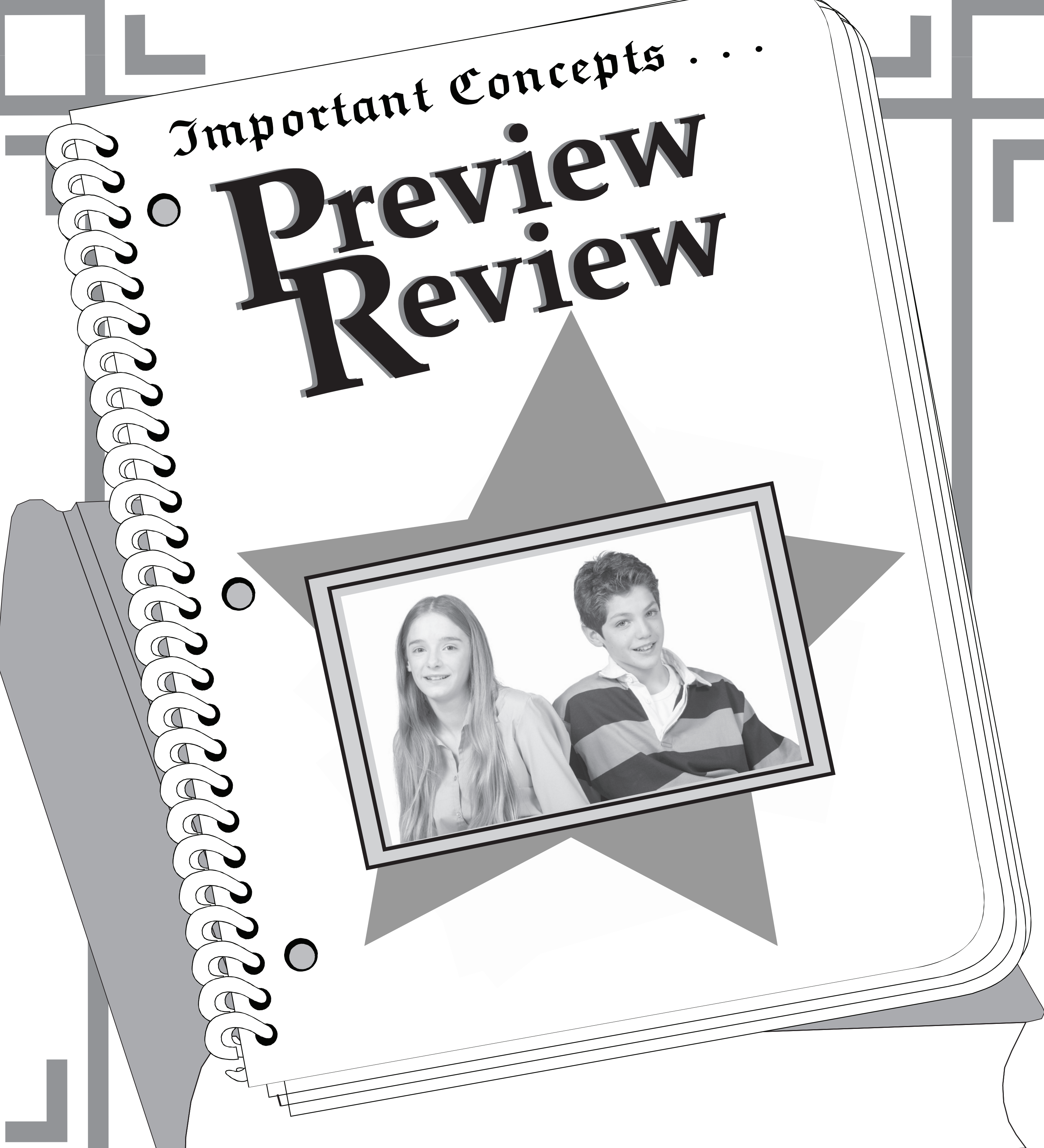

Science Grade 9 TEACHER KEY

W3 - Lesson 4: Biological and Chemical Monitoring/Acids and Bases

V5-07

Important Concepts of Grade 9 Science

Materials Required

Textbook:
Science in Action 9

Science Grade 9
Version 5
Preview/Review W3 - Lesson 4 TEACHER KEY

Publisher: Alberta Distance Learning Centre
Author: Nicole Bondarchuk
In-House Reviewer: Barb Philips

Project Coordinator: Dennis McCarthy
Preview/Review Publishing Coordinating Team: Nina Johnson, Laura Renkema, and Donna Silgard

The Alberta Distance Learning Centre has an Internet site that you may find useful. The address is as follows: **http://www.adlc.ca**

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Preview/Review Concepts
for
Grade Nine Science

TEACHER KEY

W3 - Lesson 4:
Biological and Chemical Monitoring/
Acids and Bases

OUTLINE

By the end of this lesson, you should

- identify biological indicators of water quality
- identify chemical factors that affect water quality
- explain pH, acids, and bases
- identify how acidity can affect an aquatic environment

GLOSSARY

heavy metals - metals that have a density of 5 g / cm^3 or higher (e.g., copper, zinc, lead, mercury, cadmium, nickel); heavy metals are one type of substance monitored to determine water quality

neutralization - reaction between an acid and a base that produces water and a compound called a salt.

parts per million (ppm) - a measurement used to describe very small concentrations of chemicals; a solution having a concentration of 1 ppm has one part of solute per million parts of solution

pH - measure of the percent of hydrogen ions in a solution; most solutions have a pH in the range of 0 to 14; 0 is very acid, 14 is very basic, and 7 is neutral

toxicity - the degree to which a substance is poisonous

W3 - Lesson 4: Biological & Chemical Monitoring/Acids & Bases

How long do you think you could live without water? If the weather is not too hot and dry, we can survive for about 4 or 5 days without water. Water is vital to the life of all organisms. What is present in the water is, therefore, important to know. This lesson is about biological and chemical indicators of water quality and how pH relates to water quality.

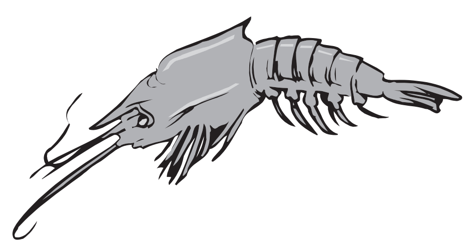
Biological Monitoring of Water

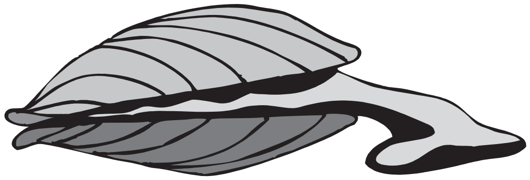
Water is very important for everyone's survival. Water quality must be monitored for it to be safe for human and animal consumption. One of the ways water quality is monitored is by investigating biological organisms living in the water.

One of the first things that scientists look at is the types of bacteria found in the water. The presence of certain bacteria (such as *Escherichia coli – E. coli*) in the water can cause health problems in humans. A small sample of water is taken and the number and types of microscopic organisms are identified.

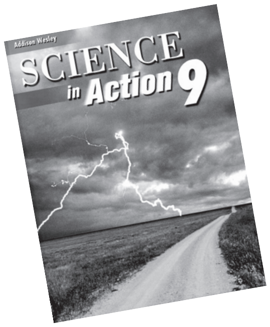
The second type of organisms scientists look for is aquatic invertebrates in the water. An **invertebrate** is an animal without a backbone. Certain invertebrates are adapted to living in good water while others are adapted to living in poor quality water.

Insects, shrimp, worms, and clams are some examples of organisms found in a body of water. A body of water that contains a wide variety of organisms is probably a healthy ecosystem. A small variety of organisms living in a body of water indicate a poor aquatic ecosystem.





Read pages 213-215 of *Science in Action 9*.



1. How does an increase in acidity affect the organisms living in a body of water?

   An increase in acidity decreases the number of organisms living in a body of water.

2. Identify two other factors that affect the type of organism living in a body of water.

   Water temperature and pH affect the type of organisms living in a body of water.

3. What are the five categories of water use?

   -Human drinking water

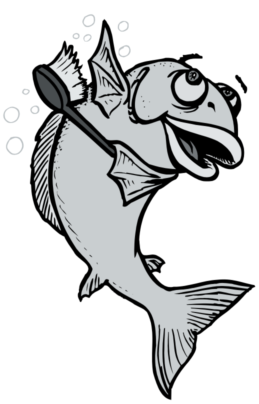
   -Recreation such as swimming

   -Livestock and wildlife drinking water

   -Irrigation

   -Protection of aquatic life

Chemical Factors that affect Water Quality

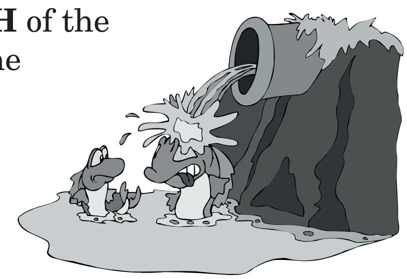


Along with looking at the types of organisms living in the water, scientists measure chemical factors. The concentration of chemicals is measured in parts per million (ppm) or milligrams per litre (mg/L).

The most important chemical factor for the survival of fish and other aquatic organisms is the amount of dissolved oxygen in the water. That level depends on the temperature of the water, turbulence in the water, the amount of photosynthesis by plants and algae in the water, and the number of organisms using the oxygen in the water. Most aquatic organisms need at least 5 ppm of dissolved oxygen to survive.

According to figure 2.4 on page 217 of *Science in Action 9*, organisms such as mayflies, stoneflies, and beetles begin to disappear at about 6 ppm of dissolved oxygen. Midge larvae and worms can survive at 2 ppm of dissolved oxygen.

The second chemical factor tested is the presence of nitrogen and phosphorus in the water. Nitrogen and phosphorus are fertilizers that enter bodies of water through surface runoff. The addition of these chemicals to the water causes an increase in plant growth. As the plants die, they increase the food source for bacteria. The population of bacteria increases, and then uses up dissolved oxygen in the water.



The third chemical factor tested is the **pH** of the water. The pH measures the acidity of the water. A pH of 7 is neutral; below 7 is acidic, and above 7 is basic. Rain mixed with chemicals (such as sulfur dioxide) can produce acid rain, which makes aquatic bodies of water more acidic. As the acidity of the water increases, plant and animal life in the water decreases. **Spring acid shock** dramatically lowers the pH of the water and can affect small fish and the eggs that fish lay.

Read pages 217-220 of *Science in Action 9*.

4. Identify the types of organisms that can survive in an aquatic body of water with a level of 4 ppm of dissolved oxygen.

   Freshwater shrimp, midge larvae, and worms can survive in a level of 4 ppm dissolved oxygen.

5. What happens to fish species in an ecosystem that has a very high amount of bacteria? Explain your answer.

   The fish will probably die. A high amount of bacteria consume valuable dissolved oxygen in the water so not enough dissolved oxygen is available to support fish species.

6. What are the initial sources of nitrogen and phosphorus in an aquatic body of water?

   Sewage outfalls and runoff from fertilized fields are initial sources of nitrogen and phosphorus.

7. Explain spring acid shock and how it affects young fish and fish eggs.

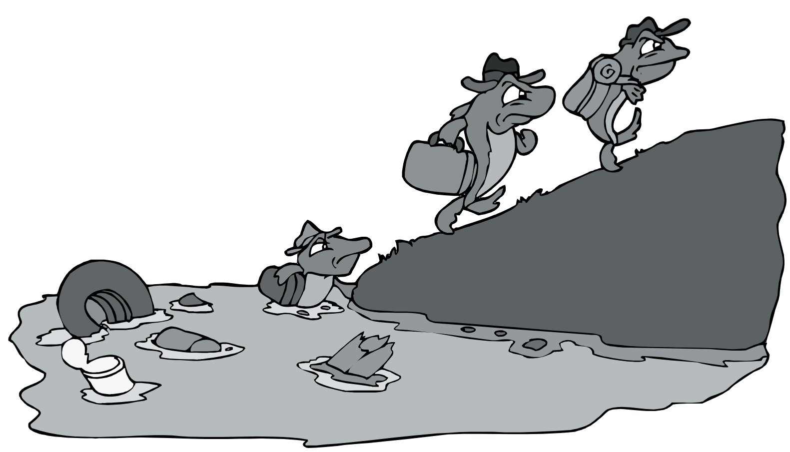
   Snow and ice containing acid precipitation melts quickly causing the pH of the water to lower rapidly (become acidic). This prevents fish eggs from hatching and may kill young fish.

8. Look at the invertebrate table on page 223 of *Science in Action 9*. Rate the sites identified from those having a high dissolved oxygen level to those having a low dissolved oxygen level.

   Refer to Fig 2.4 on page 217

   Site 4 – highest dissolved oxygen level

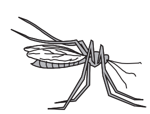
   Site 1 –
   Site 3 –
   Site 2 – lowest dissolved oxygen level

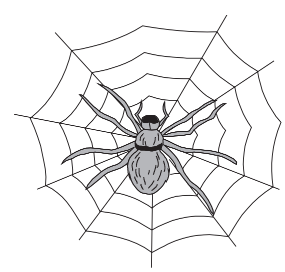


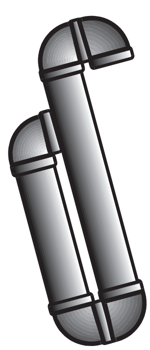
More Chemical Factors

The fourth chemical test for water identifies the presence of pesticides. A **pesticide** is a chemical used to kill pests. **Herbicides** kill weeds. **Insecticides** kill insects. **Fungicides** kill fungi. Any chemicals applied to the land end up in the water through surface runoff. One of the main concerns about pesticides in the water is that insects exposed to them become resistant to them. Pesticides can also accumulate in body tissue. This happens when they are fat-soluble and are stored rather than released in the urine, for example. Several pesticides mixed together can form a poisonous substance. **Toxicity** describes the extent a substance poisonous.

A **toxin** is a substance that can cause serious health problems in or death of an organism. Scientists use the measurement **LD50** to describe toxicity. LD50 is the amount of a substance that is a lethal dose for 50% of the test subjects. LD testing is often done on rats and mice. How the substance is delivered to the test subject is also recorded.







The last chemical test of this lesson determines the presence of heavy metals. A **heavy metal** is a substance that is five times heavier than an equal volume of water. A list of heavy metals includes mercury, copper, lead, zinc, cadmium, and nickel. These substances are very toxic to a large number of organisms. For example, symptoms of mercury poisoning include numbness of arms and legs, nerve damage, and brain damage. Normally, heavy metals are not easily available to enter plants and animals. However, some environmental conditions can cause heavy metals to be present in water bodies. For example, acidic water can dissolve lead from pipes.

Read pages 221-222 of *Science in Action 9*.

9. Explain why pesticides produced today are not as harmful as those produced in the past.

   Pesticides produced today are designed to last only one growing season and are broken down by bacteria to become non-toxic. Pesticides in the past remained more than one growing season.

10. Identify the LD50 of caffeine. What do the units of this number mean?

    192 mg/kg

    This is the amount of caffeine in milligrams per kilogram of body mass that can kill an organism.

11. Why is lead harmful to children? Where can lead come from?

    Lead can cause permanent brain damage in children. It can come from lead pipes, gasoline, and paints containing lead, etc.

12. How do most people get exposed to mercury?

    by eating contaminated fish

Acids, Bases, & pH

Have you ever tasted lemon juice? Besides the fact that it tastes sour, lemon juice is also very acidic. An **acid** is a compound that dissolves in water to form a solution with a pH lower than 7. The pH scale is a measure of the concentration of hydrogen ions in a solution. It rates the acidity of a substance. Lemon juice has a pH of about 2.0.

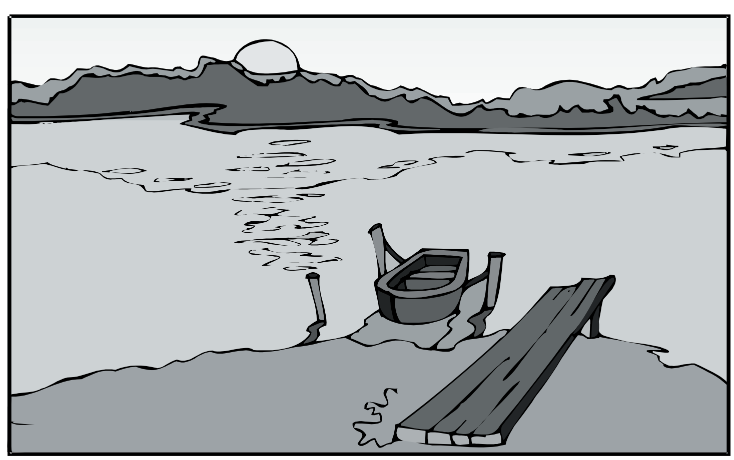
Look at Figure 1.10 on page 191 of *Science in Action 9*. It shows the pH scale. A pH of 7 is neutral (neither an acid nor a base). Anything lower than a pH of 7 is considered to be acidic. Anything higher than 7 is considered to be basic. Each number on the pH scale increases or decreases by a factor of 10.

The pH of a substance can be measured in two ways. A pH meter can be placed in a solution to indicate the pH of a substance. The second way pH can be measured is through an acid-base indicator.

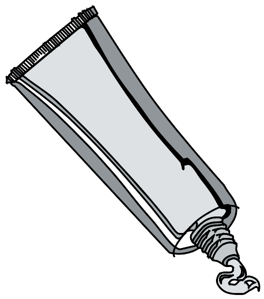
One type of indicator is litmus paper. Red litmus paper turns blue when exposed to a base. Blue litmus paper turns red when exposed to an acid. A second type of acid-base indicator is a universal indicator. After drops of the indicator solution are added, a clear fluid changes colour. The specific colour is then compared to a wide range pH chart to determine the fluid's pH.

If an acid is spilled accidentally, the solution can be cleaned up by adding a base to it. This causes a **neutralization reaction** that brings the two substances to a neutral pH of 7. A neutralization reaction always produces at least a salt and water as end products.

A body of water that is acidic due to acid rain can be returned to a neutral pH by adding a basic substance such as lime (calcium hydroxide).



Read pages 191-195 of *Science in Action 9*.



13. Find the pH of the following substances using the pH scale on page 191 of *Science in Action 9*.

   a. vinegar ***2.2***

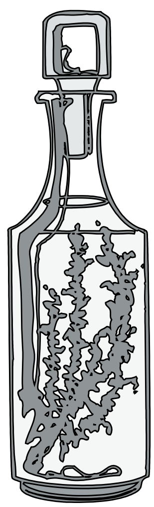
   b. toothpaste ***10***

   c. milk ***6.0***

   d. normal rain ***5.6***

   e. drain cleaner ***13.8***

   f. stomach acid ***1.0***



14. Imagine you are given an unknown solution and a piece of blue and red litmus paper. Explain how you could identify whether the solution was an acid or a base.

   If you dip blue litmus paper in the solution and it turns red, the solution is an acid. If it stays blue the solution is a base. If you dip red litmus paper in the solution and it turns blue, the solution is a base. If it says red, the solution is an acid.

15. Give an example of a word and chemical equation of a neutralization reaction. ***Answers will vary.***

hydrochloric acid + sodium hydroxide sodium chloride + water

$HCl_{(aq)} + NaOH_{(aq)} \quad NaCl_{(s)} + H_2O_{(l)}$

or

calcium hydroxide + sulfuric acid calcium sulfate + water

$Ca(OH)_{2(aq)} + H_2SO_{4(aq)} \quad CaSO_{4(s)} + 2\,H_2O_{(l)}$

Internet Websites

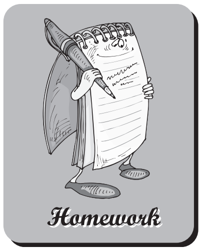
The addresses for the websites below were valid at the time of printing.

http://www.ec.gc.ca/water_e.html

http://www.cotf.edu/ete/modules/waterq3/WQintermpuzzle.html

http://pbskids.org/zoom/kitchenchemistry/virtual-start.html

http://www.miamisci.org/ph/default.html



Homework

Here are some pH/acids & bases experiments you can try at home.

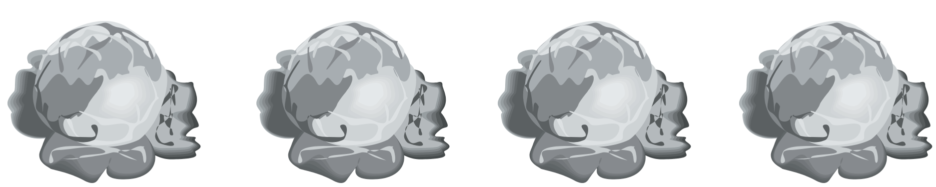
16. Make a cabbage juice pH indicator:

    a. Cut up a quarter of a head of red cabbage.
    Boil 1 cup water in a saucepan.
    Add cut up cabbage to boiling water and remove from heat.
    Let the solution stand for 30 minutes.
    Strain the liquid from the solution and discard the cabbage pieces.
    You now have your indicator solution.

    b. Test the pH of a variety of solutions (such as vinegar, lemon juice, soda pop, baking soda, etc.).
    Add a small amount of each solution to a clear glass.
    Add 1 or 2 drops of the cabbage indicator solution.
    Record your results based on the following pH scale.

Cabbage Indicator Scale

red					rose	purple		blue			green		yellow
1	2	3	4	5	6	7	8	9	10	11	12	13	14



17. Make a neutralization reaction.

    Fill a glass half full of water.
    Colour the water with food colour.
    Add 2 teaspoons baking soda, 2 tablespoons sugar, and 2 tablespoons lemon juice.
    Record your observations.
    Have a taste!
    Try to explain what happened.

    The solution should start bubbling. When the acid (lemon juice) and base (baking soda) reacted, gas ($C0_2$) was produced.

18. Write a secret message.

    Find a blank piece of white paper.
    Write a message on the paper using a Q-tip dipped in lemon juice.
    Hold the paper up to a light bulb. (Be careful with the heat source!)
    Describe what happens.
    Try to explain what happened.

    The message becomes visible (brown). The paper turned brown in a chemical reaction wherever the acid was present due to exposure to heat.