MiSP CHEMICAL REACTIONS, L3
Teacher Guide

Introduction

This weeklong unit should be included with other chemistry content teaching and learning. It is designed to follow Intermediate Level Science Core Curriculum Performance Indicator 3.1 and instruction about atomic theory, but it could be modified to precede that topic. It would be helpful but not vital for students to understand that higher temperatures produce greater atomic and molecular motion.

It should be kept in mind that students are not expected to gain an in-depth knowledge of chemical kinetics and collision theory. That will occur in high school.

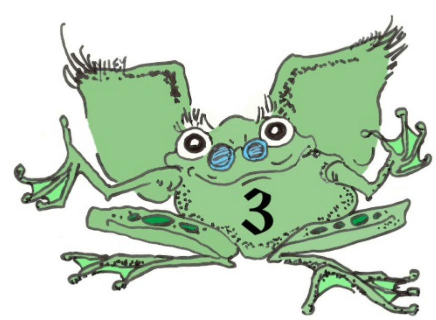
Standards

ILST Core Curriculum — Major Understandings:
Standard 4 Physical Setting 3.2a, 3.2c, 3.2e, 3.3d, 4.3a

Lesson Objectives:

After completing this unit, students will be able to:

- Compare and contrast physical and chemical changes
- Describe evidences of chemical change
- Model that new substances are formed in a chemical reaction when bonds are changed and atoms are rearranged
- Create and interpret a graph showing the effect of temperature on the rate of cooking
- Conduct an experiment that compares the rates of reaction at different temperatures AND/OR different concentrations
- Graph and interpret experimental results: the effect of temperature AND/OR different concentrations on a chemical reaction
- Determine the unit rate of change in rates of reaction at different temperatures AND/OR different concentrations (L2)
- Calculate the formulas for segments of the temperature / rate of reaction graph AND/OR concentration / rate of reaction graph, and use those formulas to calculate rate of reaction at different temperatures AND/OR concentrations (L3).



Day 1 — Physical and Chemical Change

Define *chemical change* and *physical change* and use simple demonstrations to show that, in the first kind of change, there is no new substance, and in the second, one or more new substances may be formed. Be aware of the common misconception that physical change does not involve energy. Stress that phase changes are physical changes and they occur due to heat being added to or removed from the substance.

Simple demonstrations include tearing paper, melting ice, evaporating alcohol, sanding wood, burning a match, reacting an iron nail with copper sulfate solution, and combining 6 M hydrochloric acid with magnesium. Choosing which reactions to show will be based on the instructor's experience and comfort with different demonstrations.

Use molecular models to show how physical and chemical changes are different at the molecular level. Water (H_2O) is simple to use. Make several water molecules and show how they remain H_2O when they are in the solid, liquid, or gas states. Then show the molecules breaking down to hydrogen and oxygen, and show that bonds break and rearrange when two hydrogen molecules react with one oxygen molecule to form H_2O.

Hands-on experience with a chemical reaction (which may also be demonstrated) is described in the GEMS guide *Chemical Reactions* (Lawrence Hall of Science)
[see http://www.lawrencehallofscience.org/gems/GEM320.html]. Although it is outside the scope and sequence of this unit, teachers may want to use the guide for a significant (and fun) study of chemical reactions.

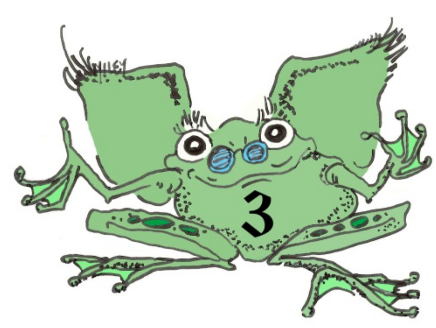
CHEMICAL CHANGE: OBSERVING SUBSTANCES IN A BAG

Introduction:

Chemical change occurs when one or more substances produce one or more new substances that have different chemical properties.

There are several things that *may* indicate that a chemical change has occurred. For example, heating, cooling, production of a gas, a different odor, and precipitation may occur when a chemical change occurs. The only sure indicator is chemical or other analysis that proves that a new substance has been produced.

Many things happen in this experiment, and there are three different substances at the start of the reactions. So, which ones are reacting, which ones are involved with which changes, and what happens if one or more of the substances is not included?



Materials (amounts are for 30 students doing the experiment two to three times):

- Ziplock bags — one-quart (1 L) size — at least one per group
- Baking soda (sodium bicarbonate)1.5 lbs/750 g
- Calcium chloride — 3 lbs/1.5 KG
- Plastic spoon — two per group or several per baking soda and calcium chloride distribution points
- Plastic stir sticks (coffee stirrers or wooden splints) — two per group or several per baking soda and calcium chloride distribution points — to level the teaspoon measurements
- Phenol red indicator solution or red cabbage juice — 4 L to 5 L
- Medicine cups — one per group (other small containers, like film canisters, bottle tops, or pill vials, may be used)
- Graduated cylinders or other liquid measuring device for the phenol red or cabbage juice

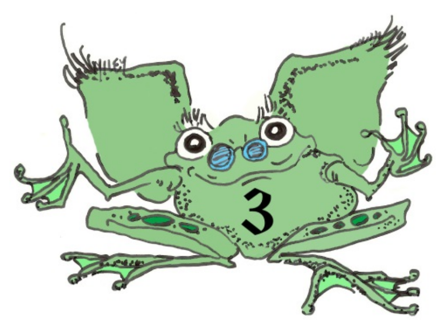
Safety notes: GOGGLES SHOULD BE WORN. Safe handling of chemicals and how to smell a chemical safely should be discussed.

Procedures: If time is limited, the bags may be set up before class begins but it is best for the students to do all the steps.

- ☐ Get a ziplock bag and open it.
- ☐ Observe the three chemicals to be used in the experiment. Write descriptions of each.
- ☐ Add one level measuring spoon of baking soda to the bag.
- ☐ Add two level measuring spoons of calcium chloride to the bag.
- ☐ Put 10 ml of phenol red solution into the medicine cup.
- ☐ Carefully place the medicine cup in the bottom of the bag (standing upright).
- ☐ Being careful not to spill the phenol red solution, squeeze the air out of the bag and seal it.
- ☐ Tip the medicine cup of phenol red and let it mix with the other two chemicals.
- ☐ Observe what happens. Write down your observations.

Explanation:

Calcium chloride, baking soda, and water combine to produce carbon dioxide gas. Calcium chloride and water produce heat. Besides carbon dioxide, the other products of the reaction are sodium chloride (table salt) and calcium carbonate (chalk). Phenol red is an acid base indicator. It is red when neutral or in the presence of a base. It turns yellow in the presence of an acid. The cabbage juice similarly detects a pH change (green – base, purple – neutral, pink – acid).



Suggested Questions and Ideas for Further Study:

1. What evidence is there that there was a chemical reaction? [*A new substance, a gas (carbon dioxide), is produced. Students may also detect a different odor after the reaction.*]
2. Are all three substances necessary to produce the carbon dioxide? [*A series of experiments will show that the phenol red is not needed. It is the water in the solution that is necessary. Also, if you have water with a low pH, you may get a production of carbon dioxide when the water reacts with just the baking soda.*]
3. Why does the phenol red change to orange or even red after the bag is opened? [*The* CO_2 *(when mixed with water) produces an acid. When the bag is opened, the carbon dioxide escapes and the water solution's pH increases.*]
4. Is the reaction (are the reactions) exothermic or endothermic? [*exothermic*]
5. What chemicals caused the heat? [*the calcium chloride and the water*]

Question of the Day:

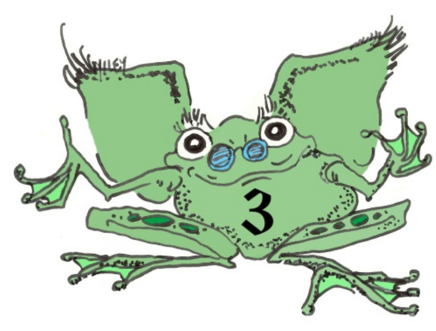
What are some of the chemical reactions that humans want to occur and what are some of the chemical reactions that we do not want to occur?

Day 2 — How Temperature Affects Cooking Temperatures

Some work from day 1 may roll over to day 2. *Students should work on Chemical Reactions Worksheet #2 — Hot News About Baking Potatoes.*

Question of the Day:

The making and baking of bread involves adding yeast to flour and other ingredients. The yeast is alive and does a series of chemical reactions called "fermentation," which produces a gas — carbon dioxide (CO_2) — that makes the bread rise (get airy and light, filled with air bubbles). Most bread recipes instruct the baker to put the bread dough in a warm place to rise. Why?



Days 3 and 4 — Temperature and Rate of Reaction AND/OR Concentration and Rate of Reaction Lab *(Teachers may choose either lab or, if time allows, do both labs.)*

Temperature and Rate of Reaction procedure notes:

This lab gives more reliable results than the concentration lab.

The water at the three different temperatures must be measured and added to the film canister, the Alka-Seltzer quarter-tab must be dropped in, and the lid must be put on very quickly so that the water temperature is close to its expected value.

It is important that the Alka-Seltzer tabs be divided into four equal segments. This has been relatively successfully done with a razor blade and hammer.

Concentration and Rate of Reaction procedure notes:

The laboratory was modified (in July 2011) to be a reaction between baking soda (0.3 g) and the three concentrations of vinegar.

In both labs, the expected results should produce a straight line. Since there are only three data points and varied results are expected from middle school–age experimenters, a class average would help to “smooth out” the data. Regardless, a best-fit line should probably be utilized.

If the data is unacceptable, the teacher should select one of the two line segments (temperature — cold to room temperature *or* room temperature to hot; concentration — 25%–50% *or* 50%–75%) for levels 2 and 3 analysis.

Day 5

Administer the assessment: *MiSP Chemical Reactions Assessment L3*.