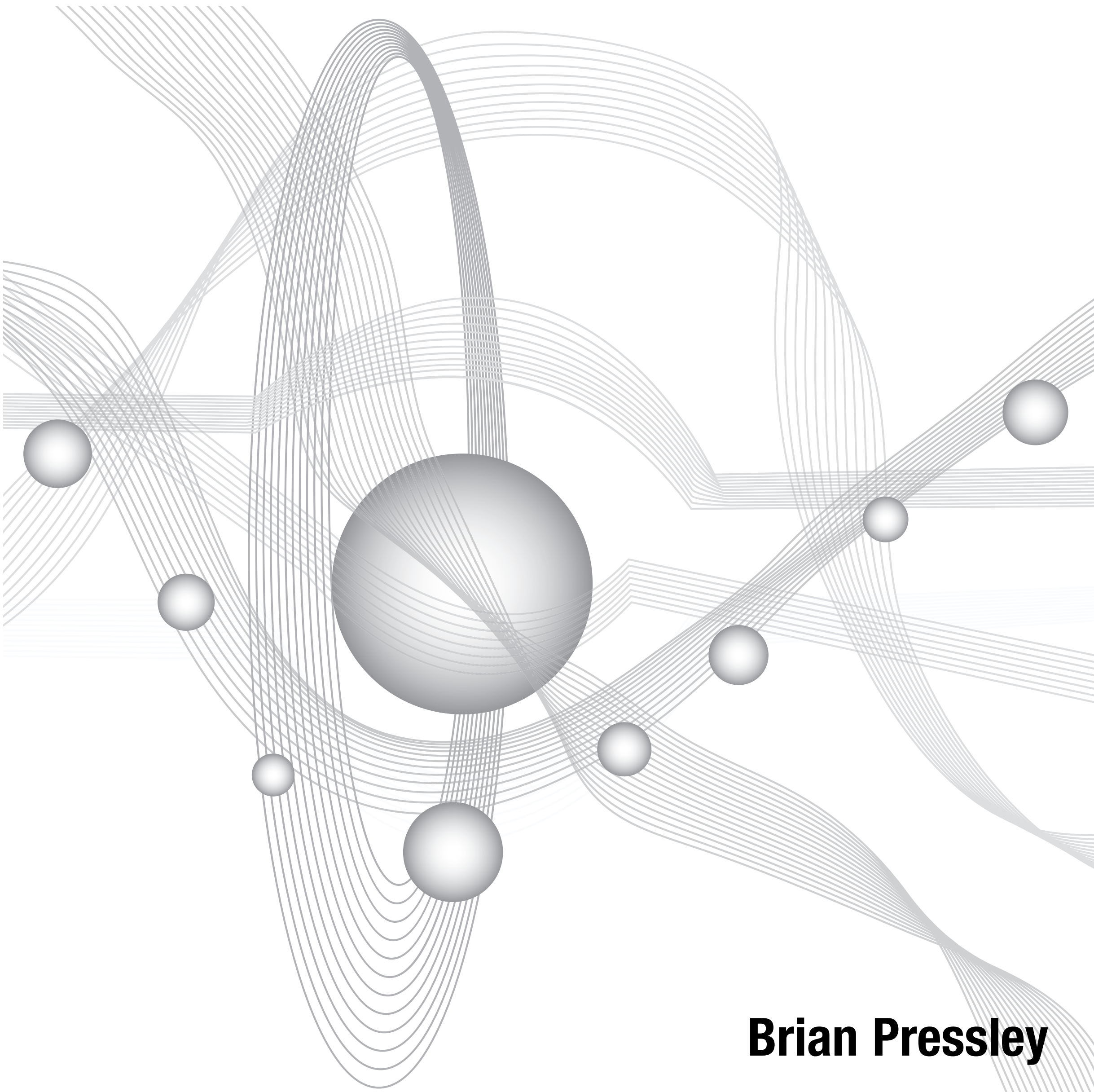
# Real-Life Science

## CHEMISTRY



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# Introduction

The *Real-Life Science* series is designed to engage students with topics of high interest that involve places, phenomena, technology, and concepts that they may encounter in their everyday lives. The topics were chosen by professionals in science education, and the National Science Education Standards were used to develop lessons that addressed a number of content standards. Each book in the series has a correlations chart that shows core standards that are addressed by each lesson, as well as other standards that are addressed, but are not the main focus of the lesson.

Using "real-life" examples is a technique that is well supported by the National Science Teaching Standards as well. The list below includes some of the standards that suggest that quality instruction can and should include material that does more than just require students to memorize and repeat basic facts.

## Teaching Standard A

Teachers of science plan an inquiry-based science program for their students.

- Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.

## Teaching Standard B

Teachers of science guide and facilitate learning.

- Focus and support inquiries while interacting with students.
- Orchestrate discourse among students about scientific ideas.

## Teaching Standard E

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

- Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.
- Model and emphasize the skills, attitudes, and values of scientific inquiry.

Each book in the *Real-Life Science* series features lessons you can use in your classroom today. Use these engaging lessons to help your students explore the intriguing ways that science is at work all around them.

# National Science Education Standards Correlations

C = Core standard X = Other or optional skill

| Title | Physical Science Content Standard B Grades 9–12: Structure of atoms | Physical Science Content Standard B Grades 9–12: Structure and properties of matter | Physical Science Content Standard B Grades 9–12: Chemical reactions | Physical Science Content Standard B Grades 9–12: Motions and forces | Physical Science Content Standard B Grades 9–12: Conservation of energy and increase in disorder | Physical Science Content Standard B Grades 9–12: Interactions of energy and matter | Science and Technology Content Standard E Grades 9–12: Abilities of technological design | Science in Personal and Social Perspectives Content Standard F Grades 9–12: Personal and community health | Science in Personal and Social Perspectives Content Standard F Grades 9–12: Natural and human-induced hazards | History and Nature of Science Content Standard G Grades 9–12: Historical perspectives |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. What Is Fire Made Of? | | C | C | | | X | | | | |
| 2. What Is Smoke Made Of? | | C | C | | | X | | | X | |
| 3. What Substances Burn Under Water? | | C | C | | | X | | | | |
| 4. How Do Fire Extinguishers Stop Fires? | | C | C | | | X | X | X | X | |
| 5. Why Does Dynamite Explode? | | C | C | X | X | | | | | |
| 6. Why Does Hydrogen Peroxide Fizz on a Cut? | | | C | | | C | | X | | |
| 7. How Do Soap and Shampoo Make Me Clean? | | C | | C | | | | X | X | |
| 8. What Does Hand Sanitizer Do That Soap Doesn't? | | C | | | | | | X | | |
| 9. How Does Antiperspirant Stop Me from Sweating? | | C | C | | | | X | X | | |
| 10. What Does Moisturizer Do to My Skin? | | C | C | | | | X | X | | |
| 11. How Does Sunless Tanning Work? | | C | C | | | | X | X | X | |
| 12. How Do Teeth Whiteners Whiten Teeth? | | C | C | | | | X | X | X | |
| 13. Where Do Artificial Flavors Come From? | | C | | | | | X | X | X | |

*(continued)*

# National Science Education Standards Correlations

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|---|---|---|---|---|---|---|---|---|---|---|
| 14. Why Do Pop Rocks® Pop? | | C | C | | | | X | | | |
| 15. What Is MSG? | | C | | | | | | X | X | X |
| 16. Why Doesn't Chewing Gum Dissolve When I Chew It? | | C | | | | | | | | X |
| 17. How Do Drain Cleaners Remove Clogs? | | C | C | | | X | | | X | |
| 18. Why Is There an Expiration Date on Bottled Water? | | C | | | | C | X | X | | |
| 19. Why Do Some Plastics Glow in the Dark? | C | X | | | | C | | | | |
| 20. How Does Glue Hold Things Together? | | C | | | | | X | | | |
| 21. How Does All That Air Get into a Can of Keyboard Duster? | | C | | | C | | X | X | | |
| 22. How Do Scratch-and-Sniff Stickers Have Smells? | | C | | | | | X | | | |
| 23. Why Are There Packets of Silica Gel in the Electronics I Buy? | | C | C | | | | X | X | | |
| 24. Why Is the Statue of Liberty Green If It's Made from Copper? | | C | C | | | | | | | |
| 25. How Is Something Decaffeinated? | | C | C | | | | | | | |

National Research Council. *National Science Education Standards*. Washington, DC: National Academy Press, 1996.

National Research Council. "National Science Education Standards." http://books.nap.edu/readingroom/books/nses/6e.html#csa912.

Name ______________________________ Date ______________________

# 1. What Is Fire Made Of?

## Explanation

In every science class, the question is asked sooner or later—is fire solid, liquid, gas, or plasma? There are a couple ways to answer this question. The first is that fire is a chemical reaction and isn't made of anything. This answer, however, avoids the spirit of the question, which is more about the materials we see in and around a fire. The majority of the common fires that we see, such as from wood or paper burning, are made up of hot gases and tiny solid particles that are so hot they glow. The kind of materials found in a flame can be solid, gas, and plasma. Some research suggests that some flames, such as candle flames, contain microscopic drops of liquid that are moved about by currents in the fire.

The fire triangle is made up of three components: fuel, oxygen, and heat. Fuel can be any material that will burn in the presence of oxygen, such as wood, gasoline, or dry grass. Oxygen makes up about 20% of Earth's atmosphere and is necessary for a material to burn. Cutting off the supply of oxygen is one of the main ways of extinguishing a fire. The third component, heat, is often supplied by a source that is already quite hot, such as an open flame, or from a source that can produce heat from friction, such as a lighter or a match.

Generally, a heat source comes in contact with the fuel in the presence of oxygen, and a self-sustaining chemical reaction occurs. As long as fuel and oxygen are present, the fire continues. Fires are exothermic, which means they give off heat. As fires give off heat, it is possible for enough heat to escape to allow the materials involved to go below the ignition temperature, which is the temperature the fuel needs to reach before it will ignite. If the temperature of the materials in the fire drops below this point, the fire will go out.

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assessment page

# 1. What Is Fire Made Of?

Circle the letter of the best answer.

1. Fire _____.

   a. is a chemical reaction
   b. requires only fuel
   c. does not need oxygen
   d. occurs in the absence of heat

2. Fires may be made out of _____.

   a. solids
   b. gases
   c. plasmas
   d. all of the above

3. The fire triangle _____.

   a. consists of fuel, oxygen, and light
   b. consists of fuel, oxygen, and heat
   c. consists of plasma, gases, and solids
   d. consists of fire, air, and wood

4. Fuel _____.

   a. is not part of the fire triangle
   b. can be in the form of heat
   c. is any substance that will burn in the presence of oxygen
   d. is any substance that will not burn in the presence of oxygen

5. Oxygen _____.

   a. makes up about 25% of Earth's atmosphere
   b. makes up about 20% of Earth's atmosphere
   c. can support a fire without the presence of heat
   d. is not part of the fire triangle

*(continued)*

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**assessment page**

# 1. What Is Fire Made Of?

6. Heat ______.

   a. is part of the fire triangle
   b. is not part of the fire triangle
   c. is never found in a fire
   d. is a chemical found in all fires

7. Exothermic reactions ______.

   a. absorb heat from their surroundings
   b. do not involve heat
   c. cause fires to go out
   d. give off heat as a product

8. Ignition temperature ______.

   a. is the highest temperature a fire can reach
   b. is the temperature at which oxygen is created in a fire
   c. is the temperature below which a fire will go out
   d. is the temperature at which a fire turns from orange to blue

9. Fire often has _____.

   a. a large amount of liquid in it
   b. tiny solid particles that are so hot they glow
   c. very low-temperature solids
   d. ice crystals that form and melt

10. A fire can be extinguished by ______.

    a. adding more heat
    b. adding more fuel
    c. cutting off the supply of nitrogen
    d. cutting off the supply of oxygen

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# 8. What Does Hand Sanitizer Do That Soap Doesn't?

## Explanation

In general, soap is able to speed the dissolving process for dirt. It also has the ability to chemically remove oils from surfaces and then carry those oils away with rinse water. Hand sanitizers, also called *alcohol gels,* are designed to allow people to clean their hands of germs when they don't have access to soap and water. The alcohol in hand sanitizer breaks down the cell walls of germs, which causes the germs to die. The germs are then shed from hands along with dead skin cells or are washed off when the hands are washed with soap and water. Standard hand sanitizers usually contain 60% alcohol or higher to be effective. When the amount is too high (between 90% and 100%), the lack of water can actually impair the effectiveness and prevent the sanitizer from doing its job.

The alcohols in hand sanitizers are there to kill bacteria and viruses. However, not all of the bacteria and viruses are killed by the standard alcohols that are used. Most hand sanitizers use ethanol ($C_2H_5OH$) or isopropanol ($C_3H_7OH$). These are effective at killing a wide variety of, but not all, germs and viruses. In addition, hand sanitizers generally do not dissolve dirt. They are not recommended for use when there is visible dirt on the surface of the hands. (However, the hand sanitizer may still give some protection against germs in such a situation.) Hand sanitizers are also made less effective by the presence of certain kinds of oils, fats, and proteins. One common combination of fats and proteins that resists the sterilizing power of alcohol gels is raw meat. Raw hamburger, chicken, pork, turkey, steak, and a number of other meats all limit the effectiveness of the alcohols in hand sanitizers. Therefore, hand sanitizers are unable to kill a significant amount of the germs. This means that using hand sanitizers to clean one's hands while preparing food is neither safe nor effective.

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# 8. What Does Hand Sanitizer Do That Soap Doesn't?

Complete each sentence by writing the missing word or words on the line.

1. In general, soap is able to speed the ___________ process for dirt.
2. Soap has the ability to remove oils from ___________.
3. Hand sanitizers allow people to clean ___________ from their hands when they don't have access to soap and water.
4. Hand sanitizers break down the ___________ of germs.
5. Hand sanitizers generally need to have an alcohol content of at least ___________.
6. Alcohol contents higher than ___________ can limit the effectiveness of hand sanitizers.
7. Hand sanitizers generally contain either isopropanol or ___________.
8. Oils and ___________ may reduce the effectiveness of hand sanitizers.
9. In general, hand sanitizers don't dissolve ___________.
10. Cleaning your hands with hand sanitizer isn't safe or effective when ___________.

Name ____________________ Date ____________________

# 20. How Does Glue Hold Things Together?

## Explanation

There are a number of factors that allow glue to do its job. However, scientists are still discovering new factors that determine how well a glue holds two surfaces together. Glues are more generally known as adhesives because they experience adhesion. Adhesion is the property of a material that allows its molecules to be attracted to the molecules of a different material. It is similar to cohesion, which is the property of a material that allows the molecules of the material to be attracted to themselves. For example, grease has lots of adhesion, which means it sticks to everything. But grease also has poor cohesion, meaning that it does not stick to itself in a manner that holds it together very strongly.

Good glue will have both high adhesion and high cohesion. Many types of glue have good adhesion and cohesion because of van der Waals forces. Van der Waals forces are the attraction experienced between two polar molecules. A polar molecule is one that has a positively charged end and a negatively charged end. The opposite charges attract, so the positive end of one molecule is attracted to the negative end of another molecule. For adhesion to work, the surfaces must be in extremely close contact with each other. This is why most glues are wet. The moisture in the glue allows it to spread thinly so that it contacts as much of the surface as possible. This also reduces the need for cohesion in the glue itself.

The second major factor in the way that glue sticks surfaces together is the physical interlocking of the surfaces involved. Almost any surface you see, no matter how smooth, is full of bumps, holes, and jagged edges at the microscopic level. This is another reason why many types of glue are liquids. Glue works itself into these irregular surfaces and then dries. This allows the nooks and crannies to be filled with solid glue, which holds the surfaces together.

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**assessment page**

# 20. How Does Glue Hold Things Together?

Complete each sentence by writing the missing word or words on the line.

1. Glues are more generally know as ____________.

2. Adhesion is the property of a material that allows its ____________ to be attracted to the molecules of a different material.

3. Cohesion is the property of a material that allows the molecules of the material to be attracted to ____________.

4. Grease makes a bad glue because it sticks to ____________ better than it sticks to itself.

5. Glues have high adhesion and high ____________.

6. Van der Waals forces are the attraction experienced between two ____________ molecules.

7. ____________ in a glue allows the glue to spread thinly so that it contacts as much of a surface as possible.

8. One major factor in the way that glue sticks surfaces together is the physical ____________ of the surfaces involved.

9. A polar molecule is one that has a negatively charged end and a ____________ charged end.

10. Most surfaces are full of bumps, holes, and jagged edges at the ____________ level.

Name ______________________________ Date ______________________

# 25. How Is Something Decaffeinated?

## Explanation

Caffeine ($C_8H_{10}N_4O_2$) is a chemical that acts as a mild stimulant in the human body. Caffeine is naturally occurring and can be found in a wide variety of plants, such as coffee beans and leaves, tea leaves, cocoa beans, kola nuts, and guarana berries. In many of the plants caffeine is present, it is used as a natural pesticide. Products made from these plants have different amounts of caffeine in them, depending on the nature of the plant. For example, some kinds of coffee beans, such as those used to make espresso, have very high levels of caffeine. Cocoa beans, on the other hand, have a smaller amount of caffeine.

There are a number of processes for removing caffeine. One of the first methods was invented by a German coffee merchant named Ludwig Roselius. His process involved soaking coffee beans in salt water, steaming them with another saltwater solution, and then washing them with benzene. This process removed about 97% of the caffeine and was used for many years. Unfortunately, research eventually revealed that benzene is a strong carcinogen, and the process was abandoned.

There are many common methods of decaffeination that are used today. Water extraction and carbon dioxide ($CO_2$) extraction are two basic techniques. In water extraction, beans are soaked to remove both flavor and caffeine. The caffeine is removed by a carbon filter. Then a second batch of beans is soaked in the same water (now flavored with natural coffee-flavor chemicals). Caffeine, but not flavor, comes out of the second batch. The beans are then 99.9% caffeine-free.

In the second method, $CO_2$ extraction, coffee beans are soaked and then exposed to $CO_2$ at very high pressures. At these high pressures, the $CO_2$ spreads across the beans like a gas, but dissolves caffeine like a liquid. The $CO_2$ is removed, and the beans are 97% caffeine-free or better.

Many other products that are caffeine-free have simply never had caffeine added to them artificially. Scientists are also using genetic engineering to try and create plants such as coffee beans and tea leaves that don't have caffeine in them to start with, but still have the same flavors that people enjoy.

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# 25. How Is Something Decaffeinated?

Circle the letter of the best choice to complete each sentence.

1. Caffeine has a chemical formula of _____.

   a. $C_7H_{10}N_4O_2$
   b. $C_8H_{10}N_4O_2$
   c. $C_9H_{10}N_4O_2$
   d. $C_8H_{11}N_4O_3$

2. In plants, caffeine is used as a natural _____.

   a. pesticide
   b. herbicide
   c. fertilizer
   d. perfume

3. The Roselius method of decaffeination involved soaking coffee beans in _____.

   a. sulfuric acid
   b. hydrochloric acid
   c. soap
   d. salt water

4. The Roselius method of decaffeination removed about _____ of the caffeine from coffee beans.

   a. 25%
   b. 7%
   c. 97%
   d. 89%

5. _____, used in the Roselius method of decaffeination, was found to be a strong carcinogen.

   a. Salt water
   b. Steam
   c. Benzene
   d. Aluminum chlorohydrate

# 25. How Is Something Decaffeinated?

6. In the water extraction method, caffeine is removed by a _____ filter.

   a. carbon
   b. zinc
   c. phosphorus
   d. sodium

7. Using water extraction, coffee beans can be made _____ caffeine-free.

   a. 49.9%
   b. 69.9%
   c. 89.9%
   d. 99.9%

8. Using the $CO_2$ extraction method, coffee beans can be made 97% caffeine-free using _____ $CO_2$.

   a. low-pressure
   b. high-pressure
   c. liquid
   d. solid

9. The food that does not contain caffeine is _____.

   a. coffee
   b. tea
   c. cocoa
   d. apples

10. Scientists are beginning to research how to make caffeine-free plants through _____.

    a. applying fertilizers
    b. genetic engineering
    c. applying pesticides
    d. mechanical engineering