

# Properties of Acids and Bases

## Lab 52

Text reference: Chapter 18

### Introduction

Acids and bases are common chemicals in everyday life. Many products—from shampoos to fruit juices, from medicines to cleaning agents—derive much of their usefulness from their activity as acids or bases. Acids can be classified as substances that ionize in aqueous solutions to produce hydronium ions,  $\text{H}_3\text{O}^+$ . Acids react with metals to produce hydrogen gas and turn litmus paper red. Bases can be classified as substances that dissociate in aqueous solutions to produce hydroxide ions,  $\text{OH}^-$ . Bases turn litmus paper blue and feel slippery. The strengths of acids and bases depend on the extent to which they ionize, or dissociate. Strong acids or bases dissociate almost completely, while weak acids or bases dissociate to a lesser degree.

In this investigation you will observe some reactions of acids and bases with each other, with other compounds, and with various indicators. From your observations, you should be able to describe some of the characteristic properties of acids and bases.

### Pre-Lab Discussion

Read the entire laboratory investigation and the relevant pages of your textbook. Then answer the questions that follow.

1. What is an acid? \_\_\_\_\_  
\_\_\_\_\_
2. What is a base? \_\_\_\_\_  
\_\_\_\_\_
3. What is an indicator? What indicators will you be using in this experiment? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
4. Write balanced chemical equations for the reactions that occur when the following solutions are mixed:
  - a.  $\text{HNO}_3(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow$  \_\_\_\_\_
  - b.  $2\text{HCl}(\text{aq}) + \text{Ca}(\text{OH})_2(\text{aq}) \rightarrow$  \_\_\_\_\_
5. What safety precautions need to be observed when handling acids and bases? \_\_\_\_\_  
\_\_\_\_\_

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6. For what gas is the reaction product being tested in Step 8? Step 10? \_\_\_\_\_
7. Give an example of each of these reactions from the investigation:
- a. neutralization \_\_\_\_\_
- b. double replacement \_\_\_\_\_

## Problem

How do you observe the properties of acids and bases?

## Materials

chemical splash goggles	zinc (Zn)
laboratory apron	magnesium ribbon (Mg)
latex gloves	iron filings (Fe)
marking pen	copper wire or sheet (Cu)
well plate	5 test tubes, 18 × 150 mm
hydrochloric acid (HCl), 3.0 M and 1.0 M	test-tube rack
acetic acid (HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ), 1.0 M	wooden splint
sodium hydroxide (NaOH), 0.5 M	match
litmus paper, red and blue	rubber stopper, 1-hole, fit with right-angle bend glass tubing
pH paper	limewater
phenolphthalein	calcium carbonate (CaCO <sub>3</sub> )
microspatula	2 micropipets





## Safety



Wear your goggles and lab apron at all times during the investigation. Acids are corrosive and bases are caustic; avoid contact with skin or clothing. Wash spills and splashes with plenty of cold water. Note the caution alert symbols here and with certain steps of the Procedure. Refer to page *xi* for the specific precautions associated with each symbol.


## Procedure

### Part A: Using Indicators



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 Put on your goggles and lab apron. Add five drops of each of the following solutions to separate labeled depressions in the well plate: 1.0 M HCl; 1.0 M HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>; 0.5 M NaOH. **CAUTION:** Handle solutions with care. Acids are corrosive and bases are caustic. They can cause serious injury if they come into contact with skin or eyes. Wash spills and splashes with plenty of water.
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 Place a drop of each solution onto a piece of red litmus paper. Record your observations in Data Table 1. Discard the litmus paper in a solid waste container.

3. Repeat Step 2, using blue litmus paper and then pH paper. Record your observations.
4. Add one drop of phenolphthalein to each solution. Record your observations. Discard the solutions by rinsing them down the drain with plenty of water. Rinse the well plate with water and dry.


**Part B: Reactions of Acids with Metals**

5. To four separate, clean, labeled depressions in your well plate, add a small piece of zinc, magnesium, iron, and copper.
-  6. To each of these depressions, add enough 1.0 M HCl to cover the metal. Observe and compare the relative speed of reaction of the metals with the acid. Record your observations in Data Table 2.
7. Repeat Steps 5 and 6, using clean wells but substituting 1.0 M acetic acid ( $\text{HC}_2\text{H}_3\text{O}_2$ ) for 1.0 M HCl. Compare the reactivity of each metal with  $\text{HC}_2\text{H}_3\text{O}_2$  to its reactivity with HCl. Record your observations. Discard the contents of the well plate by putting the metals into a solid waste container using the microspatula and rinsing the solutions down the drain. Rinse and dry the well plate.
8. Add a small amount of zinc to a depression in your well plate. Cover the zinc with 1.0 M HCl. As the reaction proceeds, hold an inverted test tube over the zinc for about two minutes. Without turning the test tube upright, quickly insert a burning splint into the test tube. Record your observations. Discard the contents of your well plate as you did in Step 7. Clean and dry the well plate.

**Part C: Reactions of Acids with Carbonates**


-  9. Put on your latex gloves. Half fill a clean test tube with lime-water solution. Into a second test tube, place a small amount of calcium carbonate ( $\text{CaCO}_3$ ). Obtain from your teacher a rubber stopper with a right-angle bend of glass tubing.
-  10. Add enough 3.0 M HCl to cover the  $\text{CaCO}_3$ . **CAUTION:** *Acids are corrosive. They can cause serious injury if they come into contact with skin or eyes. Wash spills and splashes with plenty of water.* Insert the rubber stopper into the test tube containing  $\text{CaCO}_3$  and HCl. Place the open end of the glass tubing into the lime-water. Record your observations. Discard the solutions and place any leftover  $\text{CaCO}_3$  into the solid waste container. Clean the test tube.

**Part D: Neutralization**

-  11. Using a micropipet, add ten drops of 1.0 M HCl to a clean test tube. Add one drop of phenolphthalein. Test with pH paper. Record your observations.
12. Using a second micropipet, add 0.5 M NaOH to the acid, one drop at a time. After the addition of each drop, swirl the test tube to thoroughly mix the contents. Count and record the total

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number of drops of NaOH needed to cause a permanent color change. Once the color change is observed, test the solution again with pH paper. Record your results. Pour the solution down the drain and clean the test tube.

-  13. Clean up your work area and wash your hands before leaving the laboratory.

## Observations

**DATA TABLE 1** Reactions with Indicators

Solution	Red litmus	Blue litmus	pH paper	Phenolphthalein
1.0 M HCl				
1.0 M HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>				
0.5 M NaOH				

**DATA TABLE 2** Speed of Reaction with Metals

Metal	1.0 M HCl	1.0 M HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>
zinc		
magnesium		
iron		
copper		

Test results with burning splint: \_\_\_\_\_

Test results with limewater: \_\_\_\_\_

pH of acid solution: \_\_\_\_\_

Number of drops of 0.5 M NaOH added: \_\_\_\_\_

pH of neutral solution: \_\_\_\_\_

## Critical Thinking: Analysis and Conclusions

1. For each metal that reacted with HCl, write a balanced chemical equation. (*Interpreting data*)

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2. For each metal that reacted with  $\text{HC}_2\text{H}_3\text{O}_2$ , write a balanced chemical equation. (*Interpreting data*)  
\_\_\_\_\_  
\_\_\_\_\_
3. List the reactivity of the metals in decreasing order (fastest to slowest). (*Making comparisons*) \_\_\_\_\_
4. Explain the difference in reaction rates of a given metal with the two different acids. (*Drawing conclusions*) \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
5. Explain the differences in volumes (number of drops) of HCl and NaOH required to produce a neutral solution in Part D. (*Making comparisons*) \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Critical Thinking: Applications

1. Describe the type of reaction that occurs between certain metals and an acid. (*Applying concepts*) \_\_\_\_\_  
\_\_\_\_\_
2. What is the effect of acid rain on statues made of marble (calcium carbonate)? (*Making inferences*) \_\_\_\_\_  
\_\_\_\_\_
3. Based on your data, write a brief paragraph summarizing some properties of acids and bases. (*Using the writing process*) \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Going Further

1. Research the effects of acid rain on lakes. Find out the impact of increased acidity on living organisms in a lake. Report on how acid rain is neutralized in some lakes by natural processes or human intervention.
2. Design an experiment to test the effects of acidic and basic soils on plant growth.