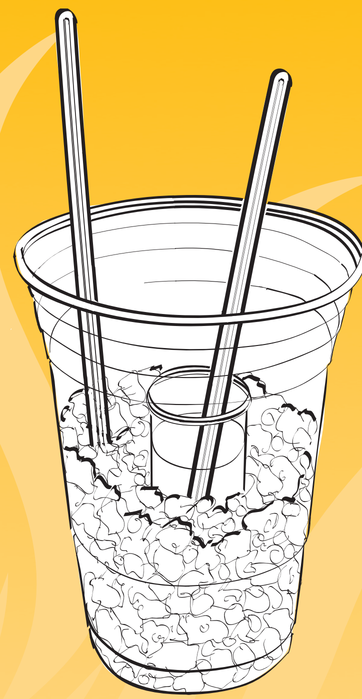
OVERVIEW

CHEMICAL INTERACTIONS COURSE



WELCOME TO CHEMICAL INTERACTIONS

From the dawn of reason, inquisitive people have looked at the magnificently diverse world around them and wondered. Some pondered its creation and purpose, others wondered about the usefulness of its riches, and there were those who contemplated the fundamental nature of all things tangible. It was this last disposition that led human enterprise into the vast sector of knowledge that we now call chemistry.

Chemistry is the systematic unveiling of the nature of matter—its properties, composition, and structure—and the energy dynamics that accompany matter transformations. Chemistry is also the intellectual process of uncovering the nature of matter and energy that contributes to the ever-expanding body of understanding we accept as chemical knowledge.

The earliest analysis of the composition of matter was at once simplistic and stunningly sophisticated. Twenty-five hundred years ago the Greek philosophers held that everything was composed of four elements: fire, air, earth, and water. By tinkering with the elements and their proportions, the four could be forged into all the different materials in the world. In time this four-element model was pushed aside as more-compelling models gained acceptance. But the core idea that basic substances, when combined in certain proportions, produce all the forms of matter on Earth was sound. Interestingly, the four ancient elements, when considered from an energetics perspective, are solid (earth), liquid (water), gas (air), and energy (fire).

Today we understand matter on Earth to be composed of 90 elements. We accept that the nature of matter depends on the number and arrangement of atoms of those elements and the particular energy load carried by that association of atoms at a particular time.

So, we know it all? Hardly. The frontiers of chemistry, like most of science, are active, and like all interfaces between the known and the unknown, chemistry is exciting for those prepared to confront the challenges.

FOSS AND NATIONAL STANDARDS

The **Chemical Interactions Course** for grades 7–8 supports the following National Science Education Standards.

SCIENCE AS INQUIRY

Develop students' abilities to do and understand scientific inquiry.

- Design and conduct scientific investigations.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the connections between evidence and explanations.
- Communicate scientific procedures and explanations.
- Use mathematics in scientific inquiry.
- Understand that scientific explanations emphasize evidence.

CONTENT: PHYSICAL SCIENCE

Develop students' understanding of properties and changes of properties in matter and understandings of transfer of energy.

- A substance has characteristic properties such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.
- Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group.
- Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids. There are more than 100 known elements (90 of them naturally occurring) that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter.
- Energy is a property of many substances and is associated with heat and the nature of a chemical. Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. In most chemical reactions, energy is transferred into or out of a system.

HISTORY AND NATURE OF SCIENCE

Develop students' understanding of the nature of scientific inquiry.

- Scientists formulate and test their explanations of nature, using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation.

FOSS MIDDLE SCHOOL PROGRAM COMPONENTS

FOSS for Middle School is a general science curriculum for students and their teachers in grades 6–8. The curriculum is organized into topical courses in three strands: **Earth and Space Science, Life Science,** and **Physical Science and Technology.** Each course is an in-depth unit requiring 9–12 weeks to teach.

This course, designed for students in grades 7–8, includes the following five interconnected components:

- A detailed ***Chemical Interactions Teacher Guide*** in a three-ring binder, including an overview, materials preparation, goals and objectives, an at-a-glance investigation chart, science background, lesson plans, transparency masters, teacher answer sheets, assessments with masters and scoring guides, a multimedia user guide, and references (books, multimedia, websites). Chapters of the teacher guide are separated by tabs for easy use. **Chemical Interactions** has ten investigations, each with multiple parts.
- A **kit of laboratory equipment** packaged for multiple classes of 32 students each. The kit also contains class resource materials such as posters and videos. Each course is designed for one teacher working with five sections of students per day. The kit includes transparencies for the investigations.
- The **FOSS *Chemical Interactions Lab Notebook*** consisting of prepared sheets and organizers for students to use during the investigations. Multiple copies of the lab notebook can be obtained in order to provide one for each student, or individual sheets can be photocopied and distributed to students as needed.
- Thirty-two **FOSS *Chemical Interactions Resources*** books containing reference materials (the periodic table of the elements) and readings that are used throughout the course.
- The **FOSS *Chemical Interactions Multimedia* program**, intended for use as a whole-class demonstration tool and an individual or small-group interactive instructional tool. The multimedia program is woven into the instruction and is linked to many investigations. The multimedia program is provided in the kit on five CD-ROMs, and is also available on-line at www.fossweb.com.

SYNOPSIS	SCIENCE CONCEPTS
1	
Substances (5–6 sessions) Students are introduced to chemistry lab tools and procedures. They experience chemical reactions and learn three ways to identify chemical substances: common name, scientific name, and chemical formula. They use macroscopic evidence from reactions to identify reactants.	• A substance is a form of matter with a unique composition and distinct properties. • Substances can be represented with common names, scientific names, and chemical formulas. • A chemical reaction occurs when substances interact to form new substances (products).
2	
Elements (4 sessions) Students learn that elements are the fundamental substances from which all matter on Earth is made. They study the periodic table to become familiar with the 90 naturally occurring elements and search product ingredient lists for elements they contain.	• An element is a basic substance that cannot be broken into simpler substances during chemical interactions. • There are 90 naturally occurring elements on Earth. • Elements combine to make all the substances on Earth. • The relative abundance of elements varies with location in the universe. • The periodic table of the elements displays all the naturally occurring and synthesized elements.
3	
Particles (5 sessions) Students investigate the macroscopic properties of gas and develop a particulate model to describe the invisible composition and interactions that account for the observable behaviors of gas.	• Matter is made of particles. Particles in gas are widely spaced. • Every substance is defined by a unique particle. • Gas is matter—it has mass and occupies space. • Gases are composed of widely spaced individual particles in constant motion. • There is nothing between gas particles except space. • Gas compresses under force and expands when force is withdrawn. • During compression and expansion, the number and character of particles in a sample of gas do not change; the space between the particles does change.
4	
Kinetic Energy (4–5 sessions) Students observe expansion and contraction of solids, liquids, and gases, and explain the phenomena in terms of kinetic theory—the constant motion of particles.	• Kinetic energy is energy of motion. • The particles in substances gain kinetic energy as they warm, and lose kinetic energy as they cool. • Matter expands when the kinetic energy of its particles increases; matter contracts when the kinetic energy of its particles decreases.
5	
Energy Transfer (6 sessions) Students experience the effects of energy transfer and learn to conceptualize the process of energy transfer as changes of particle kinetic energy resulting from particle collisions. Students are introduced to calories to measure heat and discover that energy is conserved.	• Substances "heat up" and "cool down" as a result of energy transfer. • Energy transfers between particles when they collide. Energy transfer by contact is conduction. • Energy always transfers from particles with more kinetic energy to particles with less kinetic energy. • Heat is measured in calories.

THINKING PROCESSES	MEDIA	READINGS
• Mix substances with water in order to determine the identity of an unknown mixture of substances. • Observe and compare reactions while they occur and the residues left behind. • Explain that a reaction changes initial substances into new, different substances.	FOSS Multimedia: *Two-Substance Reactions*	• *White Substances Information*
• Use information in the periodic table to analyze substances in terms of their elemental composition. • Explain that all common matter is made of elements.	FOSS Multimedia: *Periodic Table*	• *Elements* • *Elements in the Universe*
• Use standardized procedures to determine the volume of gas produced in a reaction. • Use syringes to observe the effects of pressure on gases. • Explain the composition of gas in terms of individual particles in constant motion. • Use drawings and words to explain gas compression and expansion.	FOSS Multimedia: *Periodic Table* FOSS Multimedia: *Gas in a Syringe*	• *Particles* • *Three Phases of Matter*
• Heat and cool gas, liquid, and solid matter to observe expansion and contraction. • Explain expansion and contraction in terms of kinetic energy. • Explain how a thermometer works.	FOSS Multimedia: *Particles in Solid, Liquid, and Gas*	• *Particles in Motion* • *Expansion and Contraction*
• Mix hot and cold water to observe energy transfer. • Calculate energy transfer in calories. • Explain energy transfer in terms of change of particle kinetic energy resulting from collision.	FOSS Multimedia: *Energy Transfer by Collision* FOSS Multimedia: *Mixing Hot and Cold Water* FOSS Multimedia: *Thermometer* FOSS Multimedia: *Energy Flow*	• *Energy on the Move*

SYNOPSIS	SCIENCE CONCEPTS
6	
Heat of Fusion (optional; 2 sessions) Students conduct experiments to determine the amount of heat needed to convert a mass of ice at 0°C to a mass of liquid water at 0°C.	• Heat of fusion is the energy needed to change a solid substance into liquid. • Heat of fusion does not change the kinetic energy of particles in a substance. • The heat of fusion for water is about 80 calories per gram.
7	
Phase Change (7–8 sessions) Students experience three common phases (states) of matter—solid, liquid, and gas—and investigate the conditions that induce substances to change from one phase to another.	• Matter exists on Earth in three common phases (states). • Change of state is the result of change of energy in the particles in a sample of matter. • During phase change, particles do not change; relationships between particles do change. • Different substances change phase at different temperatures. • The processes of phase change are evaporation, condensation, melting, freezing, sublimation, and deposition.
8	
Solutions (6 sessions) Students compare aqueous mixtures, one with a soluble solid and one with an insoluble solid. They then dissolve table salt and Epsom salts to determine saturation and discover that different substances have different solubilities. In the last part, students engage the concept of concentration, the ratio of solute to solvent in a solution.	• A solution is a mixture in which one substance dissolves in another. • Dissolving occurs when one substance (solute) is reduced to particles and is distributed uniformly throughout the particles of a second substance (solvent). • Dissolving involves both kinetic interactions (collisions) and attractive forces (bonds). • Concentration is the ratio of solute particles to solvent particles.
9	
Reaction (7 sessions) Students blow bubbles into limewater, observe the precipitate, and move atom tiles (representations) to simulate the rearrangement of atoms to form new substances (particles). Students conduct two other reactions—hydrochloric acid/baking soda and an antacid neutralization reaction—and learn to balance chemical equations.	• Atoms are the fundamental particles of elements. • A compound is a substance made of two or more elements. • Atoms combine to make particles of substances: molecules and ionic compounds. • Molecules and ionic compounds are held together by attractive forces called bonds. • A chemical reaction is a process in which atoms of substances (reactants) rearrange to form new substances (products).
10	
More Reactions (5 sessions) Students conduct more chemical reactions, learning about limiting factors and reactants in excess. They observe the oxidation of iron (rusting) and confirm the concentration of oxygen in air by assuming that oxygen is the limiting factor.	• The quantities of reactants available at the start of a reaction determine the quantities of products. • The limiting factor is the reactant present in the lowest concentration. • Rusting is a reaction between atmospheric oxygen and iron. • Reactants that remain in their original form after a reaction has run to completion were present in excess.

THINKING PROCESSES	MEDIA	READINGS
• Mix hot water, ice, and ice water to discover heat of fusion. • Calculate heat of fusion from data. • Explain the apparent discrepancy in energy transfer when hot water melts ice. • Explain that heat of fusion is energy that melts ice without changing the kinetic energy of particles.		• *Heat of Fusion*
• Use ice, hot water, and flame to transfer heat to and from substances to observe phase change. • Explain phase in terms of the relationship of particles to one another in a substance. • Discuss phase change in terms of kinetic energy and energy transfer.	FOSS Multimedia: *Particles in Solid, Liquid, and Gas*	• *Rock Solid*
• Use balances to compare densities of solutions and to infer concentration. • Explain the process of dissolving. • Explain how to find the amount of solute needed to saturate a volume of solvent. • Describe the characteristics of a solution at the particle level.	FOSS Multimedia: Explore *Dissolving*	• *How Things Dissolve* • *Concentration*
• Use chemical formulas and balanced chemical equations to represent chemical reactions. • Conduct a neutralization reaction to determine the effectiveness of an antacid. • Explain chemical reaction as a process in which atoms rearrange to form new substances.		• *How Do Atoms Rearrange?* • *Antoine-Laurent Lavoisier* • *Organic Compounds* • *Dr. Donna Nelson—Chemist*
• Measure the volume of gas produced in a reaction to infer the concentrations of reactants. • Use water displacement to determine the volume of oxygen consumed during the oxidation of iron.	Video: *Atoms and Molecules*	• *New Technologies* • *Gertrude B. Elion*

FOSS TEACHER GUIDE

The ***Chemical Interactions Teacher Guide*** is just that—a guide. It is designed to be an information and planning tool to help you understand and enjoy your introduction to chemistry, much like an interpretive brochure might guide your visit to historic Williamsburg. A good guide will suggest the best path to follow and will enrich your visit with history, facts, and lore as you proceed. Like any good guide it will also point out places to rest and where to stop for refreshments. You should feel comfortable and confident that you know what you are doing as you go along.

Like a good guide, it may be pressed into service less as you become more and more familiar with the territory. On your third visit to Williamsburg you might head straight for the main street, passing by some of the introductory exhibits, and you might visit your favorite spots in a slightly different order than you did before. You might even leave the trail here and there to drink in some of the historical ambiance in a way quite different from that intended by the preparer of the brochure.

The first time you visit the FOSS **Chemical Interactions Course**, we hope you will follow our suggested sequence to get the lay of the land. The guide is filled with information to help you have an excellent first use of the course. It may seem overwhelming at first, but in a short time you will discover how to use it effectively. Here's what we suggest.

Look at the **Table of Contents** to see how the teacher guide is assembled. You'll notice that the guide is subdivided into chapters. Turn each tab to see how much information there is in each section.

Next read the **Overview** chapter completely. This describes the scope of the course content and discusses issues of instruction, assessment, management, and safety.

Now turn all the pages in the guide, pausing to read the **Goal** and **Objectives** of each investigation carefully. In this way you will be able to get a very good sense of the curriculum.

Finally, digest Investigation 1, *Substances,* thoroughly. Read the science background carefully and study the **at-a-glance chart** to see how the investigation is subdivided. The chart also provides a dissected overview of the several days of classroom actions, including the use of media (website, video, and readings) and the assessments. Project the actions you read about into your classroom. Visualize students grappling with the problems and working with materials in small groups. If you have the kit at hand, bring out the materials as you read and do the investigations. Then read Investigation 2 carefully, then 3, 4, 5, and so forth. Keep the *Chemical Interactions Teacher Guide* close at hand (even in hand) during your first excursion into this topic to ensure a safe and productive adventure.