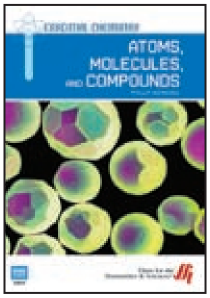

Films for the Humanities & Sciences®

Instructor's Guide

Essential Chemistry
ATOMS, MOLECULES, AND COMPOUNDS

Introduction

This Teacher's Guide provides information to help you get the most out of *Atoms, Molecules, and Compounds.* The contents of the guide will allow you to prepare your students before using the program and to present follow-up activities to reinforce the program's key learning points.

The five-part *Essential Chemistry* series covers core chemistry concepts in a fast-paced, straightforward style. After watching the films, students should have a grasp of the basics of states of matter, the periodic table, chemical reactions, metals, and atoms, molecules, and compounds. Subject matter experts explain these topics in a clear, concise manner, making them both interesting and transparent to students. Accompanying visuals bring chemical reactions and technical explanations to life. Overall, the five films in this series are practical, easy to understand, and should help students clarify the building blocks of the science of chemistry.

The series includes the following titles:

- *Atoms, Molecules, and Compounds*
- *Chemical Reactions*
- *Metals*
- *The Periodic Table*
- *States of Matter: Gases, Liquids, and Solids*

Learning Objectives

After viewing the program, students will be able to:

- Define and distinguish atoms, molecules, ions, and compounds
- Define and distinguish electrons, protons, and neutrons
- Understand how electron configuration influences the way in which elements are organized on the periodic table
- Explain different types of energy connected to atoms
- Explain how different compounds affect each other and make up the world around us

Educational Standards

National Standards

This program correlates with the National Education Standards Overview from the National Academies of Science. The content has been aligned with the following educational standards and benchmarks from this organization.

- The physical properties of compounds reflect the nature of the interactions among their molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.
- Chemical energy is associated with the configuration of atoms in molecules that make up a substance. Some changes of configuration require a net input of energy whereas others cause a net release.
- The number of protons in the nucleus determines what an atom's electron configuration can be and so defines the element. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms. Atoms form bonds to other atoms by transferring or sharing electrons.
- An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.
- Energy is released whenever the nuclei of very heavy atoms, such as uranium or plutonium, split into middleweight ones, or when very light nuclei, such as those of hydrogen and helium, combine into heavier ones. For a given quantity of a substance, the energy released in a nuclear reaction is very much greater than the energy given off in a chemical reaction.

English Language Arts Standards

The activities in this Teacher's Guide were created in compliance with the following National Standards for the English Language Arts from the National Council of Teachers of English.

- Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.
- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

- Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

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Technology Standards

The activities in this Teacher's Guide were created in compliance with the following National Education Technology Standards from the National Education Technology Standards Project.

- Creativity and Innovation: Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.
- Research and Information Fluency: Students apply digital tools to gather, evaluate, and use information.
- Critical Thinking, Problem Solving, and Decision Making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

The National Education Technology Standards reprinted with permission from the International Society for Technology Education.

Program Overview

This program, part of the five-film *Essential Chemistry* series, reviews the definitions of and differences between atoms, molecules, and compounds. Students review the nucleus of an atom and the subatomic particles — protons, neutrons, and electrons — that affect its weight and ability to form chemical bonds. Particular attention is paid to electrons, with the film including extensive review of electron configurations and energy shells. Additionally, students review how the periodic table is assembled and how the periodicity of the elements is due largely to recurring patterns in their electron configurations. The film also covers the energy of atoms and the chemical reactions that create molecules. Finally, the film concludes with a look at chemistry in the modern world and molecules in the world around us. Students learn how water and salt — basic and common substances often taken for granted — have interesting and unique properties that help make our lives possible. Overall, this film provides a comprehensive look at the large and lasting impacts made by some of the smallest particles known to humankind.

Main Topics

Topic 1: The Nucleus
The film begins by describing the nucleus of the atom, and the subatomic particles within and around it. Fission and fusion are defined.

Topic 2: The Electrons
Here, the film provides an in-depth look at electrons, reviewing energy shells, valance electrons, the principal quantum number, and orbitals.

Topic 3: The Elements
This section explains how the periodic table is organized, and how recurring patterns in the electron configurations of elements help build the table. Students learn the definition of ionization energy and electronegativity, and how and why they are periodic characteristics.

Topic 4: The Energy of Atoms
Types of chemical reactions, such as exothermic and endothermic, are presented here. Viewers learn about activation energy, and how it is sometimes needed to get a chemical reaction going.

Topic 5: Common Compounds
The program's final section shows how the study of chemistry is at the heart of environmental and quality-of-life issues today. It also provides an in-depth look at the properties of salt and water, including how and why they behave as they do.

Fast Facts

- On July 16, 1945, the first atomic bomb was detonated in New Mexico. Scientists had been able to harness the power of the atom, especially its dense, central core.
- The weight of an atom comes from its protons and neutrons, not its electrons.
- "$E=mc^2$" solves for the amount of energy generated by breaking apart the nucleus of an atom. The equation means that energy equals mass multiplied by the speed of light in a vacuum, squared.
- Fusion releases even more energy than does fission; scientists are currently working to harness this power to produce clean energy.
- The Heisenberg Uncertainty Principle says that you can't know both the position of a particle and its velocity at the same time.
- Knowing the energy levels of orbitals enables us to build the periodic table atom by atom.

- The system of notation used to figure out electron configuration is based on the noble gases, the unreactive elements with filled electron shells.

- The difference in elements' first ionization energies determines the type of bonds that will form between the two elements.

- Some molecules, especially those assembled in living organisms, can be huge. By contrast, a hydrogen molecule is very simple, composed of two hydrogen atoms bonded together. A diamond is one of the largest naturally occuring molecules.

- Salt is hydrophilic, meaning it attracts water. This allows salt to act in preserving food — it pulls water out, slowing the growth of unwanted bacteria.

Vocabulary Terms

electron: A negatively charged subatomic particle that can act as a particle or as a wave. Electrons orbit the nucleus of an atom in energy shells, and govern many common physical interactions.

electronegativity: The ability of an atom to attract electrons. Electronegativity generally decreases going down the periodic table, and increases going from left to right on the periodic table.

fission: The energy released from the nucleus of an atom being destabilized and broken apart.

fusion: The opposite process from fission, and more powerful. Fusion joins the nuclei of two light elements to form a more massive element, and releases energy in the process.

Gibbs free energy: Used to help distinguish a spontaneous reaction from a non-spontaneous one, Gibbs free energy measures potential energy, or the ability to do work.

ionization energy: The energy required to remove an electron from an atom in the gaseous state.

nucleus: The dense center of an atom that contains positively charged protons and neutral neutrons.

proton: Positively charged particle found in the nucleus of an atom.

spontaneous reaction: A reaction that proceeds without requiring added energy after it is initiated.

valence electrons: Electrons in an atom's outermost orbital which govern how atoms combine with each other to form compounds.

Pre-Program Discussion Questions

1. What is an atom? What is the different between an atom and a molecule? An atom and an ion?
2. Do you know what the equation $E=mc^2$ means, or what it measures?
3. How did scientists organize the periodic table? How might you organize elements if you were asked to?
4. What is a chemical reaction? How are atoms and molecules connected to chemical reactions?
5. Why is the study of chemistry important? How are environmental issues and chemistry connected?

Post-Program Discussion Questions

1. Why is the core of an atom so powerful? How has this power been used? How could it be used in the future?
2. What happens to an atom if you remove an electron? Remove a proton?
3. How do energy shells and electrons affect how elements interact with each other? How do they affect the organization of the periodic table?
4. What is activation energy? What is an example of activation energy?
5. Why is water an interesting and unique substance? How does it help make life possible?

Activity Ideas

- Have students research and report on the similarities and differences between fission and fusion. Reports should specifically consider the energy created by both processes and the uses for this energy, and how these compare and contrast (for instance, the devastation of the atomic bomb vs. the potential for clean energy). Students might include information on the cold fusion debate.

- Encourage students to closely review the periodic table — both the actual table and the history behind its creation and expansion. What do they notice? What patterns begin to emerge? Utilizing close examination of the table and investigation into its development, they should find and articulate the patterns present. Then have students create a visual representation of the periodic table that illustrates some of these patterns.

- Working in small groups, have students create visual representations of an atom of each element on the periodic table, with the electron shells and valence electrons correctly depicted. The depictions may be drawn, painted, created digitally, or students may create and then photograph a model of their atom. (The class might divide up groups and rows between small groups of students, or each student might be assigned a few elements to complete individually.) As space permits, hang the illustrations around the room in the approximate order of the periodic table.

- Have the class build a searchable Web site or database of chemistry vocabulary words, equations, and helpful illustrations and visuals. Work with the class to set the parameters of the project, perhaps focusing on the topics covered in the five-part *Essential Chemistry* series. Not only will creating the resource be an excellent way to really grasp key concepts, but the project will hone their computer skills as well.

- As appropriate in a lab setting, work with students to demonstrate activation energy. One simple depiction might be lighting coals to cook food, as depicted in the film. Beyond what you illustrate in the lab, ask students to research at least two other examples of activation energy and share these with the class. Encourage creativity — challenge students to present examples that will be new or particularly interesting to their peers.

Assessment Questions

1. What determines the weight of an atom?
   a) Electrons and protons
   b) Protons
   c) Protons and neutrons
   d) Valence electrons

2. The energy from what process is calculated with the equation $E=mc^2$?
   a) Fission
   b) Fusion
   c) Activation energy
   d) Gibbs free energy

3. The lowest energy shell (the innermost with the least energy) in an atom is written as ______.
   a) $1s^1$
   b) n=1
   c) G=H – TS
   d) n=2

4. What shape is the P orbital?

5. True or False: As an atom gets bigger, its electrons contain less energy.

6. What does the angular quantum number indicate?
   a) Number of electrons
   b) Velocity
   c) Noble gases
   d) Orientation

7. What is the Heisenberg Uncertainty Principle?

8. What is the equation to calculate Gibbs free energy?
   a) G=1
   b) G=H – TS
   c) $1s^2 2s^1$
   d) $E=mc^2$

9. Why did the Hindenburg catch on fire and explode?

10. When two elements have similar electronegativities, what type of bond do they form?
    a) Covalent
    b) Ionic
    c) Principal quantum bond
    d) Fission bond

Assessment Questions Answer Key

1. What determines the weight of an atom?
   a) Electrons and protons
   b) Protons
   c) Protons and neutrons
   d) Valence electrons

A: (c) Protons and neutrons. Electrons basically have no weight, and so it is the subatomic particles within the nucleus that determine the weight of an atom.

2. The energy from what process is calculated with the equation $E=mc^2$?
   a) Fission
   b) Fusion
   c) Activation energy
   d) Gibbs free energy

A: (a) Fission, the energy generated from the nucleus of an atom being destabilized and broken apart.

3. The lowest energy shell (the innermost with the least energy) in an atom is written as ______.
   a) $1s^1$
   b) n=1
   c) G=H – TS
   d) n=2

A: (b) n=1. The next lowest is written n=2, and so on.

4. What shape is the P orbital?

A: The P orbital is shaped approximately like a dumbbell.

5. True or False: As an atom gets bigger, its electrons contain less energy.

A: False. The bigger the atom, the more energy contained in its electrons.

6. What does the angular quantum number indicate?
   a) Number of electrons
   b) Velocity
   c) Noble gases
   d) Orientation

A: *(d) Orientation. There are three different ways something can be oriented in space.*

7. What is the Heisenberg Uncertainty Principle?

A: *Not being able to determine both the position and the velocity of a particle at the same time.*

8. What is the equation to calculate Gibbs free energy?
   a) G=1
   b) G=H – TS
   c) $1s^2 2s^1$
   d) $E=mc^2$

A: *(b) G=H – TS, in which G is the Gibbs free energy, H is enthalpy (or heat), T is temperature, and S is entropy (or disorder).*

9. Why did the Hindenburg catch on fire and explode?

A: *Activation energy. The Hindenburg was filled with hydrogen gas, and a spark ignited the hydrogen and oxygen, causing the fire and explosion.*

10. When two elements have similar electronegativities, what type of bond do they form?
   a) Covalent
   b) Ionic
   c) Principal quantum bond
   d) Fission bond

A: *(a) Covalent. Elements with similar electronegativities will share electrons. If their electronegativities are far apart, they will form an ionic bond.*

Additional Resources

American Chemical Society
http://acswebcontent.acs.org/home.html

General Chemistry Online!
http://antoine.frostburg.edu/chem/senese/101/index.shtml

NIST Chemistry WebBook
http://webbook.nist.gov

Nobel Prizes in Chemistry
www.nobelprizes.com *(click on "Chemistry")*

CHEMystery: An Interactive Guide to Chemistry
http://library.thinkquest.org/3659

eMolecules
www.emolecules.com

The Discovery of the Electron
www.aip.org/history/electron

MathMol Home Page
www.nyu.edu/pages/mathmol

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Bohr's Model of the Atom (DVD/VHS)
A good way to introduce quantum theory is to profile the individuals who pioneered it. This program focuses on Niels Bohr's contributions to our understanding of the atom and the behavior of subatomic particles according to quantum mechanics. Outlining theoretical precursors of quantum physics—including the ideas of John Dalton and J. J. Thomson—and a brief biography of Bohr, the video shows how the Danish physicist devised his atomic model and sheds light on his first and second postulates. Clever animation and helpful summaries enrich this valuable survey of the history and legacy of Bohr's achievements. *Viewable/printable educational resources are available online.* (26 minutes) © 2007 (# 40282)

Nuclear Chemistry: Inside the Atom (DVD/VHS)
From the ancient Greek concept of "atomos" to today's fission and fusion technologies, this program guides viewers through the landscape of atomic theory and the hidden world of subatomic particles. Topics include the makeup of atomic nuclei and the factors that make them stable or unstable; the discovery and use of radioisotopes; and the difference between fission and fusion. Providing historical perspective, the video illustrates major discoveries about the nucleus and presents concise profiles of pioneering atomic physicists—such as Henri Becquerel, Irène Joliot-Curie and Frédéric Joliot, Ernest Rutherford and Frederick Soddy, and many others. *Viewable/printable educational resources are available online.* (20 minutes) © 2007 (# 40291)

Atoms and Molecules (DVD/VHS)
In this concise and logically formatted program, students discover the fundamental building blocks of the universe: the elements. Lively computer animation makes the atom and its constituent parts—the proton, neutron, and electron—easy to understand. The Bohr Model and the Quantum Mechanical Model of the atom are clearly differentiated. Working from these concepts, students can then make sense of the Periodic Table with its arrangement according to Atomic Mass. The program also explains the concept of the mole and the different chemical bonds within molecules and compounds. A valuable summary at the end of the video reinforces all the concepts. Correlates to Project 2061 Benchmarks for Science Literacy from the American Association for the Advancement of Science. A Cambridge Educational Production. (16 minutes) © 2001 (# 29558)

Chemical Bonding (DVD/VHS)
This four-part series provides a comprehensive introduction to the chemical bonding processes. Using computer-generated models and examples from everyday life, each program illustrates the principles of bonding relevant to high school and college chemistry courses. *Viewable/printable educational resources are available online.* (4-part series, 17-22 minutes each) © 1997 (# 7743)

Electron Arrangement and Bonding (DVD/VHS)
In six short programs, chemistry students will learn the importance of the electron to chemical compounds. Through computer animation, the series explores the development of the atomic model by scientists such as Niels Bohr and Ernest Rutherford, and relates their contributions to an understanding of the functions of electrons. It illustrates various aspects such as energy levels, orbitals, charges, relative mass, bonding, and electron configuration, explaining clearly and concisely how the properties of an atom may be predicted by studying its electrons. *Viewable/printable educational resources are available online.* (6-part series, 10 minutes each) © 1994 (# 3609)

The Atom Revealed (DVD/VHS)
This program introduces the concept of "nanospace" or micro-space, and reviews over 380 years of research into microscopy. Compelling photography of microscopic organisms fascinates us, and a visual scale, the "nano-gate," is introduced that helps to explain the concept of an object magnified a billion times its normal size. We journey into the atomic structure of the substances that make up our world and view atoms through the largest electron microscope ever built. The program concludes with the first view of the atom 20 years ago, and hints at things to come with the recent ability to "write" with atoms. (50 minutes) © 1993 (# 6143)

The Chem Lab: Safety in Every Step (DVD/VHS)
"Maximize your knowledge and minimize your risk!" That's the primary message of this program, an informative introduction to the chemistry laboratory that shows high school and first-year college students precisely how to conduct themselves in a safe and professional manner. Familiarity with the properties and safe handling of all materials used in the lab is stressed, including how to dispose of hazardous waste, and the proper use of safety gear and equipment is explained. How to react in the case of a lab emergency is also discussed. *A viewable/printable instructor's guide is available online.* Correlates to the National Science Education Standards developed by the National Academies of Science; Project 2061 Benchmarks for Science Literacy from the American Association for the Advancement of Science; and the National Education Technology Standards from the National Education Technology Standards Project. A Films for the Humanities & Sciences Production. (19 minutes) © 2008 (# 39218)

Chemistry Video Library **(DVD/VHS)**
Contains 19 video clips on atomic and molecular structure, chemical reactions, elements, and forensics:
- Elements, Atoms, and Atomic Models
- Atomic Number and the Periodic Table
- Introduction to Chemical Reactions
- Fire
- Fireworks
- Elements Used in Space Travel
- Carbon
- Crime Lab
- Forgery
- Mummies
- Atoms, Energy Levels, and Isotopes
- Bonding, Compounds, and Mixtures
- Fuel Cells
- Biochemistry
- Introduction to Elements
- Light
- Crime Scene Investigation
- DNA
- Arson

The *Chemistry Video Library* is part of the complete *Discovery Channel/Films for the Humanities & Sciences Science Video Library.* Correlates to National Science Education Standards. A User's Guide is included, containing an overview; a numbered index of clips, with brief descriptions and lengths; time codes (for VHS only); suggested instructional strategies; and a list of additional resources.
A Discovery Channel/FFH&S Production. © 2003 (# 30958 DVD; # 30973 VHS)