Films for the Humanities & Sciences®

Instructor's Guide

Essential Chemistry
STATES OF MATTER: GASES, LIQUIDS, AND SOLIDS

Introduction

This Teacher's Guide provides information to help you get the most out of *States of Matter: Gases, Liquids, and Solids.* 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:

- Describe the three common states of matter: solids, liquids, and gases
- Understand the processes of evaporation and condensation
- Understand the processes of melting and freezing
- Understand the processes of sublimation and deposition
- Demonstrate knowledge of other states of matter beyond solids, liquids, and gases

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 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.
- The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others.
- 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.

From BENCHMARKS FOR SCIENCE LITERACY by the American Association for the Advancement of Science, copyright 1993 by the American Association for the Advancement of Science. Used by permission of Oxford University Press, Inc. Please note: judgments about the alignment of content presented here with the learning goals in BENCHMARKS FOR SCIENCE LITERACY are those of the author and do not represent the opinion or endorsement of the AAAS or Oxford University Press, Inc.

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.

Standards for the English Language Arts, by the International Reading Association and the National Council of Teachers of English, copyright 1996 by the International Reading Association and the National Council of Teachers of English. Reprinted with permission.

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, examines states of matter and the processes that affect them. Students learn the basics about solids, liquids, and gases, as well as the transformative processes (evaporation, condensation, melting, freezing, sublimation, and deposition) that cause changes from one state to another. In addition, the film briefly looks at other states of matter such as plasma and liquid crystals. Key chemistry concepts such as intermolecular forces, the ideal gas law, covalent and ionic bonds, and kinetic energy are addressed throughout the exploration of states of matter. After viewing this film, students should be comfortable describing different states of matter and what factors and forces compel them to change states.

Main Topics

Topic 1: Solids, Liquids, and Gases
This section kicks off the film by clarifying what makes matter a solid, liquid, or gas. It also introduces the concept of intermolecular forces and the equation for the ideal gas law.

Topic 2: Evaporation and Condensation
Here, the film explains the processes by which matter changes between the liquid and gaseous states. These processes, evaporation and condensation, are defined and depicted.

Topic 3: Melting and Freezing
Here, the film explains the processes by which matter changes between the solid and liquid states. These processes, melting and freezing, are defined and depicted.

Topic 4: Sublimation and Deposition
Here, the film explains the processes by which matter changes directly between the solid and gaseous states. These processes, sublimation and deposition, are defined and depicted.

Topic 5: Other States of Matter
The film's final section takes a look at states of matter that are not clearly categorized as solid, liquid, or gas, such as plasma, liquid crystals, and Bose-Einstein condensates. Students are introduced to the 'superstate' as well — matter that has properties of more than one state.

Fast Facts

- An endothermic reaction absorbs energy (examples are sweat and fog).
- In solids, particles vibrate differently according to their energy. This is measured in temperature.
- Intermolecular forces hold together the molecules in solids (strong bond) and liquids (weaker bond). They are nonexistent in gases.
- A covalent bond is a strong attraction between atoms sharing electrons. An ionic bond is a force created when atoms gain or lose an electron to each other.
- A cation is an atom that loses an electron in an ionic bond. An anion is an atom that gains an electron in an ionic bond.
- The triple point is the temperature and pressure at which the solid, liquid, and gaseous forms of one type of matter are all equally possible.
- A superfluid flows like a liquid but with no viscosity. A supersolid has a crystal structure on the outside but, on the inside, atoms move with perfect freedom and fluidity.
- Plasma is the most common phase of matter in the universe. It is an ionized (charged) gas that conducts electricity extremely well.
- The melting point is the temperature at which a solid becomes a liquid. This varies depending on the substance – for instance, the melting point of solid gold is approximately 2000 degrees F.
- Liquid crystals are a substance that does not fit one single state of matter — they are between a liquid and a solid. The molecules are arranged in structured, crystal-like patterns but are able to flow more like a liquid. Used for LCD television displays.

Vocabulary Terms

condensation: Process by which a gas changes to a liquid (example: liquid on cold glass in the sun).

deposition: Process by which a gas changes directly to a solid (example: frost).

electron: Subatomic particle with a negative charge.

evaporation: Process by which a liquid changes to a gas.

gas: State of matter in which molecules move freely and are far apart and not organized. Gas expands beyond a container into which it is placed.

Ideal Gas Law: $PV = nRT$, where P = pressure, V = volume, n = number of moles of gas, R = the universal gas constant, and T = temperature.

intermolecular forces: Forces between molecules. Examples are hydrogen bonds, dipole-dipole forces, and dispersion forces.

liquid: State of matter where molecules are loosely held together and there is no strong bonding of atoms. Liquids take the shape of the container they are in.

solid: Relatively dense state of matter with clear volume and shape and molecules packed close together.

sublimation: Process by which a solid changes directly to a gas (example: dry ice).

Pre-Program Discussion Questions

1. What are states of matter? Can you name any states of matter?
2. Why would a solid change to a liquid or gas, and vice versa? What might happen to a substance to change it to another form?
3. Why does melting occur? Why does freezing occur? What happens to water that freezes or ice that melts?
4. How is ice different from water? What makes them different?
5. Have you heard of plasma? What is it? When might you encounter it? What about liquid crystals? Have you heard or seen those words used to describe anything you have or want?

Post-Program Discussion Questions

1. Name and describe each of the three common states of matter. What is an example of another state of matter?
2. How and why does a liquid change to a gas and vice versa (also ask about liquid/solid and solid/gas)? What are the vocabulary terms for these processes?
3. What is an intermolecular bond? What breaks down an intermolecular bond?
4. What does water look like as a solid, liquid, and gas? Explain each state and how/why one state of water might change to another.
5. What is a supersolid? What is a superfluid? How are these different from a regular solid or liquid?

Activity Ideas

- Find activities/experiments in your chemistry textbook or workbook that deal specifically with states of matter or changes from one state to another. Even if you have run these already, go through them again referencing the new (or refresher) knowledge from the film. Note with the class if there is anything different to acknowledge or discuss.

- Try some basic ways of changing the state of matter (like melting ice, boiling water, or creating condensation). Have students observe and record what they see and what they have to do (create a high temperature, etc.) to cause the state change. How and when do these same types of changes occur naturally? When or where else have students seen these processes occur?

- Assign students vocabulary or concepts from the film (intermolecular forces, ideal gas law, covalent and ionic bonds, quantum superstate) and have them research each in more depth. Invite students to present their topics for the rest of the class and take questions.

- Ask students to solve for different variables in the ideal gas law equation by plugging in 'real' numbers for the majority of the components. Following this, discuss the concept of 'ideal' versus 'realistic' when looking at the behavior of gases.

- Examine different examples of states of matter under a microscope and note similarities and differences. Ensure you look at different types of the same state (for instance, a solid with a crystal structure as well as one with a closely packed structure made up of atoms of all the same size).

Assessment Questions

1. What state of matter has molecules loosely bonded together and takes on the shape of the container into which it is placed?
    a) solid
    b) liquid
    c) gas
    d) plasma

2. Which of these is NOT an intermolecular force?
    a) dispersion forces
    b) dipole-dipole forces
    c) deposition
    d) hydrogen bonds

3. Does table salt (NaCl) have a crystal building block structure or a close packed structure with atoms of all the same size?

4. Which of the following equations represents the ideal gas law?
    a) G = PTn
    b) PV = nRT
    c) N = VPG
    d) $E = mc^2$

5. The process by which gas converts to a liquid is called:
    a) condensation
    b) evaporation
    c) freezing
    d) sublimation
    e) superstate

6. Intermolecular forces are strongest in:
    a) liquids
    b) solids
    c) plasma
    d) gas
    e) fog

7. What process creates fog?

8. In an ionic bond, the atom that gains an electron is called:
    a) cation
    b) axiom
    c) anion
    d) covalent

9. What is the definition of a melting point?

10. What state of matter is plasma?
    a) solid
    b) liquid
    c) gas
    d) other

Assessment Questions Answer Key

1. What state of matter has molecules loosely bonded together and takes on the shape of the container into which it is placed?
    a) solid
    b) liquid
    c) gas
    d) plasma

A: (b) liquid

2. Which of these is NOT an intermolecular force?
    a) dispersion forces
    b) dipole-dipole forces
    c) deposition
    d) hydrogen bonds

A: (c) deposition — the process by which a gas changes directly to a solid.

3. Does table salt (NaCl) have a crystal building block structure or a close packed structure with atoms of all the same size?

A: Crystal building block structure. Na and Cl atoms are different sizes and thus form building blocks.

4. Which of the following equations represents the ideal gas law?
    a) G = PTn
    b) PV = nRT
    c) N = VPG
    d) $E = mc^2$

A: (b) PV = nRT (pressure times volume = number of moles of gas times universal gas constant times temperature)

5. The process by which gas converts to a liquid is called:
    a) condensation
    b) evaporation
    c) freezing
    d) sublimation
    e) superstate

A: (a) condensation

6. Intermolecular forces are strongest in:
    a) liquids
    b) solids
    c) plasma
    d) gas
    e) fog

A: (b) solids – Intermolecular forces hold together solids, which are relatively dense. They are a little weaker in liquids and nonexistent in gases.

7. What process creates fog?

A: Condensation (gas changing to liquid) — as temperature falls, moisture in the air condenses, creating fog.

8. In an ionic bond, the atom that gains an electron is called:
    a) cation
    b) axiom
    c) anion
    d) covalent

A: (c) anion. The atom that LOSES an electron is called a cation.

9. What is the definition of a melting point?

A: The temperature at which a solid becomes a liquid (varies from substance to substance).

10. What state of matter is plasma?
    a) solid
    b) liquid
    c) gas
    d) other

A: (d) other — plasma does not fit in any of the three 'common' states of matter. Plasma is a charged gas and is actually the most common type of matter.

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")*

Additional Products from Films Media Group

Available from Films Media Group • www.films.com • 1-800-257-5126

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)

Changing States of Matter (DVD/VHS)
This program demonstrates the changeability of solids, liquids, and gases with real-world, easy-to-understand examples. Set at a campsite, the video utilizes simple tools at hand—a camp stove, pots and pans, boiling water, and ice—to explain the concepts of state change, latent heat, expansion, contraction, and sublimation. Viewers will become familiar with the particle theory of matter, how heat or cold changes the characteristics of a wide variety of materials, and how a great deal of technology relies on these transformations. Helpful animation sequences and concise chapter summaries reinforce essential physics and chemistry concepts. *Viewable/printable educational resources are available online.* (28 minutes) © 2004 (# 35306)

Gases and States of Matter (DVD/VHS)
In part one of this program, chemistry authorities, including "Helium Man" and two janitors, lay down the law—Boyle's Law, Graham's Law, and Dalton's Law. They also present the Kinetic Molecular Theory and the Ideal Gas Equation and elaborate on partial pressures and the difference between diffusion and effusion. Part two investigates kinetic energy; ion-dipole, dipole-dipole, and London dispersion forces; hydrogen bonds; phase diagrams; and vapor pressure. (33 minutes) © 2000 (# 10131)

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)