric acid.
3. Trim eight pieces of magnesium metal ribbon to the indicated lengths. Fold each piece to a size that will fit into the neck of a balloon. Fold the cut ends of each piece of magnesium metal ribbon inward to avoid puncturing the balloon.
4. Place the folded pieces of ribbon into eight balloons—keeping them arranged according to activity setup.
5. Here's the tricky part. Stretch the necks of each of the Group 1 balloons over the mouths of the appropriate test tubes. Do not allow the ribbon pieces to drop into the test tubes at this time. Since the balloon will naturally drape over and down the side of the tube, this shouldn't be a problem.
6. With all Group 1 balloons in place, lift the balloons up to allow the ribbon to drop into the tube. Make sure the magnesium drops into the acid and that the neck of the balloon stays firmly in place on the tube.
7. The reaction will be vigorous and immediate. In the tubes with the larger pieces of ribbon, the frothing may force the ribbon upwards in the tube. Tap the base of the tube on a resilient surface to force the ribbon back down into the acid solution. The tubes will get hot so take care and handle them near their lips, or with a clamp.
8. When all of the Group 1 test tubes have completely reacted, record all relevant observations. Note the relative sizes of the expanded balloons and whether or not any unreacted magnesium remains in any of the tubes.
9. Repeat steps 5 through 8 for the Group 2 tubes. Invite the students to predict the outcome of Group 2 based on their

Group 1 observations.

## Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Hydrochloric acid solution can be disposed of according to Flinn Disposal Method #24b.

## Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

***Unifying Concepts and Processes: Grades K–12***

Systems, order, and organization

Evidence, models, and explanation

***Content Standards: Grades 9–12***

Content Standard A: Science as Inquiry

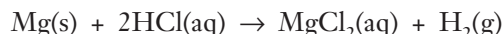
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

## Tips

- It is recommended that the balloons be manually inflated (i.e., blown up) prior to the activity to stretch and condition them. Using different colors of balloons increases the overall visual impact of the activity.
- Fold the magnesium ribbon into a small ball so it does not stick inside the balloon.
- To determine the number of moles of magnesium available for each reaction, mass a long length of magnesium ribbon and use a conversion factor (g/in) to calculate the mass of each piece.

## Discussion

The reaction taking place in this activity is:



Technically, a *limiting reagent* is defined as the reactant that directly determines (limits) the amount of product that may be formed. An appropriate food analogy might be the pizza maker who has enough cheese for 20 pizzas and enough dough and other ingredients for 30 pizzas. The amount of cheese will determine the number of pizzas produced—20! The cheese is the “limiting ingredient.”

In biological systems, the term *limiting nutrient* is often encountered. In lakes and ponds, for example, phosphorus is usually the nutrient that directly limits primary production (growth of plants, algae, and phytoplankton). All other essential elements (nitrogen, sunlight, etc.) are normally present in abundance. Adding phosphorus to a biological system will generally stimulate an immediate increase in production. This is analogous to giving the pizza maker more cheese.

In Group 1, the amount of hydrogen gas evolved in each test tube is directly proportional to the length of magnesium ribbon added. In each tube, all of the magnesium is consumed. Magnesium is the limiting reagent in Group 1 since there is approximately 15 mmol of HCl and a maximum of 6 mmol of Mg. In Group 2, each balloon will expand equally—again in direct proportion to the length of ribbon—and the magnesium in each tube is fully consumed. Magnesium is again the limiting reagent. (Tube 5 has 6 mmol HCl and 2.3 mmol of Mg).

In all eight tubes, magnesium is the limiting reagent. Had there been magnesium ribbon left, unreacted, in any of the tubes, then the hydrochloric acid would have been the limiting reagent. This could be accomplished by reducing the volume of acid, reducing the concentration of acid, or increasing the length of the magnesium metal ribbon.

Materials for *Magnesium Metal Ribbon* are available from Flinn Scientific Inc.

Catalog No.	Description
H0034	Hydrochloric Acid Solution, 3 Molar, 500 mL
M0139	Magnesium Metal Ribbon, 12.5 g, (60 ft)
M0001	Magnesium Metal Ribbon, 25 g, (120 ft)

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.