



# Chemistry in the Gem & Mineral Hall

## High School

### Duration

2-3 classes and a  
Museum visit

### Location

Gem & Mineral Hall

### Supplies

- See individual lessons

### Standards

Chemistry 1.2.3.6.7.9

## Module Overview

How is chemistry used to study mineral composition and formation?

## Module Purpose

This lesson set allows students to see chemistry in action! The study of gem formation encompasses a variety of chemical concepts and involves multiple chemical and physical processes acting in tandem, so a visit to the Gem and Mineral Hall can be used to reinforce nearly a year's-worth of chemistry content. Because students should have a basic understanding of the individual processes if they are to comprehend the overall concepts, it is recommended that the following activities be used toward the end of the year once students have studied most of the California Chemistry Standards.

Alternatively, if your class visits the museum before completion of the course, you may wish to complete only those activities for which they are prepared. If time remains, they may read through the information in the remaining exhibits to provide real-world relevance for those concepts as you reach them.

## Module Outline

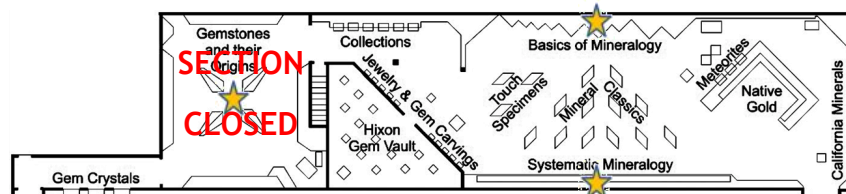
- Concepts are correlated to specific displays in the Gem and Mineral Hall and suggested activities are outlined on the following page. Some sample worksheets are also included, although the teacher may want to create their own depending upon the needs of their class.

## Alternative Concepts Addressed

- The identity of the molecules of a substance changes during a phase change
- Chemical reactions involve two reactants,
- A chemical reaction occurs when a substance dissolves,
- A chemical reaction occurs during a change of state
- A chemical reaction must take place in a laboratory
- Only water undergoes the processes of melting/freezing and boiling/condensing.
- Solvents are always liquids and solutes are always solids.
- Dissolving and melting are the same thing.

## Chemical Concepts Linked to the Gem and Mineral Hall

The tables below outline exhibits and displays in the Gem and Mineral Hall and correlate them with chemical concepts. Below the table you will see some sample activities regarding this topic.



Topic: Atomic and Molecular Structure, Including Bonds	
<b>Basics of Mineralogy</b>	
<b>Color and streak:</b> determined by chemical composition of the mineral	<ul style="list-style-type: none"> <li>Quantum electron configurations</li> </ul>
<b>Cleavage:</b> dependent upon location of weakest bonds between atoms	<ul style="list-style-type: none"> <li>Crystal structure</li> <li>Ionic bonds, network covalent bonds</li> </ul>
<b>Specific Gravity:</b> depends on chemical composition and atomic arrangement	<ul style="list-style-type: none"> <li>Atomic structure</li> <li>Crystal structure</li> </ul>
<b>Gemstones and their Origins</b>	
<b>Gemstone descriptions:</b> include chemical names throughout this display	<ul style="list-style-type: none"> <li>Naming compounds and using chemical formulas</li> <li>Using the periodic table</li> <li>Polyatomic ions</li> <li>Molar mass</li> </ul>
<b>Gemstones Formed in from Metamorphism</b> (ruby, emerald, garnet, chrysoberyl, nephrite, jadeite jade) and <b>Gemstones Formed in Earth's Mantle</b> (quartz, feldspar, peridot, diamonds)	<ul style="list-style-type: none"> <li>Atomic arrangement in crystal structure</li> <li>Network covalent bonds (diamonds)</li> </ul>
<b>Systematic Mineralogy</b>	
<b>Gemstone descriptions:</b> include chemical names throughout this display	<ul style="list-style-type: none"> <li>Naming compounds and using chemical formulas</li> <li>Using the periodic table</li> <li>Polyatomic ions</li> <li>Molar mass</li> </ul>
Explanation of system and individual classes	<ul style="list-style-type: none"> <li>Ions and ionic compounds</li> <li>Periodicity</li> <li>Elements and compounds</li> <li>Polyatomic ions</li> <li>Ionic compounds</li> <li>Naming compounds</li> <li>Crystal structures</li> </ul>

### Sample activities

(Worksheet: Exploring the Atomic and Molecular Structure of Minerals)

1. Read about the underlying chemical foundations of mineral properties at the museum; review these in more detail back in the classroom.
2. Choose one of the minerals in the exhibit. Research the mineral, finding its chemical nomenclature and determine its empirical formula and molar mass. Explain how the subatomic, atomic and molecular structure of the mineral explains its color and streak, cleavage pattern, and density.

## 2 Chemistry in the Gem & Mineral Hall

## Topic: Chemical Reactions—Including Acids and Bases

### Gemstones and their Origins, Gemstones Formed from Surface Water

Formation by Chemical Reaction (turquoise and malachite)

- Acid/base chemistry, including salt formation, weak acids, and equilibrium
- Chemical reactions, including those involving more than two reactants

### Sample Activities

(Worksheet: Exploring Chemical Reactions)

1. Read the descriptions of the reactions involved in the formation of turquoise and malachite.
2. Translate these descriptions into word equations, and then into *unbalanced* chemical equations. Some of the descriptions use general terms like "sulphides" and do not give you the actual formula for each compound. Do your best to approximate the compounds.
3. Identify the reactions that involve acids.
4. Identify the reactions that involve *weak* acids by showing that these reactions exist in equilibrium using a double arrow.

## Topic: States of Matter and Solutions

### Gemstones and their Origins, Gemstones Formed from Surface Water

Formation by Evaporation (opals)

- Dissolving process
- Process of evaporation
- Effect of concentration on solubility
- Equilibrium
- Colloids
- Types of solutions (solid state solutions)
- Effect of time on crystal formation

Formation by Cooling of Heated Water (quartz: amethyst and agate)

- Convection
- Dissolving process
- Effect of temperature on solubility
- Supersaturation
- Effect of concentration on crystal formation

Gemstones Formed from Hydrothermal Vents (benitoite, topaz, emerald, amethyst)

- Effect of temperature on solubility
- Supersaturation
- Rate of crystal formation
- Phase diagrams for water

Gemstones Formed in Pegmatites (tourmaline, topaz, fluorite, apatite, ruby, sapphire, emerald)

- Effect of temperature on solubility
- Effect of concentration on solubility
- Effect of pressure on solubility
- Melting vs. dissolving/ freezing vs. precipitation

Gemstones Formed from Molten Rock (ruby, sapphire, moonstone feldspar, zircon)

- Effect of temperature on crystal formation
- Melting/freezing

Gemstones Formed from Molten Rock (ruby, sapphire, moonstone feldspar, zircon)

- Phase diagrams

### Sample Activities

(Worksheet: Exploring States of Matter and Solutions)

1. Classify the gemstone formation processes into those that involve dissolving/precipitation, those that involve melting/freezing, and those that involve both.
2. For each process, identify the factors that influence crystal formation.
3. Identify at least one *solid solution* that is a gem.

## References and Resources

Lee, O., Eichinger, D. C., Anderson, C. W., Berkheimer, G. D., & Blaskeslee, T. D. (1993). Changing middle school students' conceptions of matter and molecules. *Journal of Research in Science Teaching*, 30(3), 249-270.

Cavallo, A. M. L., McNeely, J. C., & Marek, E. A. (2003). Eliciting students' understandings of chemical reactions using two forms of essay questions during a learning cycle. *International Journal of Science Education*, 25, 583-603.

Eilks, I., Moellering, J., & Valanides, N. (2007). Seventh-grade students' understanding of chemical reactions: Reflections from an action research interview study. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(4), 271-286.

Novak, J. D., & Musonda, D. (1991). A twelve-year longitudinal study of science concept learning. *American Educational Research Journal*, 28, 117-153.

BouJaoude, S. B. (1992). The relationship between students' learning strategies and the change in their misunderstandings during a high school chemistry course. *Journal of Research in Science Teaching*, 29(7), 687-699.

Stavridou, H., & Solomonidou, C. (1998). Conceptual reorganization and the construction of the chemical reaction concept during secondary education. *International Journal of Science Education*, 20(2), 205-221.

Herrmann-Abell, C. F., & DeBoer, G. E. (2009, April). Using content-aligned assessment to probe middle school students' understanding of ideas about energy. Paper presented at the National Association for Research in Science Teaching (NARST) Annual Conference, Garden Grove, CA.



# Example Lesson Set

## Suggested Structure

### Duration

2-3 classes with a  
Museum visit

### Location

Classroom and Gem &  
Mineral Hall

### Supplies

- Worksheet
- Pencils
- Periodic tables
- Clipboards with LED or similar lights (optional)

## Pre-Visit

1. Identify concepts you explore during your visit to the Museum, and which concepts your students would need to be familiar with before visiting the museum.
2. Determine activities you would like students to complete at the Museum.
3. Create or print any worksheets to suit your needs.
4. Review concepts as appropriate with your students.
5. Introduce Museum activities to students, and review behavioral expectations.

## Museum Visit

1. Assign students to groups of 2-3 before arriving at the museum. Depending on how long you will be at the museum, you may want to give different groups different properties to focus on.
2. **Whole Group:** Gather students in front of the hall, pointing out the general layout of the hall. Each group should start in a different part of the hall to avoid clumping. Make sure each group knows where they are starting and when and where the class will meet up again. (5-10 min)
3. **Small Group:** Students work in groups to complete the assignment, observing the exhibits as they go. (30 min)
4. **Whole Group:** Once it is time for your class to move on to the next part of the museum, gather the class back at the entrance to the exhibit.
5. **Small Group:** Either on the bus or back in class, allow students time to share their results with another group or two.

## Post-Visit

1. Review students' responses to the Museum activity, either in class, or by grading their sheets.
2. Reflect on the lesson and address any continuing alternative conceptions with additional activities, readings, and laboratory experiments.
3. Consider making rock candy with students using different variables based on the knowledge they gained about crystal formation while at the museum (i.e. solution temperature, concentration, pressure, cooling time, impurities).

## Worksheets

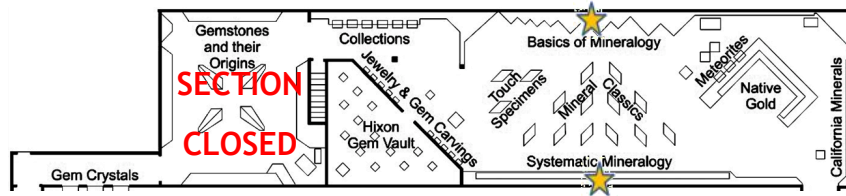
1. Exploring the Atomic and Molecular Structure of Minerals
2. Chemical Reactions
3. Exploring State of Matter and Solutions



## Exploring the Atomic & Molecular Structure of Minerals

Observe the following exhibits

Use your observations to answer the following questions.



### Basics of Mineralogy

1. Explain the underlying concepts that determine the following properties of minerals...

A. Color and streak:

B. Cleavage pattern (draw a picture to show what you mean):

C. Specific Gravity:



# Exploring the Atomic & Molecular Structure of Minerals

## Systematic Mineralogy

2. How are minerals classified?

### Throughout Exhibit

3. Choose one of the minerals in the exhibit to closely observe.

a. What is it called?

b. Draw a picture of the mineral below:

c. Observe and describe as many of its properties as you can, describing them below.

4. After visiting the museum Research the mineral you chose and find the following information:

a. Chemical nomenclature:

b. Empirical formula:

c. Molar Mass:





## Exploring the Atomic & Molecular Structure of Minerals

d. Explain how the subatomic, atomic, and molecular structure of the mineral you chose determines each of the following properties (use a separate sheet of paper if necessary):

Color and streak

Cleavage pattern

Density





## Chemical Reactions

3. Write the *unbalanced* chemical equations for the reactions that form turquoise and malachite. Some of the descriptions use general terms like "sulphides" and do not give you the actual formula for each compound. Do your best to approximate the compounds and ions involved.

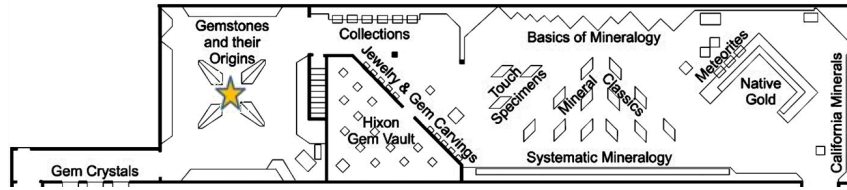

4. Identify the reactions that involve acids by circling them.

5. Identify the reactions that involve *weak* acids by showing that these reactions exist in equilibrium using a double arrow.



# Exploring State of Matter and Solutions

## Gem and Mineral Hall



## Gemstones and their Origins

1. Read through the exhibit. Then, using the Venn diagram below, classify the gemstone formation processes into those that involve dissolving/precipitation, those that involve changes in state, and those that involve both.

