Suggested time allotment: 5 to 6 hours

MODULE 4

ACIDS AND BASES

In Module 1, you identified common properties of solutions using different methods. You learned how to report the amount of the components in a given volume of solution. You also found out that not all solutions are liquid. Some of them are solids and others are gases. Towards the end of the module, you investigated the factors that affect how fast a solid dissolves in water.

In Module 3 you learned about compounds. In Module 4 you will study a special and important class of compounds called acids and bases. Examples of acids are acetic acid in vinegar and citric acid in fruit juices. The solution used for cleaning toilet bowls and tiles is 10-12% hydrochloric acid. It is commonly called *muriatic acid*. These acids in these mixtures make the mixtures acidic. We can say the same about bases and basic solutions. An example of a base is sodium hydroxide used in making soaps and drain cleaners. Sodium hydroxide is also called *lye* or *caustic soda*. A common drain cleaner used in most homes in the Philippines is called *sosa.* Another base is aluminum hydroxide used in antacids. The bases in these mixtures make the mixtures basic.

In this module you will investigate the properties of acidic and basic mixtures using an **indicator,** a dye that changes into a specific color depending on whether it is placed in an acidic solution or in a basic one. Aside from knowing the uses of acidic and basic mixtures, you will also find out the action of acid on metals and think of ways to reduce the harmful effects of acids. Knowing the properties of acids and bases will help you practice safety in handling them, not only in this grade level, but in your future science classes.

How acidic or basic are common household materials?
Does water from different sources have the same acidity?
What is the effect of acid on metals?

Activity 1

How Can You Tell if a Mixture is Acidic or Basic?

How will you know if a mixture is acidic or a basic? In this activity, you will distinguish between acidic and basic mixtures based on their color reactions to an indicator. An **indicator** is a dye that changes into a different color depending on whether it is in acid or in base. There are many indicators that come from plant sources. Each indicator dye has one color in an acidic mixture and a different color in a basic mixture. A common indicator is ***litmus***, a dye taken from the lichen plant. Litmus turns red in acidic mixtures and becomes blue in basic mixtures.

You will first make your own acid-base indicator from plant indicators available in your place. This is a colorful activity. You may select a local plant in your community. You can use any of the following: violet eggplant peel, purple *camote* peel, red *mayana* leaves or violet *Baston ni San Jose*. These plant materials contain anthocyanins. These plant pigments produce specific colors in solutions of different acidity or basicity.

In this activity, you will:

1. Prepare a plant indicator from any of the following plants: violet eggplant peel, purple *camote* peel, red *mayana* leaves or violet *Baston ni San Jose;* and

2. Find out if a given sample is acidic or basic using the plant indicator.

TAKE CARE!

It is dangerous to taste or touch a solution in order to decide if it is acidic or a basic.

Part A. Preparation of Indicator*

In this part of Activity 1, you will prepare a plant indicator that you will use to determine if a given sample is acidic or a basic.

*University of the Philippines. National Institute for Science and Mathematics Education Development (2001). *Practical work in high school chemistry: Activities for students.* Quezon City: Author, pp. 29-33.

Materials Needed

- 1 pc mature, dark violet eggplant or camote leaves of *Mayana* or *Baston ni San Jose*
- alum (*tawas*) powder
- sharp knife or peeler
- small casserole or milk can
- plastic egg tray or small transparent plastic cups
- brown bottle with cover
- alcohol lamp
- tripod

Procedure

1. Peel an eggplant as thin as possible. (You may also use the skin of purple *camote* or the leaves of red *mayana or Baston ni San Jose.)*

   Cut the materials into small pieces and place in a small casserole or milk can. You may keep the flesh of the eggplant or *camote* for other purposes.

2. Add about ⅓ to ½ cup tap water to the peel depending on the size of the eggplant or *camote* used. Boil for 5 minutes. Stir from time to time.

3. Transfer the mixture into a bottle while it is still hot. There is no need to filter, just remove the solid portion. The mixture may change if left in open air for more than 5 minutes.

4. Immediately add a pinch (2-3 matchstick head size) of alum (*tawas*) powder into the solution or until the solution becomes dark blue in color. Stir well while still hot. This is now the indicator solution.

Note*: Alum will stabilize the extract. The extract will be more stable with alum but it is recommended that the solution be used within a few days. Keep the extract in the refrigerator or cool dark place when not in use.*

Part B. Determining the acidity or basicity of some common household items

In this part of the activity, you will find out if a given household material is acidic or basic using the plant indicator you have prepared in Part A.

Materials Needed

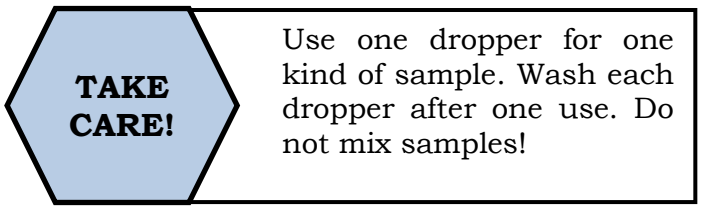
- plant indicator prepared in Part A
- vinegar
- distilled water
- tap water
- baking soda
- baking powder
- calamansi
- Other food/home items with no color:
  (toothpaste, shampoo, soap, detergent, fruit juice like buko juice, sugar in water, soft drink)
- 2 plastic egg trays or 12 small plastic containers
- 6 droppers
- 6 plastic teaspoons
- stirrer (may be teaspoon, barbecue stick or drinking straw)

Procedure

1. Place one (1) teaspoon of each sample in each well of the egg tray.

2. Add 8-10 drops (or ½ teaspoon) of the plant indicator to the first sample.

Note: If the sample is solid, wet a pinch (size of 2-3 match heads) of the solid with about ½ teaspoon of distilled water.



3. Note the color produced. Record your observations in column 2 of Table 1.

Table 1. Acidic or basic nature of household materials

Sample	Color of indicator	Nature of sample
calamansi		
tap water (water from the faucet)		
Distilled water		
vinegar		
sugar in water		
baking soda		
baking powder		
soft drink (colorless)		
coconut water (from buko)		
toothpaste		
shampoo		
soap		

4. Repeat step number 1 of Part B for the other samples.

5. Determine the acidic or basic nature of your sample using the color scheme below for eggplant or *camote* indicator and record the nature of each sample in Table 1.

   Strongly acidic: red to pale red
   Weakly acidic: blue
   Weakly basic: green
   Strongly basic: yellow

Part C. Determining the acidity or basicity of water from different sources

In this part of Activity 1, you will find out how acidic or basic the samples of water from different sources are.

Materials Needed

At least one cup water from each of the following sources of water:

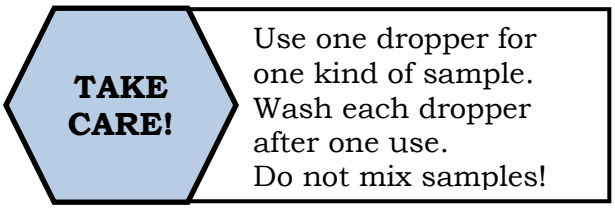
- plant indicator prepared in Part A
- rainwater
- river, lake or stream
- pond
- canal
- faucet
- deep well or hand pump
- bottled water (mineral water) or distilled water
- 2 plastic egg trays or 8 small plastic containers
- 6 droppers
- 6 plastic teaspoons

Procedure

1. Place one (1) teaspoon of each sample in each well of the egg tray.

2. Add 8-10 drops (or ½ teaspoon) of the plant indicator to the first sample.

Note: If the sample is solid, wet a pinch (size of 2-3 match heads) of the solid with about ½ teaspoon of distilled water.



3. Note the color produced. Record your observations in column 2 of Table 2.

Table 2. Acidic or basic nature of water from different sources

Water sample from source	Color of indicator	Nature of sample
rainwater		
river, lake or stream		
Pond		
Canal		
water from faucet		

4. Determine the acidic or basic nature of your sample using the color scheme below for eggplant or *camote* indicator and record the nature of each sample in Table 2.

   Strongly acidic: red to pale red
   Weakly acidic: blue
   Weakly basic: green
   Strongly basic: yellow

You can now operationally distinguish between acidic and basic mixtures using plant indicators. More than that, using the plant extract you have prepared allowed you to further determine the degree of acidity or basicity of a mixture, that is, you were able to find out how strongly acidic or basic the mixtures were. It should now be clear to you that the samples you used in Activity 1, Parts B and C are not called acids nor bases but rather these samples may have either acids or bases in them which make them acidic or basic.

Another method can be used to distinguish acidic from basic mixtures. It is through the use of the pH scale, which extends from 0 to 14. The pH scale was proposed by the Danish biochemist S.P.L. Sorensen. In this scale, a sample with pH 7 is *neutral.* An *acidic* mixture has a pH that is less than 7. A *basic* mixture has a pH that is greater than 7. In general, the lower the pH, the more acidic the mixture and the higher the pH, the more basic is the mixture.

It is useful for you to know the pH of some samples of matter as shown in Table 1 and illustrated in the pH scale drawn in Figure 1.

Table 3*. The pH values of some samples of matter

Sample of Matter	pH
Gastric juice	1.6-1.8
Lemon juice	2.1
Vinegar (4%)	2.5
Softdrinks	2.0-4.0
Urine	5.5-7.0
Rainwater (unpolluted)	5.6
Milk	6.3-6.6
Saliva	6.2-7.4
Pure water	7.0
Blood	7.4
Fresh egg white	7.6-8.0
Seawater	8.4
Laundry detergents	11
Household bleach	12.8
Drain cleaner	13.0

*Adapted from: Hill, J. W. & Kolb, D. K. (1998). *Chemistry for changing times*, 8th ed., p. 187.

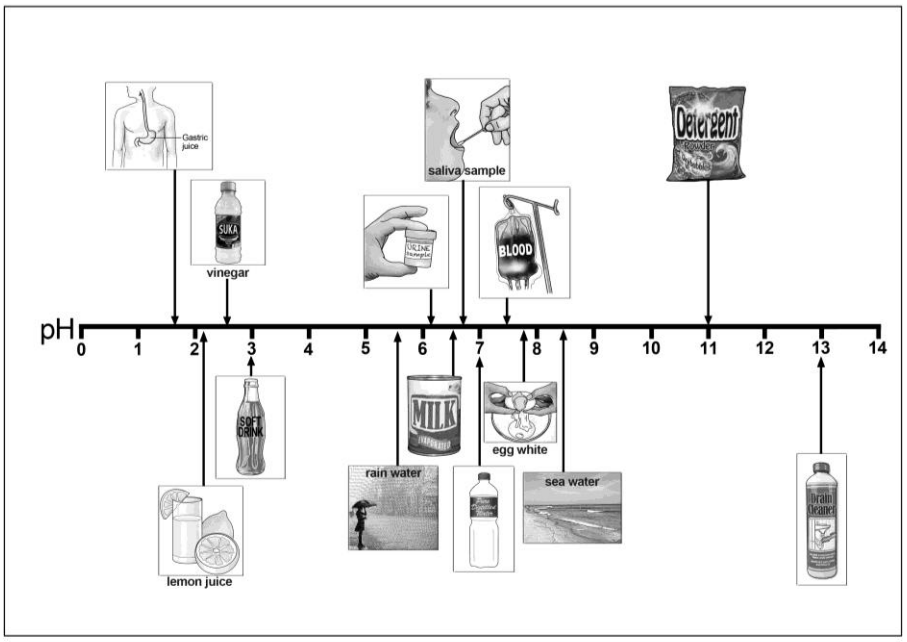


Figure 1. The pH values of some samples of matter.

Activity 2
Color Range, pH Scale!

In this activity, you will use the results in Activity 1, Parts B and C, to determine the pH of the solutions you tested. Use the following pH scale for eggplant indicator to determine the pH of the common mixtures you tested in Activity 1. Present your results in a table similar to Table 4.

The eggplant indicator shows the following color changes.

pH 1 2 3 4 5 6 7 8 9 10 11 12 13 14
red/ pale/ red blue /green /yellow

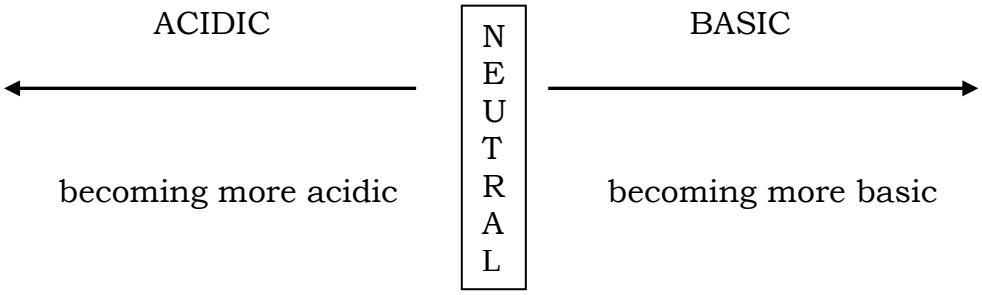


Table 4. pH of samples from Activity 1

Sample	pH based on eggplant/*camote* indicator	Acidic or Basic

Now that you are aware of the pH of some common mixtures, why do you think is it important to know about pH? The following facts give you some information on how pH affects processes in the body and in the environment, as well as in some products you often use.

Importance of pH

pH and the Human Body

Acids and bases perform specific functions to balance the pH levels in the body. When your body has too much carbon dioxide, the blood becomes too acidic. You breathe slowly. Breathing is slowed to increase the pH in the blood. If pH in the body is too basic, you will hyperventilate to lower the pH. This acid and base control is an important part of biological homeostasis (balance) in humans. In fact, human life is sustained only if the pH of our blood and body tissues is within a small range near 7.4.

Use of pH in Food Processing and Fruit Preservation

During food processing, pH is closely followed. Changes in pH affect the growth of microorganisms, which cause food spoilage. Most bacteria grow best at or near pH 7. To prevent the growth of harmful bacteria, pickling is an effective food preservation method because it lowers pH.

The control of pH is also needed in wine and jam preparation. A few species of bacteria grow in a basic medium of pH 9-10. This is the pH range of stale eggs. Most molds grow within the pH range of 2- 8.5. In acidic conditions, many fruits and products made from fruits are easily attacked by molds unless the fruits are properly protected.

Control of pH in Soil

The pH of soil is very important. Some plants grow well in acidic soil while others prefer basic soil. Farmers need to know the pH of their soil since plants will only grow in a narrow pH range. The pH also affects how much nutrients from the soil become available to plants.

Most plants in the Philippines grow in acidic soils. These plants are banana, *kaimito*, durian, pineapple, soybean, coffee, eggplant, squash, *kamote*, and rice. Other plants like grapes and *pechay* require basic soils. Some plants grow best in almost neutral soil like orange, peanut, watermelon, beans, cabbage, tomato, corn garlic, and onion.

pH of Rainwater

The average pH of rain is 5.6. This slightly acidic pH is due to the presence of carbon dioxide in the air. In many areas of the world, rainwater is much more acidic, sometimes reaching pH 3 or even lower.

Rain with a pH below 5.6 is called "acid rain." The acidic pollutants in the air that come from the burning of fuels used in power plants, factories, and vehicles produce gases which are acidic. These gases enter the atmosphere and dissolve in water vapor in the air. Some acid rain is due to natural pollutants like those from volcanic eruptions and lightning.

Maintaining pH of Personal Care Products

Most personal care products have pH kept at specific levels to avoid harmful effects on the body. This is true for hair products. For example, at pH 12, hair already dissolves, that is why hair removers usually have pH of 11.5 to12. Most shampoos are within the pH range of 4 to 6. This is because the pH of the product must be compatible with that of the hair, which is in the range pH 4 to 5. Hair is least swollen and is strongest at this pH range. But very often, using shampoo leaves the hair basic. So, in order to avoid eye irritation and stinging, shampoos for infants and children have a pH similar to that of tears (pH 7.4).

Hair has a protective covering called sebum. The use of conditioners after using shampoo puts back this oily coating and penetrates the hair shaft itself.

You may look up other references to learn more about the importance of knowing about pH.

Now that you have discussed with your teacher the importance of keeping the proper pH in the human body, in food processing and food preservation, in farming and in personal care products, it is also essential that you know the effects of acids on some common metals. An important property of acids is their tendency to react with certain metals. At higher grade levels, you will learn that the nature of the metal determines how it is affected by specific types of acid. However, in this grade level, you will simply investigate the effect of an acid on a common metal like iron.

Effect of an Acidic Mixture on Metal

What do you think will happen when an acid and a metal come in contact with each other? What happens after the metal has been in contact with the acid for some time? What changes take place?

In Activity 3, you will investigate the effect of an acid on a common metal like iron. In Module 1, you have learned that vinegar is about 5% acetic acid. You will be using vinegar in this investigation since it is safe to

handle and easily available. Vinegar will simply be an example that can show the action of an acidic solution when it comes in contact with a metal. There are other acids that affect metals but you will learn about them in Grades 8 and 9.

Activity 3
What Happens to a Metal when Exposed to an Acidic Mixture?

Objective

In this activity, you will find out the effect of an acidic mixture, like vinegar, on iron.

Materials Needed

- 3 pieces, small iron nails (about 2.5 cm long)
- 1 cup white vinegar (with 4.5 to 5 % acidity)
- 3 small, clear bottles or 100 mL beaker
- 1 cup water
- 2 droppers

Procedure

1. Prepare a table similar to the one below.

Setup	Observations		
	After one day	After 2 days	After 3 days
Iron nail (1)			
Iron nail (2)			
Iron nail (3)			

2. Clean and wipe dry all the iron nails and the bottles.

3. Place **one piece** of the iron nail in each bottle.

Q1. Why do you think are there three different bottles for each sample of iron nail?

4. Put two to three drops (just enough to barely cover the sample) of vinegar on top of the iron nail in each bottle.

5. After adding vinegar to all samples, put aside the bottles where you can observe changes for three days.

6. Write your observations after one day, two days, and three days on the data table in step #1.

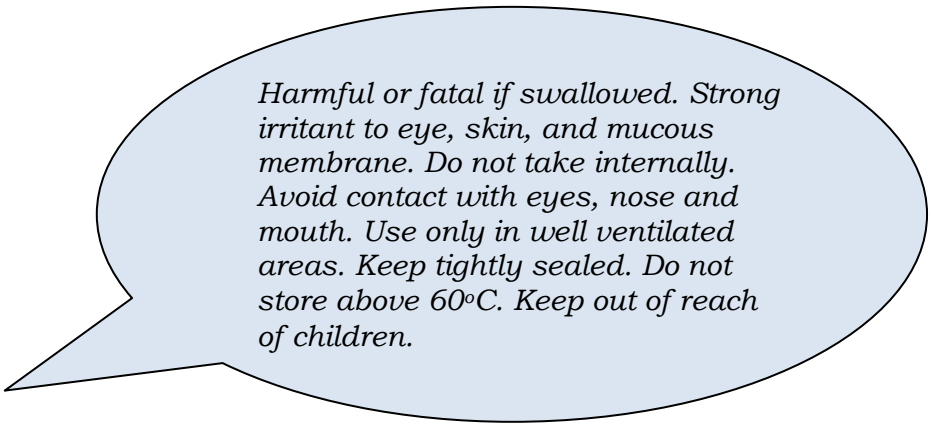
Q2. At the end of three days, describe completely what happened to each sample.

Q3. Give explanations for the results you have observed.

You have observed the action of vinegar, an acidic mixture, on metal such as iron in Activity 3. Do you think other types of acidic mixtures act in the same way with other metals? What about other types of materials? You will learn a lot more about the action of acids on metal and on different types of materials in Grades 8 and 9.

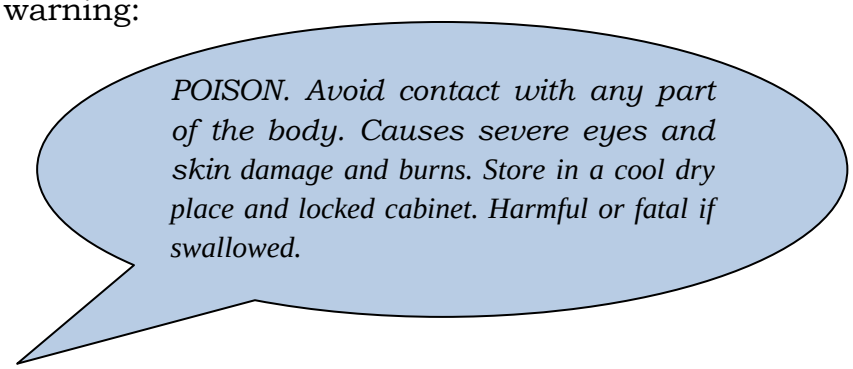
Safety in Handling Acids and Bases

Now that you know the properties of acidic and basic mixtures, you can handle them carefully. Acids and bases with high concentrations can cause serious burns. For example, hydrochloric acid (commonly called muriatic acid) is used in construction to remove excess mortar from bricks and in the home to remove hardened deposits from toilet bowls. Concentrated solutions of hydrochloric acid (about 38%) cause severe burns, but dilute solutions can be used safely in the home if handled carefully. You can find the following caution in a bottle of muriatic acid:



Acidic mixtures can easily "eat away" your skin and can make holes in clothes. However, since vinegar is only 5% acetic acid, it will not irritate the skin and destroy clothes.

Sodium hydroxide (commonly called lye or liquid *sosa)* is used to open clogged kitchen and toilet pipes, sinks, and drains. Its product label shows the following warning:



For your safety, you should make it a habit to read product labels before using them. It is also important to know the proper way of storing these products, as shown in the label of liquid *sosa*.

What happens when acids and bases combine?

Look back at the pH color chart of Activity 2. You will find a pH value that is not acidic or basic. Mixtures that are not acidic or basic are called ***neutral***. When an acid mixes with a base, water and salt are produced. Such a process is called **neutralization**.

If a basic mixture is added to an acidic mixture, the resulting mixture will no longer have the properties of the acidic mixture. In the same way, if enough acidic mixture is added to a basic mixture, the properties of the basic mixture are changed. This is because the acid and the base in each of the mixtures neutralize each other to produce a mixture with a different set of properties.

The process of neutralization has some uses in everyday life. The following are some examples:

- ***Treating indigestion.*** The acid in our stomach, gastric juice, is hydrochloric acid with low concentration. It helps in the digestion of food. If we eat too much food, the stomach produces more acid which leads to indigestion and pain. To cure indigestion, the excess acid must be neutralized by tablets called antacids. These contain bases to neutralize the excess acid in the stomach.
- ***Using toothpaste to avoid tooth decay***. Bacteria in the mouth can change sweet types of food into acid. The acid then attacks the outermost part of the tooth and leads to tooth decay. Toothpaste contains bases that can neutralize the acid in the mouth.

- ***Treating soil.*** You will recall in the earlier part of this module that some plants grow well in acidic soil while others prefer basic soil. Farmers need to know the pH of their soil. Most often, the soil gets too acidic. When this happens, the soil is treated with bases such as quicklime (calcium oxide), slaked lime (calcium hydroxide) or calcium carbonate. The base is usually spread on the soil by spraying.

- ***Treating factory waste.*** Liquid waste from factories often contains acid. If this waste reaches a river, the acid will kill fish and other living things. This problem can be prevented by adding slaked lime (calcium hydroxide) to the waste in order to neutralize it.

After completing this module, you learned about the properties of acidic and basic mixtures. You can now prepare indicators from plants anytime you need to use them. You are more aware of the use of the pH scale, which will become more helpful as you study science in higher grade levels. You now recognize the importance of knowing the acidity or basicity of common mixtures we use, as well as the relevant uses of the process of neutralization.

References and Links

Brady, J.E. & Senese, F. (2004). *Chemistry: Matter and its changes*, 4th edition. River Street Hoboken, NJ: John Wiley & Sons, Inc

Bucat, R.B. (Ed.) (1984). *Elements of chemistry: Earth, air, fire & water*, Volume 2. Canberra City, A.C.T., Australia: Australian Academy of Science.

Bucat, R. B. (Ed.) (1983). *Elements of chemistry: Earth, air, fire & water,* Volume 1. Canberra City, A.C.T., Australia: Australian Academy of Science.

Burns, R. A. (1999). *Fundamentals of chemistry, 3rd edition.* Upper Saddle River, N.J. Prentice-Hall, Inc.

Elvins, C., Jones, D., Lukins, N., Miskin, J., Ross, B., & Sanders, R. (1990). *Chemistry one: Materials, chemistry in everyday life.* Port Melbourne, Australia: Heinemann Educational Australia.

Gallagher, R. & Ingram, P. (1989). *Co-ordinated science: Chemistry.* Oxford, England: Oxford University Press.

Heffner, K. & Dorean, E. (n.d.) Must it rust? The reaction between iron and oxygen. Retrieved Feb 16, 2012 from http://www.haverford.edu/educ/knight-booklet/mustitrust.htm

Heyworth, R. M. (2000). *Explore your world with science discovery 1*. First Lok Yang Road, Singapore. Pearson Education South Asia Pte Ltd.

Hill, J.W. & Kolb, D.K. (1998). *Chemistry for changing times*, 8th edition. Upper Saddle River, NJ: Prentice Hall.

Philippines. Department of Education. (2004). Chemistry: Science and technology textbook for 3rd year. (Revised ed.). Quezon City: Author.