Temperature Rising: Phase Changes

Victoria Essien

INTRODUCTION

"Chill out;" "I'm about to boil over;" "She has a hot temper;" "I feel my temperature rising;" "You should cool down;" "He's very cold hearted;" "Let out a little steam;" "Try not to freeze up." We have all probably heard these idiomatic expressions before and perhaps have even used them in some form ourselves. And although it is nearly certain that a person would never get so angry that he would boil over or so resolved that he would cool down to the point that there is a significant change in his body temperature, such expressions go a long way in opening up a classroom matter, ***phase change!***

In this curriculum unit, we will look at some of the following questions: How hot can a sample get before it changes states? How cold can a sample of matter become? What does freezing really mean? How does matter reach the boiling point? What is the lowest temperature a sample of matter can reach?

It has always been a conscious and on-going challenge for me to create a curriculum for my students that will keep them actively involved. I believe that the more students are involved in the construction of their own learning experiences in the classroom, the more they will learn, and the more connected the learning will be for them. The use of inter-disciplinary types of activities and varying the way concepts are introduced and presented – including the use of technology whenever possible – are great ways of getting students started and involved in the construction of their own learning experiences. Unit planning must start with an assessment of the learners needs and then must proceed along the lines of how well the learner comprehends the connections between the concepts being presented. It is not enough to complete a curriculum unit with the learner understanding isolated concepts, but every effort should be made on the part of the curriculum designer to link the different concepts together.

This unit will use an inter-disciplinary approach to teach and link those key concepts related to phase change in matter. It can be taught as an introduction to phase change in chemistry or in physical science. The unit is designed to be taught in whole or in part. Since we often have to work around school schedules that might in ways dictate how long we can devote to a particular topic, teachers must have the option of teaching either part of the unit or the entire unit.

Before each section is presented, the teacher should make a list of questions on the board or overhead projector that are pertinent to the section. I use this strategy to help students focus on the content of the lesson.

UNIT FORMAT

The unit will be presented in three sections. Each section title will include several objectives and an activity to go along with each objective. All objectives presented under a particular section title will be related to that title. Each activity will be labeled to assist teachers with lesson planning. This is important because the activities will be labeled according to the learning cycle: If the activity is a focusing activity it will be labeled with an *F* for focus; if the activity is one that allows the students to explore or gather information on a particular concept, then it will be labeled *X* for exploration; activities that give the students a chance to build a model, make a diagram, conduct an experiment, construct a program, perform or do a presentation will carry the label *A* for application. In addition to the labeled activities, each section will include a suggested activity that will employ the use of technology. Teachers will have the flexibility to chose which labeled activities are more useful for their particular students or which are more feasible given the facilities available to them. Each section will be preceded by pre-discussion questions and will end with suggested topics for short essays.

The following is an outline of how the sections and objectives in this unit will be arranged. By following the outline teachers should be able to delete activities or rearrange them and still present a standard lesson cycle.

UNIT OUTLINE

Section One

Describe the characteristics of solids, liquids, and gases using the Kinetic Theory of Molecules.

Objectives

- Students will become more familiar with those key terms that are used in the explanation of phase change. Activity One: *Word Cross* (**F**).
- Students will recognize the different properties of solids, liquids, and gases. Activity Two: *The Shape of Matter* (**F**).
- Students will be able to observe and classify samples of matter according to their properties. Activity Three: *Observing Change* (**X**).
- Students will observe the changes that take place when a sample goes from the liquid state to the solid state. Activity Four: *Clean Change: Making Soap* (**X**).
- Students will understand the connection between key terms related to phase change and be able to present these terms in a concept web. Activity Five: *Phase change concept mapping* (**A**).
- Students will use a thermistor provided by the LabWorks interface to measure the temperature of a sample in its solid and liquid state. Technology-link. Activity Six: *Thermistor Calibration* (**A**).

Section Two

Explore key concepts related to the energy of the heats of fusion and vaporization in phase change.

Objectives

- Students will investigate temperature change as it relates to motion. Activity One: *Heat and Motion* (**F**).
- To explore the relationship between heat of fusion, vaporization, melting point, and boiling point. Activity Two: *Heat of Fusion and Vaporization* (**X**).
- Using a closed system model, observe and discuss what happens when the system reaches dynamic equilibrium. Activity Three: *Phase Equilibrium* (**X**).
- Observe what happens to the temperature of a substance when a solvent is added. Activity Five: *Freezing Point Depression Analysis of the Ice Cream Process* (**X**).
- Observe the temperature of a substance as it changes from the solid to liquid to gaseous phase. Activity Five: *Temperature and Phase Change* (**X**).
- Observe the temperature at which a solution boils when different chemicals are added to it in different concentrations; record and graph the data collected. Use a graphing calculator. Activity Six: *Boiling Point Elevation* (**A**).

Section Three

Exploring matter in terms of heat and the effect that heat has on the expansion or contraction of molecules within a sample of matter.

Objectives

- Observe the effects of cold temperature on the size of a balloon when it is placed for a time in the refrigerator. Activity One: *Cooling Down* (**F**).
- Students will observe what happens to a balloon when it is stretched over the mouth of a glass bottle and the bottle heated. Activity Two: *Full of Hot Air* (**F**).
- Students will record what happens to air in a bottle when the sides of a balloon when the sides of the balloon is squeezed. Activity Three: *Boyle's Law: Putting on the Pressure* (**F**).
- Students will investigate Charles' Law by measuring a sample of air at a variety of temperatures at conditions of constant pressure. Activity Four: *Kinetic Theory: Charles' Law* (**X**).
- Students will observe how different metals expand differently when heated to the same temperature. Activity Five: *Not-So-Even Tempered* (**X**).
- Each student group will complete a research presentation and present it to the class. Activity Six: *Slide Show Presentation* (**A**).

Pre-Discussion Questions

1. Is it possible for a sample of matter to move from a solid state to a gaseous state without becoming a liquid first?
2. Can a sample of matter exist as a solid and have an average temperature greater or lower than room temperature?
3. Can all matter change states?
4. Is it true that the tiny particles that make up all matter are constantly moving? Are the particles that make up your desk moving?

SECTION ONE (Five Days)

Objective One

Describe the characteristics of solids, liquids, and gases using the Kinetic Molecular Theory.

Section Content

All matter takes up space and has mass, but matter can exist in different states. The four states of matter are solid, liquid, gas, and plasma. The state of a particular sample of matter depends on its temperature.

A door knob, a wooden block, and a cube of ice are all classified as solids. A solid is described as any matter that has a definite shape and a definite volume. Despite the fact that solids have definite shapes and volumes, the particles within solid matter are in constant motion. The *Kinetic Theory of Matter* (Kinetic Molecular Theory) states that particles that are in constant motion make up all matter. The particles in solid matter are held close together by forces between them, and for this reason a solid piece of matter can not be squeezed into a smaller space. The moving or vibrating particles of solid matter lack the necessary energy to move over and around each other – this explains why a solid retains a definite shape. Particles in solids are fixed in rather orderly patterns. In most solids the particles are arranged in repeating geometric patterns that resemble tiny crystals. The crystal-like shape is the result of the arrangement of atoms and molecules. This crystal-like arrangement can be interrupted at different temperatures for different samples of matter. The temperature at which atomic or molecule vibrations of a solid become so great that the particles break free from their orderly position and begin to slip and slide over each other freely is the point of phase change.

Particles in the liquid state of matter move much faster than those in the solid state. A two liter bottle of soda, a gallon of milk, and a mercury thermometer all contain matter in its liquid state. According to the Kinetic Molecular Theory the particles in a liquid are close together, and like the particles in water, liquid particles have enough energy to move over and around each other. This free movement of particles make it possible for matter in the liquid state to flow and take the shape of its container. And because its particles are held close together, liquid matter - like solid matter - has a definite volume.

In a liquid, the volume of the molecules and the intermolecular forces between them are much more significant than in a gas. In a gas the molecules constitute far less of the total volume than in the liquid state where the molecules constitute much more of the total volume. Because of this significant difference between molecules in these two states, a liquid expands and contracts only very slightly with a change in temperature and lacks the compressibility that is typical of gasses. Yet, this decrease in volume and increase in molecular attraction between neighboring molecules does not stop the particles from moving. This motion can be confirmed by viewing colloidal particles suspended in a liquid under a microscope. The particles zigzag around the colloidal particles which supports the theory of Kinetic Molecular Theory. According to the Kinetic Molecular Theory, particles of a gas sample have enough energy to separate completely from each other and continue to spread out or move apart until they are stopped by the walls of their container - they will continue until they are spread out evenly within their container. Gas does not have a definite shape or volume, because the molecules are so spread out. For this reason molecules are free to spread out as for as their containers will allow them. They are able to expand or contract to fill the space available to them.

Activity One

Word Cross **(F)**

In this focusing activity, students will work in pairs to define two to three words from a related word list. After defining their assigned words, the student groups will then make a clue to fit each definition. The clues should be refined in order to distinguish each word from the other words on the list. The teacher can prompt students to make their clues more direct. For example, a clue for the concept solid may read as follows:

> It matters not that I'm hard as rock or as soft as wool,
> I'll keep my figure as long as I'm cool.

After each pair has completed its clues, they should write their words out in block lettering on index cards. (Note: The index cards should be cut in half since only one letter should go on each piece). Next, make room on the floor or on a table to accommodate each word. Students will then arrange their words either vertically or horizontally like the words of a cross-word puzzle. (Students should cross as many common letters in their words as possible).   After the words have been arranged in a satisfactory way, the teacher or a student chosen by the teacher will then number each vertical row and horizontal column. The blocks with the words on them will be copied to a sheet of paper in the order in which they have been arranged on the table. Clues will be written in at the bottom of the puzzle according to the number assigned to its matching word. Puzzles can be switched between classes or the teacher can have the students write out the definition of each word using the clue for that word.

Activity Two

The Shape of Matter (F)

In this activity students will first be arranged into groups of four to compose a poem. Each poem will be shaped as one of three icons. The icons can be decided upon before the assignment begins. For example, a water drop could be an icon for liquid, a balloon could be used for gas, and a square block could be used for solid. Explain to the students that a poem that takes on the shape of the subject of the poem is called a *didactic poem*. After the class has decided on which icons to use in their poem the teacher can pass out word cards that will contain the word solid, liquid, or gas. It is probably a good idea to have the students mention the icon in their poem. This usually gives the students a good starting point. Below is one example using a water drop as an icon.

A
drip
A drop
I am indeed unique
peculiar, as you soon will see!
I can reshape my body as a square,
a cylinder, a rectangle all on cue
my molecules slip and slide all
over each other, never
holding shape true!

Activity Three

Observing Change (X)

Students will make observations about the properties of a sample and use their observations to classify it as either a solid, liquid, or gas. For this activity the students should be placed in groups of no more than four. Samples can be collected within the classroom. If the samples are collected by the students, the teacher should monitor sample collecting to ensure that each group's samples reflect solid, liquid, and gas matter. An alternate activity is offered at the back of this unit where samples are included. (Appendix, A-1) Students can make their own charts to classify their samples.

Activity Four

***Making Soap* (X)**

Students will investigate and observe how liquid materials can be used to make solid matter. For this activity students will be given pre-measured quantities of materials, and they will use the materials to form solid curds that can be rolled into solid soap balls. (Appendix, A-3)

Activity Five

***Concept Mapping* (A)**

Students will use their knowledge of phase change to complete a concept map. They will use each of the following terms once: *boiling*, *condensation*, *evaporation*, *freezing*, *melting*, and *sublimation*. As an extension lesson, students can define the terms and draw pictures to represents the concepts in the web. Each group can assign one person to make a oral presentation explaining their diagram and illustrated concepts. (Appendix, A-2)

Activity Six

***Thermistor Calibration* (A)**

Students will use the computer program, LabWorks, to calibrate the temperature of a sample in its solid state and in its liquid state. Students will be instructed to calibrate the temperature of a sample selected by the teacher and to follow the commands of the program to collect and calibrate their temperature readings. (LabWorks, 1995)

Short Essay Topic

Use the Kinetic Theory of Matter to explain the characteristics of solids, liquids, and gases.

Pre-Discussion Questions

1. Is there a difference in temperature between different samples of matter that are in their liquid state?
2. Does water have the same temperature as alcohol?
3. Is there a condition where a liquid will no longer evaporate?
4. Does heat have an effect on the evaporation rate of a liquid sample?
5. Can adding a solute to a liquid sample change its boiling or freezing point?
6. What is the relationship between heat and molecular motion?

SECTION TWO (Six Days)

Objective Two

To explore those concepts that are related to the heats of fusion and vaporization in phase change.

Section Content

Boiling water will cause water to change from a liquid phase to a gas state. This change of state is called *vaporization*. You can observe this change by watching bubbles of air form beneath the surface of the water. It is possible for some liquids to change into a gas state gradually over a period of time and without ever reaching the boiling point. During *evaporation* a liquid changes into gas but does not boil. When matter changes state, an energy change is always required.

Before a substance reaches its boiling point, added energy increases the motion of particles, and the temperature increases. Substances that have weak intermolecular forces evaporate easily and melt or boil at relatively low temperatures with less energy expenditure than substances with stronger intermolecular forces. *Condensation* is another change in phase. It takes place when a gas changes to a liquid.

The KineticTheory of Matter explains changes of state in terms of how much energy is needed to change form one phase to another. The *heat of fusion* is the amount of energy needed to change a material from the solid state to the liquid state. The *heat of vaporization* is the amount of energy needed to change a material from a liquid to a gas. Increases in temperature increase the average kinetic energy of molecules and increase the movement of molecules; thus the molecules in a cold liquid sample have, on average, less kinetic energy than those in warmer liquid sample. If the temperature of a liquid sample can be raised to a point where a molecule near the surface gains enough kinetic energy, it can overcome the attractive force which bonds it with neighboring molecules and escape into the gaseous phase. This is called *phase change*. When rapidly moving molecules with increased kinetic energy escape from the liquid state into the gaseous state, the average energy of the remaining molecules is lower; therefore the temperature is lowered.

Activity One

***Heat and Motion Connection* (F)**

For this activity, each group (of no more than four students) will be given a test tube, rubber stopper, funnel, and a beaker of containing sand. The teacher will instruct the students to fill the test tube half way with the sand. The students will record the temperature of the sand. The teacher will then ask the students to shake the sand vigorously for about two minutes and record the temperature after shaking it. A discussion should follow as to why there was a change in temperature. Students might want to see if they can change the temperature further by manipulating how long they shake the sand or manipulating the amount of sand inside their test tubes.

Activity Two

Heat of Fusion and Vaporization **(X)**

Students will explore the relationship between *melting point*, *boiling point*, *heat of fusion*, and *heat of vaporization*. Each student group (of no more than four) will be given a solid sample below the melting point and asked to determine the energy required to change that sample to a gas above its boiling point.

Activity Three

Phase Equilibrium **(X)**

In a closed system where the rates of evaporation and condensation equalize, phase equilibrium is said to be reached. To demonstrate this, the teacher will fill a beaker two-thirds of the way to the top and then place a glass bell jar over the top of it. Observations of this closed system would show an initial small drop in the water level, but after some time the level would become constant. (This activity takes some time and can be placed over to the side for on-going observations and recording.)

Activity Four

Freezing Point Depression Analysis of Ice Cream Process **(X)**

In this activity students will observe and record differences in temperature when a solvent is added to a substance.

Activity Five

Temperature and Phase Change **(X)**

In this activity the students will observe the temperature of a substance when it reaches it melting point and its freezing point. The students should know ahead of time that the melting point of a substance is the temperature at which the solid-to-liquid phase takes place and that the freezing point is the temperature at which the liquid-to-solid phase takes place. The melting point of a substance is the same as its freezing point. At this temperature, solid and liquid can exist together. In this investigation the students will observe what happens when the compound *para*dichlorobenzene (PDB) is cooled from a liquid to a solid, or freezes. The students will reverse the process and the solid will be heated until the substance melts and reaches above its melting point.

Activity Six

Boiling Point Elevation **(A)**

In this activity the students will observe the difference in boiling point of a sample when three different chemicals are added to a sample in two different concentrations. Students will use a graphing calculator to analyze the the data gathered. They will enter the ordered pairs (solution number, temperature) for each solution and then make a graph by connecting the coordinate dots.

Short Essay Topic

Explain why it is possible to change the boiling point or freezing point of a solution.

Pre-discussion questions

1. What is the effect of heat on the volume of a gas sample?
2. Does all solid matter expand at the same amount at the same temperature?
3. How can you increase the expansion quality of a sample?
4. How do you measure heat of different samples?

SECTION THREE (Five Days)

Objective Three

To understand the effects of heat on a sample in terms of increases or decreases in molecular motion, pressure, and volume.

Section Content

The Kinetic Theory explains that the movement of molecules accounts for the characteristics of different states of matter. The Kinetic Theory also explains what happens to these moving molecules when they are heated and when they are cooled. The characteristic of most matter that makes it expand when it is heated and contract when it is cooled is *thermal expansion*. A good example of thermal expansion is what happens to mercury in a thermometer when it is heated. Heat causes the mercury to move upward inside the narrow tube inside the thermometer.

When the temperature of a gas sample is increased, its kinetic energy is increased and this increases the motion of molecules within the sample as well. The molecules move in random order changing from one position to another; this is called *diffusion*. A good example of diffusion is what happens when you cook something on the stove and the smell of what is being cooked travels all over the house. (Barron, 64)

Related Gas Laws

Graham's Law relates the rate at which a gas diffuses to the type of molecules in the gas. It states that the rate of diffusion of a gas is inversely proportional to the square root of its molecular weight.

$$A = \sqrt{\text{Molecular weight}}$$

Charles' Law states that the volume of a gas sample will increase with increasing temperature, provided that the pressure does not change.

$$\text{Initial } \frac{V_1}{T_1} = \text{Final } \frac{V_2}{T_2}$$

Boyle's Law states that if you decrease the volume of a container of gas, the pressure of the gas will increase, provided the temperature does not change.

$$P_1V_1 = P_2V_2 \text{ at constant temperature}$$

Combined Gas Laws is a combination of Charles' Law and Boyle's law.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Pressure is the amount of force exerted per unit of area. The Pascal (Pa) is the standard unit of pressure. One Pascal of pressure is a force of one newton per square meter. The total amount of force exerted by a gas depends on the size of its container.

$$P = \frac{F}{A}$$

Activity One

Cooling Down (**F**)

To help the them better understand Charles' Law, students will do this exercise. As a focus, the students will observe what happens to a balloon when it is filled with air and placed for a time in the refrigerator. A discussion should follow.

Activity Two

Full of Hot Air (**F**)

Students will observe what happens to a balloon when it is stretched over the mouth of a glass bottle and the bottle then heated. A discussion should follow that will relate their observations to thermal expansion.

Activity Three

Boyle's Law - Putting on the Squeeze **(F)**

For this focusing activity, student groups will be given a bottle (two liter soda bottles will do) and directed to fill it two-thirds the way with water. The students will squeeze their bottles and record their observations. Their observations should be discussed in terms of how they relate to Boyle's Law.

Activity Three

Kinetic Theory - Charles Law **(X)**

Students will investigate Charles' Law by measuring a sample of air at a variety of temperatures at conditions of constant pressure.

Activity Four

Not-So-Even Tempered **(X)**:

Students will observe how different metals expand differently when heated to the same temperature. For this activity students will need two different metal rods or strips. Each metal piece should be cut to the same size and should be heated simultaneously to the same temperature. Observations should be made on how each rod expanded and by how much. Students should record their data.

Activity Five

PowerPoint Presentation **(A)**

Each student group will complete a research presentation on one scientist who has contributed to our understanding of the physical laws that govern our world – Isaac Newton, Albert Einstein, Jonas Kepler, etc. The student groups will present their research findings to the class in the form of a five minute computerized slide show. Microsoft PowerPoint, Excel, and Audas Persuasion are possible programs that have slide show features.

Short Essay Topic

Using gas laws, explain how pressure affects the volume of a contained gas.

APPENDIX

A-1: Observing Change

Each group of four or less will be given the following materials:

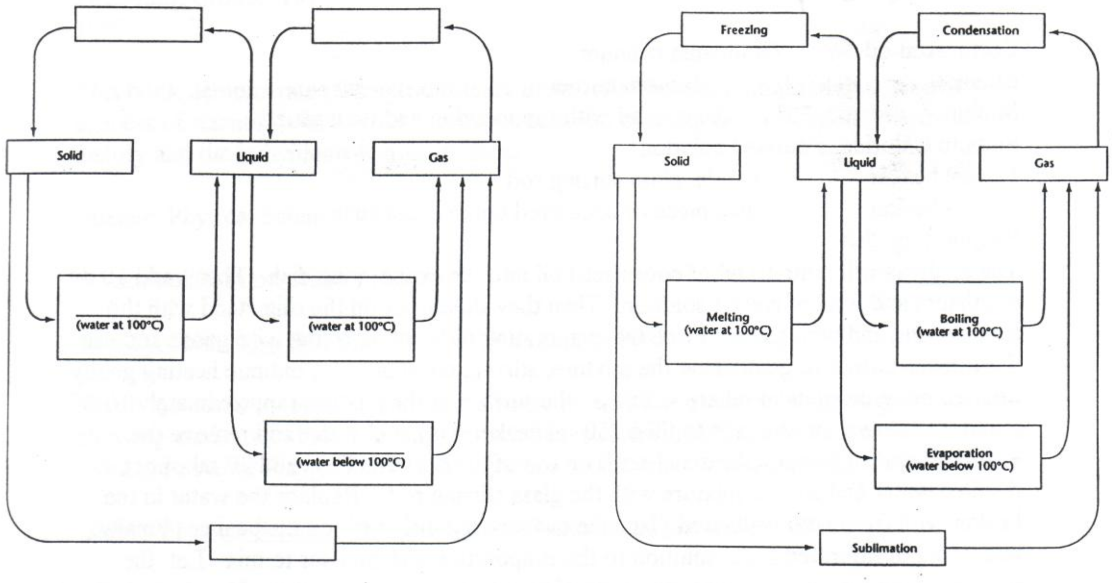
dropper	4% solution of (PVA)
food coloring	4% solution off powdered borax in water
wooden stick	graduated cylinder
paper cup	goggles
apron	

In addition to the materials, students should copy the table below and record their observations under the related columns.

Property	Observation	Interpretation
Ability to flow		
Shape change		
Volume change		

Students will use their graduated cylinders to measure 30 ml of PVA solution into a paper cup. Then they will add two drops of food coloring, and with a dropper, add about 3 ml of borax solution to the PVA in the cup. Record the volume of the liquid over to the side of the data chart. Stir the mixture vigorously with a wooden stick for about 2 minutes and note the consistency of the material. The students then should transfer the material to their hand and form the material into a ball. Place the ball into the cup and see if it will take the shape of the container. Compare the volume of the new material with the volume of the original material before stirring. The students should complete the chart and prepare to discuss their observations and interpretations with the rest of the class.

A-2: Phase Change Concept Map



A-3: Making Soap

Materials per group:

Cottonseed oil
Graduated cylinder
Ethanol
Bunsen burner
Sodium hydroxide, 30%
Ring stand with support ring and wire gauze
Sodium Chloride, saturated solution
150-ml beaker
Spatula, glass stirring rod
250-ml beaker
Small piece of uncolored commercial soap
Evaporating dish

The students will pour 10 ml of cottonseed oil into the evaporating dish. Then add 10 ml of ethanol and 5 ml of NaOH solution. Then they should set up the ring stand with the support ring and wire gauze. Place the evaporating dish on top of the wire gauze and use the Bunsen burner to gently heat the mixture, stirring constantly. Continue heating gently until no droplets of oil are visible on the surface of the mixture (approximately 10-20 minutes). Direct the students to fill a 250-ml beaker with cold water, remove the evaporating dish from the heat, and set it on top of the beaker. Then add 20 ml of hot distilled water and stir the mixture with the glass stirring rod. Replace the water in the beaker with fresh cold water and place the evaporating dish back on the beaker. Finally, add 25 ml of saturated NaCl solution to the evaporating dish and stir to mix. Let the mixture stand for two minutes until curds of soap began forming on top. Use the spatula to remove the curds and then shape the soap curds into a ball or block. Discuss and then record your observations in a science journal.

After the students have formed their balls of soap, the teacher should tell the them that under certain conditions liquid mixtures can be made to form solids or coagulate into curd.

TEACHER BIBLIOGRAPHY

A Planning Guide for Physical Science Curriculum. Houston ISD, 1990.
This curriculum guide takes a unit approach to present the scope of science objectives that should be taught in the science classroom.

Brody, Arnold and David Brody. *The Science Class You Wish You Had*. New York: Berkley Publishing Group, 1997.
This book demonstrates the extraordinary diversity of human thought in the creative process of scientific discoveries. It explores seven of the greatest scientific discoveries in history and the individuals that made them.

Bueche, Fred. *Physical Science*. Oakridge: Worth, 1972.
A textbook for non-science students.

Cassidy, John. *Zap Science*. Taiwan: Klutz Inc., 1997.
This book seeks to explain and answer some of the most ordinary happenings by actually allowing students to touch, smell, see, and hear science. The author refers to the book as a "Strange Science Playground." Many science topics are covered and explored.

Glenco Physical Science. United States: Glenco-McGraw-Hill, 1997.
Physical science textbook.

Grunwald, Ernest and Russell Johnsen. *Atoms, Molecules and Chemical Change*. New Jersey: Prentice Hall, 1975.
This resource is designed to give students a general knowledge of the experimental and logical foundations of chemistry.

Lawrence, David. *A Graphing Calculator Approach*. New Jersey: Pencilk Point Press, Inc., 1995.
This resource is designed to supplement the chemistry curriculum with quality student activities which engage them in designing mathematical models as useful tools for investigating and problem solving.

Mascetta, Joseph. *Chemistry the Easy Way*. United States: Barron's Educational Series, Inc., 1989.
This book introduces students to to basic high school chemistry concepts in a simplified manner with the use of graphs, charts, data tables, and drawings.

Salem, Lionel. *Marvels of the Molecule*. North America: VCH Publishers, Inc., 1987.
This book explores the uniqueness of the water molecule as well as other molecules and their geometrical configurations and characteristics.

Morgan, Nina. *Chemistry in Action: The Molecules of Everyday Life*. Oxford University Press, 1995.
This volume examines the the world of chemistry and the exciting ways our lives are shaped by chemical discovers and processes.

STUDENT BIBLIOGRAPHY

Aldrige, Bill. *The Ultimate Science Quiz Book*. United States: Franklin Watts, 1994.
This resource presents science facts in a way that students will be forced to explore scientific principals and laws and deduce their own answers

Bueche, Fred. *Physical Science*. Oakridge: Worth, 1972.
A textbook for non-science students.

Cassidy, John. *Zap Science*. Taiwan: Klutz Inc., 1997.
This book seeks to explain and answer some of the most ordinary happenings by actually allowing students to touch, smell, see, and hear science. The author refers to the book as a "Strange Science Playground." Many science topics are covered and explored.

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Physical science textbook.

Lawrence, David. *A Graphing Calculator Approach*. New Jersey: Pencilk Point Press, Inc., 1995.
This resource is designed to supplement the chemistry curriculum with quality student activities which engage them in designing mathematical models as useful tools for investigating and problem solving.

Napier, Albert and Philip Judd. *Mastering and Using Excel*. Boston: Boyd and Fraser Publishing Company, 1995.
This book is a self-help guide to understanding and using spreadsheet software.