Elements of Chemistry When Carbon Combines Teacher's Guide

Grade Level: 9–12 | **Curriculum Focus:** Physical Science | **Lesson Duration:** Three class periods

Program Description

Life as we know it could not exist without carbon. Introduce students to this element's unusual properties and to the crucial role it plays in everything from hydrocarbons to human tissue.

Lesson Plan Summary

Students predict what happens when a glue and water solution is mixed with a borax solution. Then they conduct an experiment and describe the properties of the new substance, applying what they have learned to the development of a definition of polymers.

Onscreen Questions

- What properties of carbon allow it to bond in many ways?
- How do functional groups make hydrocarbon derivatives?
- How are diamonds produced?
- What factors make a diamond valuable?

Lesson Plan

Student Objectives

- Predict what happens to the glue and water solution when a borax solution is added.
- Describe the properties of the new substance.
- Develop a definition of polymers.

Materials

- *Elements of Chemistry: When Carbon Combines* video
- Computer with Internet access
- Paper and pencils

For each group:

- 20 ml of 55% Elmer's glue solution in water
- 10 ml of 4% borax solution
- Two cups
- Stirring sticks
- Several plastic bags that close securely

Procedures

1. Begin the lesson by asking students to write what a polymer is and note familiar examples. If students don't know, tell them not to worry. Have them to put away the papers until the end of the lesson.
2. Tell students that they will conduct an experiment to illustrate the properties of polymers. They will combine a solution of Elmer's glue and water with a borax solution, observe what happens, and explain their results.
3. Before students proceed, allow time to watch the video *Elements of Chemistry: When Carbon Combines*. It will give important background information about carbon, hydrocarbons, and polymers.
4. Divide students into groups of three. Make sure each group has the necessary materials. First ask the groups to predict what they think will happen when they combine a solution of Elmer's glue with a solution of borax. Encourage students to write a reason for their predictions. Then have them put their predictions away until later in the lesson.
5. Give each group a few minutes to read the directions for the investigation, which are listed below.

Safety note: Unless instructed to do so, do not sniff, taste, touch, or mix any of the materials.

- Pour 20 ml of the Elmer's glue solution into a cup.
- Add 10 ml of the borax solution.
- Use the stirring stick to mix the two solutions.

6. Ask students to observe what happens to the two solutions as they are combined. *(They become solid enough to form a ball.)* Then ask students if they know why this happens. *(The borax solution added to the Elmer's glue solution forms additional links between the covalent bonds, causing the material to become more rigid. The more links, the stronger the material becomes.)*
7. Ask one person in each group to bring the new material home; have some put it in the refrigerator or freezer for 10 minutes. Tell those students to come to class prepared to discuss what happened to the materials.
8. During the next class period, ask volunteers to describe their observations of what happened to the material. Students should have observed that the material becomes more elastic after being

refrigerated for a brief period. But it will shatter in the freezer, demonstrating that it is sensitive to temperature.

9. Conclude the lesson by asking students to review their original ideas about polymers. Ask them these questions: Is the material you created a polymer? If so, why?
   Develop a definition of polymers that includes the following key points:
   - A polymer is a large molecule that forms when monomers, or smaller molecules, form covalent bonds.
   - In the material created, the monomers are made of hydrocarbons.
10. Finally, encourage students to think of other examples of polymers, such as plastics, rubber, nylon, and fiberglass. Point out that these are all synthetic polymers designed for specific purposes. For example, nylon is a synthetic fiber much like silk, and fiberglass is lighter than metal and does not rust.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- **3 points:** Students easily predicted what happens when the glue and water solution was mixed with the borax solution; demonstrated a clear understanding of how to conduct the experiment; and made significant contributions to the definition of polymers.
- **2 points:** Students predicted what happens when the glue and water solution was mixed with the borax solution; demonstrated a satisfactory understanding of how to conduct the experiment; and made some contributions to the definition of polymers.
- **1 point:** Students did not or could not predict what happens when the glue and water solution was mixed with the borax solution; demonstrated a weak understanding of how to conduct the experiment; and made few or no contributions to the definition of polymers.

Vocabulary

carbon

Definition: An element with the unique ability to form many compounds, largely because it can form four covalent bonds as well as chains and ring-shaped groups

Context: Carbon is found in more than two million compounds.

covalent bond

Definition: A bond between two or more nonmetals in which two atoms share electrons

Context: Carbon has the property of being able to form four covalent bonds, meaning that all four of its electrons can bond with other elements.

hydrocarbon

Definition: Compounds containing only hydrogen and carbon

Context: Two types of hydrocarbons are natural gas and petroleum, materials formed from the remains of living things found deep within Earth.

monomer

Definition: Subunits that form polymers, or long chains of molecules

Context: Most polymers are made of the same kind of monomer that is repeated in a pattern.

polymer

Definition: A large complicated molecule formed when chemical bonds link monomers in a pattern

Context: Natural polymers include cellulose and the silk in spider webs; plastic and fiberglass are synthetic polymers.

Academic Standards

National Academy of Sciences

The National Science Education Standards provide guidelines for teaching science as well as a coherent vision of what it means to be scientifically literate for students in grades K–12. To view the standards, visit this Web site:

http://books.nap.edu/html/nses/html/overview.html#content.

This lesson plan addresses the following national standards:

Physical Science: Chemical reactions; Structure and properties of matter

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K–12 Education addresses 14 content areas. To view the standards and benchmarks, visit http://www.mcrel.org/compendium/browse.asp .

This lesson plan addresses the following national standards:

- Science—Physical Sciences: Understands the structure and properties of matter
- Language Arts—Viewing: Uses viewing skills and strategies to understand and interpret visual media

---

DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

How To Use the DVD

The DVD starting screen has the following options:

Play Video—This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

Video Index—Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

Curriculum Units—These are specially edited video segments pulled from different sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

Standards Link—Selecting this option displays a single screen that lists the national academic standards the video addresses.

Teacher Resources—This screen gives the technical support number and Web site address.

Video Index

I. The Element of Life (4 min.)
Learn about the chemical and physical properties of carbon, the foundation of the molecular structure of all plants, animals, and microorganisms.

II. Hydrocarbons (5 min.)
See how hydrocarbon compounds are formed and learn about the differences between alkane, alkene, and alkyne hydrocarbons.

III. Functional Carbon (5 min.)
Examine the structure and function of different hydrocarbon derivatives and discover the problems associated with carbon polymers.

IV. Famous Diamonds (32 min.)
Hear tales of famous diamonds and learn how these sparkling gems are created and protected.

Curriculum Units

1. Carbon: An Overview
Pre-viewing question
Q: What do you know about the element carbon?
A: Answers will vary.

Post-viewing question
Q: What biological processes involve carbon compounds?
A: The biological processes of circulation, respiration, reproduction, digestion, and photosynthesis (used by plants and other microorganisms) involve carbon compounds.

2. Hydrocarbon Compounds
Pre-viewing question
Q: What are some types of hydrocarbons?
A: Answers will vary.

Post-viewing question
Q: What is an alkane?
A: An alkane is an alkaline carbon atom, the simplest type of hydrocarbon compound. Alkaline carbon atoms covalently bond with each other using single bonds, one electron from each atom. The molecules of an alkane are considered saturated because they are filled to capacity with hydrogen atoms. Examples of alkanes are methane, ethane, propane, and butane.

3. Hydrocarbon Derivatives
Pre-viewing question
Q: What elements commonly bond with carbon?
A: Answers will vary.

Post-viewing question
Q: What are halocarbons?
A: Halocarbons are hydrocarbon derivatives that have a halogen as its functional group; atoms from the halogen group take the place of hydrogen atoms in the covalent bonds.

4. The Curse of the Hope Diamond
Pre-viewing question
Q: Describe some common superstitions.
A: Answers will vary.

Post-viewing question
Q: Why was the Hope diamond considered cursed?
A: With 46-carats, the Hope diamond is one of the largest blue diamonds in the world, and many stories surround it. In the 17th century, its owner, King Louis XIV, died a long and painful death. Its inheritors, Marie Antoinette and King Louis XVI, lost their heads on the guillotine

during the French Revolution. Henry Hope acquired it in the 1800s and he died as a lonely bachelor. His niece inherited the stone, and her life and career ended in shambles. After Washington, D.C., socialite Evalyn Walsh McLean obtained the diamond in 1911, her son was killed in an automobile accident, her husband was committed to a mental hospital, and her daughter died from an overdose of sleeping pills.

5. India and Diamond Mining
Pre-viewing question
Q: Why are diamonds considered tokens of love?
A: Answers will vary.

Post-viewing question
Q: How are diamonds formed?
A: Diamonds form hundreds of miles deep inside the Earth, where carbon is under intense pressure and exposed to white-hot temperatures. After baking for hundreds of millions of years, a violent volcanic eruption may blast the diamond crystals to the Earth's surface very quickly. But if it takes too long, the carbon will convert to graphite, commonly used in pencils.

6. Cutting and Polishing Diamonds
Pre-viewing question
Q: Why are diamonds considered attractive?
A: Answers will vary.

Post-viewing question
Q: What makes the Millennium Star a special diamond?
A: The Millennium Star is one of only about 100 or so diamonds in the world in excess of 100 carats; each one is different and extremely rare. It is cut into a perfect, classic, beautiful diamond.

7. The Cullinan Diamond
Pre-viewing question
Q: Why do you think people have been long fascinated by diamonds?
A: Answers will vary.

Post-viewing question
Q: What was created from the Cullinan diamond?
A: Measuring about 3,106-carats, the Cullinan diamond yielded nine large diamonds and 96 smaller diamonds. Of the nine, the two largest were the 550-carat Great Star of Africa and the 317-carat Lesser Star of Africa.

8. Finding Diamonds
Pre-viewing question
Q: Describe how miners find a diamond.

A: Answers will vary.

Post-viewing question
Q: Where might the world's next large diamonds will be found, and why?
A: Answers will vary.