

# Chemistry

Dr. Dave's Teaching Manual

Second Edition

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# Introduction

This manual will give you, the teacher, everything you need to teach a unit on chemistry. From the first topic to the last class, it describes how to set up teaching presentations so that they are dynamic, exciting, and meaningful for students. You will see how easy it is to prepare for classes, and you will discover that this teaching approach allows students to experience real learning and real academic success.

Science is a wonderful topic to teach to children. Instead of lecturing for long periods or bogging students down with an avalanche of worksheets, this manual shows you how to make your presentations interesting and challenging to the mind of a child. This is easy to do—once you know how to do it. Children already possess a natural curiosity for science. This manual shows you how to take advantage of their curiosity and to present lessons in a way that creates an exciting learning environment in your classroom.

This manual describes easy teacher demonstrations that use basic materials such as playdough, marshmallows, candles, and paper towels. Most of them take only minutes to set up. Show the students atoms made of playdough as you teach about balancing chemical equations, or display a browning apple as you teach about rust. Take advantage of the students' interest in trick birthday candles as you teach about combustion. You can be sure that the students will be watching you as you launch a cork using a vinegar and baking soda reaction.

Following the teacher presentations, you can run various student activities at levels that are appropriate for your students' abilities. This manual is flexible, and there are many opportunities for integration of core subjects. A unit on chemistry offers opportunities for students to conduct experiments in which they explore the characteristics of rust and tarnish, as well as cabbage juice and other acid-base indicators. In addition, you can choose from many demonstrations, visual projects, experiments, group projects, and research projects.

This unit is naturally rich in physical science topics. As students learn about the reaction between vinegar and baking soda, they will learn about the Law of Conservation of Mass. This manual will show you how to teach about solutions, balancing chemical equations, the pH scale, and the separation of colored substances by chromatography.

This manual also offers suggestions for assessment and shows examples of exemplary student work. In addition, it provides tips on classroom management, critical-thinking questions, modifications, clean-up, and safety. The Teacher Resources section contains a variety of downloadable worksheets that you can use as homework or as in-class assignments; these are available from the Royal Fireworks Press website ([rfwp.com](http://rfwp.com)). Many of the images in this book can be projected for the students to see and will help them to understand and internalize the concepts being taught; these are available for download as well.

Children are a unique audience, and teaching science to children can be a wonderful and exciting experience. By following this manual, you will learn how easy it is to harness the enthusiasm and interest that children have for science and to direct that energy so that real learning is happening in your classroom. My wish is that this book allows you and your students to experience together the joys of science.

# Physical and Chemical Changes

## Objectives

- Students will compare and contrast physical changes and chemical changes.
- Students will be able to identify physical and chemical changes.

## Key Points

- No new substances are formed after a physical change.
- Mixing two substances, such as sand and iron filings, is an example of a physical change.
- The change in the state of water into a solid, liquid, or gas is an example of a physical change.
- Most physical changes are reversible.
- A chemical change occurs when a new substance is formed.
- Some chemical changes are irreversible, while others are reversible.
- The reaction between vinegar and baking soda is an example of a chemical change.
- Bromothymol blue turns color when added to certain chemicals.

## Vocabulary Terms

Physical Change

Chemical Change

## Teacher Demonstration: Physical Changes

Inform the students that there are two kinds of changes that they will be learning about during the course of this unit: *physical changes* and *chemical changes*.

A key characteristic of physical changes is that no new substances are formed after the change takes place. A simple demonstration to illustrate this concept is to take some playdough and mold it into another shape. Ask the students how the playdough has changed. Point out that while the shape has changed, the substance itself is still the same. The playdough is still playdough. Nothing new has been formed. For another example, rip a piece of paper into smaller pieces. Even though the paper is smaller, it is still paper.

Changes in the state of matter are also physical changes. Water provides the best example of this. Hold an ice cube in your hand, and point out how the solid is melting into a liquid. The substance is still water; only its phase has changed. Nothing new has been formed. Whether it is melting, freezing, evaporating, or condensing, it is still the same substance: water.



Have the students record their results in a table like the one below. Tell the students that recording the results is an important part of the scientific method. The students could either make their tables by hand using a ruler or create one on a computer.

What Happens?	
Chemicals	Observations
Baking Soda + BTB	Stays blue
Calcium Chloride + BTB	Stays blue, gets warmer
Effervescent Tablet + BTB	Bubbles, turns yellow
Baking Soda + $\text{CaCl}_2$ + BTB	Bubbles, turns milky yellow
Vinegar + BTB	Turns yellow
Baking Soda + Vinegar + BTB	Lots of bubbles, turns yellow, gets colder

*Teaching Tip: It's never too early for students to learn the molecular formulas for some of the more common substances used in the study of chemistry. Calcium chloride is a good example of this. Identify this substance as  $\text{CaCl}_2$ .*

To extend this activity, visual learners could create a drawing to express what they observed during this activity. The drawings should be labeled and should describe the students' observations. Students can also write a paragraph about their observations using descriptive words.

### Student Activity: Identifying Physical and Chemical Changes

Have the students complete a worksheet in which they identify various physical and chemical changes. See pages 62-63 in the Teacher Resources section of this manual for the downloadable worksheet and an answer key.

Next, point to the bottom part of the projected image, or write the following generalized equation on the board:



Tell the students that A and B in this equation represent atoms. Identify A and B as the *reactants* of this reaction—the substances you start with. These react together to produce the new substance, AB, which is the *product* of the reaction.

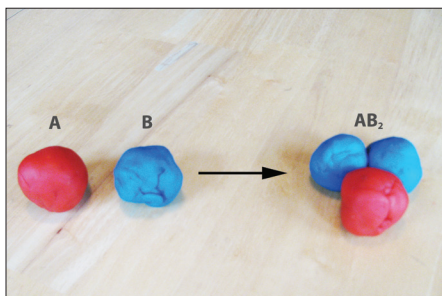
In the vinegar and baking soda reaction, the vinegar and the baking soda are the reactants, and carbon dioxide is the product. Here is another way of expressing this reaction that may help the students understand this concept:



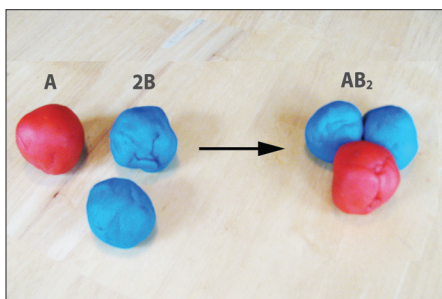
Explain to the students that when two or more atoms combine, they make a molecule.

## Teacher Demonstration: Chemical Equations

A key concept that the students need to understand about chemical equations is that there must be the same number of atoms on both sides of an equation. This rule is a law of physical science: matter cannot be created or destroyed. Thus, the number of atoms on one side of an equation must equal the number of atoms on the other side. Playdough is an excellent substance to use to help the students understand this important concept.



Show the students two different-colored balls of playdough to represent atoms A and B (for example, atom A is red playdough, and atom B is blue playdough). Tell them that these “atoms” are going to react together to make AB<sub>2</sub>. Show the students the finished product—AB<sub>2</sub>—so that the playdough makes an equation. Then ask, “What else do we need to make a molecule of AB<sub>2</sub>?” The answer, of course, is another B atom. Impress upon the students that this is key to understanding chemical equations. Whatever is created in a chemical reaction needs to have the same number of atoms as what reacts to form the reaction in the first place.



Take another ball of B atom playdough, and place it with the A and B atoms on the left side of the equation. Then project or write the equation so that the students can see it, making sure to emphasize that the number of atoms is the same on both sides.



## Teacher Demonstration: Bunsen Burners and Stove Burners

If you happen to have a Bunsen burner in your classroom, light it, and describe how it is another example of a flammable gas reacting with oxygen in a combustion reaction. Methane is the gas found in most Bunsen burners, although some are fueled by propane or butane. If you don't have a Bunsen burner, then turn the discussion to gas stoves.



Many of the students will have gas stoves at home, although some will not be aware that there are two types of stoves: gas and electric. The fuel for gas stoves is propane. Describe how modern gas stoves create an electric spark to ignite the gas when you turn the stove on. Project the image of the gas stove flame at right for the students to see.



## Fire Extinguishers and Fire Safety

The fact that fire needs oxygen to burn is the basis for carbon dioxide fire extinguishers. Explain to the students that the typical fire extinguisher works by smothering a fire in either dry chemicals or carbon dioxide, thus preventing oxygen from reaching the fuel of the fire. Showing the students how to discharge a fire extinguisher makes an impressive demonstration. If you are able and have a fire extinguisher available, take the students outside, and show them how it works. Alternatively, perhaps you could get the local fire department to come to class, give a presentation on fire safety, and demonstrate how to use a fire extinguisher.



A meaningful homework assignment is to have the students find out if they have a fire extinguisher in their home. If so, have them note the location and the reading on the gauge. Many of the students will be unaware that most fire extinguishers have a gauge that indicates whether or not the device is full. Of course, stress that fire extinguishers are not toys; they are devices to be used in an emergency.

*Technology Integration:* Search the internet using the keywords “fire extinguisher” and “video” to find websites that show how to extinguish a fire using a common fire extinguisher.

## Teacher Demonstration: Combustion of Iron Filings

Show the students the combustion of iron filings by sprinkling them over a candle flame. As the small pieces of iron burn, they produce a spark that is reminiscent of a 4th of July sparkler. In fact, you can tell the students that sparklers are made by coating a thin piece of metal with iron (and other metals). Sparkling like this when ignited is a chemical property of iron.

*Fact:* Sparklers that produce colored sparks are made by coating the thin wire with other chemicals, such as copper and barium.



*Art Integration: Pure iron oxide (rust) is widely used as a pigment in paints, ceramics, plastics, concrete, and many other materials. Painters such as Rembrandt, da Vinci, and Michelangelo all used iron-oxide paints. Iron oxide was also used by early humans in primitive cave drawings. If you have iron-oxide paint, the students could create their own paintings that mimic cave paintings.*

## The Economic Impact of Rust

Because rust commonly corrodes the iron and steel that is present in metal structures, it often breaks those structures down over time. Some of the students probably will have seen old or abandoned automobiles rusting (project the first image below to show this). The rusting of iron is also a serious problem on railroads and bridges, particularly old bridges.

The steels used to make modern cars are more resistant to rust because they are coated with zinc, a process known as *galvanizing*. Zinc provides a protective coating over the steel and prevents water, salt, and oxygen from coming into direct contact with it.

Whenever a bridge collapses, rusting is a prime suspect for the cause. The collapse of the Silver Bridge over the Ohio River in 1967 in Point Pleasant, Ohio, was attributed to the corrosion of steel and the gradual weakening of the structure over time. Corrosion was also first thought to play a role in the collapse of the I35 bridge over the Mississippi River in Minneapolis in 2007. Project the images at right to give the students a sense of this disaster.

However, sometimes the obvious answer isn't the correct answer. The bottom image shows a corroded piece of steel from the I35 bridge. The release of this image early in the investigation of this collapse led many people to believe that corrosion was the cause, although the collapse was ultimately attributed to a design flaw in the bridge. Use this as a lesson to teach the students the importance of not jumping to conclusions before considering all of the evidence.



Kevin Rofidal, U.S. Coast Guard



National Transportation Safety Board



## Teacher Demonstration/Student Activity: Erupting Volcanoes

The best thing about the vinegar-baking soda reaction is that children love to see it. This reaction is the basis of the erupting volcano—a popular entrant at elementary science fairs, in which the foam produced from the reaction simulates lava flowing out of an erupting volcano.

The typical method of building a volcano involves molding some dough or clay around a plastic water bottle. Once the clay is dry, load the volcano with baking soda. Drop in some red food coloring, pour in the vinegar, and watch the eruption.

*Activity Tip: Add a small amount of detergent to the volcano before you add the vinegar to produce more bubbles in the eruption. Remember to place the volcano in a container or on a plastic plate to collect the overflowing liquid.*

You can do this as a teacher demonstration, or you can let the students build their own volcanoes. For a simpler version of this activity, simply have the students combine the ingredients in plastic cups.

*Technology Integration: The students may be interested in searching the internet for the “largest baking soda and vinegar volcano.”*



## Teacher Demonstration/Student Activity: Blowing Up a Balloon

This is a classic demonstration in which the reaction between vinegar and baking soda is used to fill a balloon full of carbon dioxide. When performing this for the students as a teacher demonstration, it is best to scale it up—use a large bottle with a 12-inch balloon. If you choose to do this as a student activity, it may be more convenient to use smaller plastic bottles. The reaction can even be scaled down and performed in test tubes, with smaller balloons secured over the tops of the tubes, although this setup is not as exciting to watch.

Explain to the students that the reaction between vinegar and baking soda happens too quickly to try to place the balloon on the bottle after you add the two substances to it. The trick is to fill the balloon with baking soda before securing it over the opening of the container, which already contains vinegar. Stretch the mouth of the balloon over the top of the bottle without spilling any. When you're ready, lift the balloon up, and allow the baking soda to flow into the bottle. The balloon will begin to inflate almost instantly.

*Safety Tip: Make sure that you and the students wear safety goggles during this activity.*



# Water, Solubility, and Solutions

## Objectives

- Students will understand that substances can dissolve in water.
- Students will define the terms *solute*, *solvent*, and *solution*.

## Key Points

- Many substances can dissolve in water.
- Water dissolves more substances than any other liquid.
- Dissolving salt in water is an example of a physical change, not a chemical change.
- Solubility is the ability of a substance to be dissolved.
- The solute is the substance that is being dissolved.
- The solvent is the liquid that the solute is dissolved in.
- A solution is a mixture of a solute and a solvent.
- Solutes can be solids, liquids, or gases.
- Hard water contains a lot of minerals, while soft water contains few.
- Distilled water contains no minerals.

## Vocabulary Words

Dissolve	Solubility	Solute	Solvent	Solution
Mineral	Hard Water	Soft Water	Distilled Water	Residue

## Start the Class

Show the students a beaker of water, and explain that water is a special liquid. Water can do things that few other liquids can do. Display a container of sugar, and sprinkle a few crystals into the water. Then take a spoon, and start stirring. Point out that the solid sugar crystals are disappearing.

As you continue mixing, tell the students that the sugar is dissolving in the water and that this is a special property of water. The fact that water can contain other substances is a key concept for the students to understand. Describe how the sugar has disappeared to the eye but is still in the clear liquid. Identify this as an example of a physical change, as neither the sugar nor the water has permanently changed.



## Student Activity: Identifying Water Samples

For this activity, the students will place samples of different kinds of water on slides. They will then identify which water sample is which based on the characteristics of the *residue* that is left behind after evaporation.

Prepare four water samples by setting out a cup of distilled water, a cup of tap water, a cup of salt water, and a cup of sugar water. Label the cups A-D. Place a dropper in each cup. Also set out several glass slides.

*Materials Tip: Although plastic slides are safer, they just don't work as well as glass slides. Tell the students to be careful with the glass slides.*

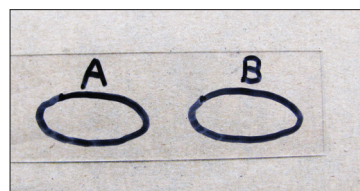
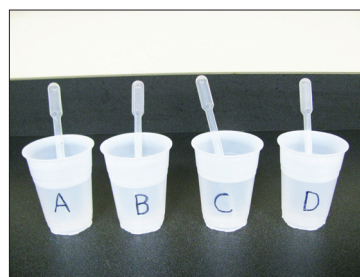
Divide the students into pairs, and have each pair come up to place the samples on the slides. Show the students how to label the slides with a marker. They should draw a circle where the drops will be so that they know where to look after the water evaporates, and they should write the corresponding letter above each circle so that they know which sample is in the circle.

It takes time for the water to evaporate, so it's best to leave the slides on a windowsill or a countertop until the next day. If you can heat the slides by placing them in the sun or near a heater, you can get faster results. The water samples can be identified by the following characteristics:

- **Distilled water:** Will leave no residue; the slide will be clear
- **Tap water:** Will leave a faint residue that is observable
- **Salt water:** Will leave an obvious white, crusty residue on the slide
- **Sugar water:** Will leave a clear, sticky residue on the slide

### Materials

distilled water  
tap water  
salt water  
sugar water  
droppers  
glass slides



Identities of Water Samples	
Water Sample	Identity
A	
B	
C	
D	

Have the students identify the water samples based on the appearance of the residues. They should record their results in a table like the one above. Afterward, hold a class discussion about evaporation and residue.

## Student Activity: Review Worksheets

Have the students complete two worksheets that review material covered up to this point in the unit. One of the worksheets comes in two versions; use the version that is appropriate for your students. See pages 78-82 in the Teacher Resources section of this manual for the downloadable worksheets and answer keys.

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