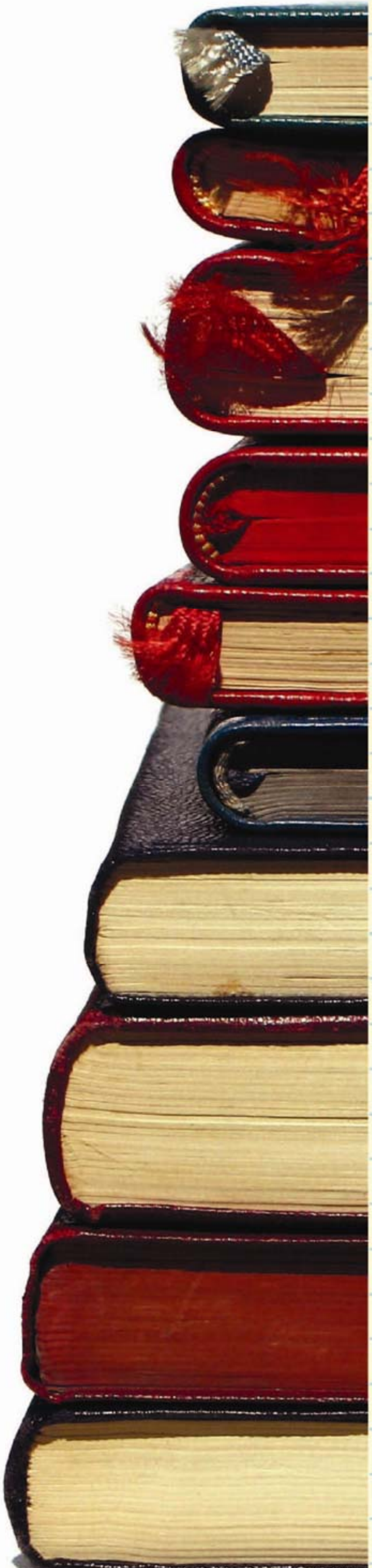

Comprehensive Curriculum

Revised 2008

Chemistry

Louisiana Department of
EDUCATION

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Chemistry

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Louisiana Comprehensive Curriculum, Revised 2008
Course Introduction

The Louisiana Department of Education issued the *Comprehensive Curriculum* in 2005. The curriculum has been revised based on teacher feedback, an external review by a team of content experts from outside the state, and input from course writers. As in the first edition, the *Louisiana Comprehensive Curriculum*, revised 2008 is aligned with state content standards, as defined by Grade-Level Expectations (GLEs), and organized into coherent, time-bound units with sample activities and classroom assessments to guide teaching and learning. The order of the units ensures that all GLEs to be tested are addressed prior to the administration of *i*LEAP assessments.

District Implementation Guidelines

Local districts are responsible for implementation and monitoring of the *Louisiana Comprehensive Curriculum* and have been delegated the responsibility to decide if

- units are to be taught in the order presented
- substitutions of equivalent activities are allowed
- GLES can be adequately addressed using fewer activities than presented
- permitted changes are to be made at the district, school, or teacher level

Districts have been requested to inform teachers of decisions made.

Implementation of Activities in the Classroom

Incorporation of activities into lesson plans is critical to the successful implementation of the Louisiana Comprehensive Curriculum. Lesson plans should be designed to introduce students to one or more of the activities, to provide background information and follow-up, and to prepare students for success in mastering the Grade-Level Expectations associated with the activities. Lesson plans should address individual needs of students and should include processes for re-teaching concepts or skills for students who need additional instruction. Appropriate accommodations must be made for students with disabilities.

New Features

Content Area Literacy Strategies are an integral part of approximately one-third of the activities. Strategy names are italicized. The link (view literacy strategy descriptions) opens a document containing detailed descriptions and examples of the literacy strategies. This document can also be accessed directly at http://www.louisianaschools.net/lde/uploads/11056.doc.

A *Materials List* is provided for each activity and *Blackline Masters (BLMs)* are provided to assist in the delivery of activities or to assess student learning. A separate Blackline Master document is provided for each course.

The *Access Guide to the Comprehensive Curriculum* is an online database of suggested strategies, accommodations, assistive technology, and assessment options that may provide greater access to the curriculum activities**.** The *Access Guide* will be piloted during the 2008-2009 school year in Grades 4 and 8, with other grades to be added over time. Click on the *Access Guide* icon found on the first page of each unit or by going directly to the url http://mconn.doe.state.la.us/accessguide/default.aspx.

Chemistry
Unit 1: Measurements and Problem Solving

Time Frame: Approximately two weeks

Unit Description

This unit focuses on measurements and problem solving with an emphasis on applying these skills in the laboratory.

Student Understandings

Students understand how to record mathematical data correctly and to solve problems utilizing significant figures, scientific notation, unit conversions, and the factor-label (dimensional analysis) method in calculations.

Guiding Questions

1. Can students use lab safety procedures correctly and consistently?
2. Can students explain the importance of standard units of measurement?
3. Can students determine the precision of a measuring instrument and relate the number of significant figures to that precision?
4. Can students explain how measurements may be precise but not accurate?
5. Can students demonstrate their knowledge of expressing numbers in correct scientific notation and significant figures in experimental calculations and other problem-solving situations?
6. Can students use the factor-label method of solving problems to perform metric conversions?
7. Can students convert measured quantities into other standard units?

Unit 1 Grade-Level Expectations (SI GLEs: 10)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
1.	Write a testable question or hypothesis when given a topic (SI-H-A1)
3.	Plan and record step-by-step procedures for a valid investigation, select equipment and materials,
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)

GLE #	GLE Text and Benchmarks
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
15.	Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)
Physical Science	
1.	Convert metric system units involving length, mass, volume, and time using dimensional analysis (i.e., factor-label method) (PS-H-A1)
2.	Differentiate between accuracy and precision and evaluate percent error (PS-H-A1)
3.	Determine the significant figures based on precision of measurement for stated quantities (PS-H-A1)
4.	Use scientific notation to express large and small numbers (PS-H-A1)

Activity 1: Safety in the Classroom

Materials List: safety video or multimedia presentation (if available); safety contracts; specific chemistry equipment for your class (beakers, burners, etc.); safety goggles and aprons

Safety is of vital importance in a chemistry class. If available, students should view a safety video or multimedia presentation. The consequences of safety issue violations must be included in a safety contract, which should be signed by the student and kept on file. Topics that should be addressed include hair and clothing issues, proper handling and disposing of chemicals and equipment, and proper behavior. Major emphasis should be placed on the fact that safety goggles are to be worn at all times within a lab. A "tour" of the lab should be conducted to familiarize the students with the location of the eye wash station, shower, fire extinguishers, vents, and exits. An actual demonstration of how to operate a fire extinguisher should be conducted. Copies of the MSDS (Material Safety Data Sheet) should be kept onsite for all chemicals used in the course. This resource provides an in-depth data sheet for each chemical including such information as hazards to consider, first aid measures, how to handle, store and dispose the chemical, etc. These can be obtained at no cost from the following site: http://www.flinnsci.com/search_MSDS.asp.

An activity that shows how to use common equipment safely should also be conducted. This activity should include instruction concerning safe disposal of chemicals that will be used throughout the course. http://www.flinnsci.com/Sections/Safety/labChemSafety.asp deals with chemical safety issues. Have students examine illustrations or scenarios of laboratory set-ups and identify unsafe practices illustrated. The site http://sciencespot.net/Media/scimthdsafety.pdf uses SpongeBob and friends in a scenario where students must read the passage and identify the unsafe practices. It includes teacher notes, an answer key, and a safety rules list.

Check with the science supervisor in your parish to see if there is a copy of a parish safety contract on file. The site http://www.flinnsci.com/Sections/Safety/safety.asp provides excellent safety material. http://www.flinnsci.com/Sections/Safety/safety_contracts.asp provides excellent documents dealing with safety issues as well as safety contracts. Also available at this site are high school and middle school safety contracts in English and Spanish as well as safety quizzes for both areas.

Another site that offers many good ideas for constructing your own safety contract can be found at http://www.labsafety.org/pdf/Student_Safety_Contract.pdf

Activity 2: Significant Figures (SI GLEs: 4, 5, PS GLEs: 3, 4)

Materials List: one blue paper ruler with marks of zero on one end and 10 on the other end; one red paper ruler divided into ten equal spaces with marks of zero on one end and then 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, 10 being on the other end; one yellow paper ruler with marks similar to the red ruler but also featuring smaller marks that divide ten equal spaces between each larger mark; several strips of green paper of different lengths marked A, B, C, D, and so on; science learning log; Specific Assessment Rubric BLM

Review the use of the science *learning log* (view literacy strategy descriptions) for recording observations and data, making predictions, and tracking investigations. (The key is to get the students to record their observations and ideas, to write descriptions in detail, to build and fill charts, and to draw clear, understandable diagrams and illustrations.)

Students traditionally have a very difficult time understanding which digits are significant, especially zeroes, in a number that represents a measured value. Using carefully selected green paper strips to measure, the students themselves can come up with the rules for which digits are significant, as well as the importance of digits to future calculations. This activity can be referred to when discussing significant figures in calculations. The following supplies are needed:

- one blue paper ruler with marks of zero on one end and 10 on the other end
- one red paper ruler divided into ten equal spaces with marks of zero on one end and then 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, 10 being on the other end
- one yellow paper ruler with marks similar to the red ruler but also featuring smaller marks that divide ten equal spaces between each larger mark
- several strips of green paper of different lengths marked A, B, C, D, and so on (Make sure some of the lengths are in units of ten.)

Have a volunteer use the blue paper ruler to measure several smaller strips of green paper and record the measurements in a student-generated data table. Next, have another volunteer use the red paper ruler to measure the same green paper strips and record the results. Finally, have a third volunteer use the yellow paper ruler to measure the same green paper strips and record results. Students are to analyze the results and discuss which digit in the measurement is the most certain and which digit in the measurement is the first uncertain digit. Discuss with students those measurements with zeroes in them, and help students understand when those zeroes are significant and when they are not. Conclude this task by instructing students to respond in their science *learning log* to the following: The more sensitive the measuring instrument, the closer we can get to the true value. What is a significant digit and how does it relate to the true measurement? (Significant figures are defined as the number of places found on the instrument and one more place value that the student must estimate. The number of significant figures then determines how close students will be able to come to the actual/true measurement of the item.)

Note: The above activity can also be done as a teacher demonstration.

Antoine Uncertainty in Measurement Tutorial: This Web site provides an excellent interactive look at precision and significant figures in measuring applications. The students are taken through a tutorial designed with appropriate feedback and remediation at each level. This tutorial is available online at http://antoine.frostburg.edu/cgi-bin/senese/tutorials/sigfig/index.cgi.

http://www.fordhamprep.org/gcurran/sho/sho/lessons/lesson23.htm provides a tutorial of significant figures as well as quizzes and worksheets (with answers) dealing with significant figures (digits.)

After completing the activity, provide students with problems that require determining the correct number of significant figures in measurements.

Instructions should be given to the students on how to convert large and small numbers to correct scientific notation, and how to solve problems using scientific notation and significant figures. http://www.fordhamprep.org/gcurran/sho/sho/lessons/lesson25.htm provides tutorials and practice with scientific notation and significant figures.

Activity 3: Accuracy and Precision of Scientific Equipment (SI GLEs: 1, 3, 4, 5, 10, 15; PS GLEs: 2, 3)

Materials List: various sizes of graduated cylinders and beakers, pipettes, and if available, burets; water source; Accuracy and Precision BLM; science learning logs.

This activity is an introduction to *accuracy* and *precision*. Activate prior knowledge by asking students to explain the terms *accuracy* and *precision* as they relate to measurements. After a discussion of these terms, ask students how a measurement can be precise but not accurate. Copy and distribute the modified *word grid* (view literacy strategy descriptions) on the Accuracy and Precision Worksheet BLM; ask the students to determine the accuracy and precision of each of the pictures and to explain their decisions. A *word grid* involves building a grid in which the important properties, key words, or phrases are listed on the vertical axis and possible characteristics or important ideas are placed on the horizontal axis. Students will fill in the grid, indicating the extent to which the key words possess the stated features. Once the grid is completed, students are led to discover both the shared and unique characteristics of the properties of the items listed in the vertical axis. In this modified *word grid*, the concepts of accuracy and precision are related to the three different figures. The *word grid* can also be used by students as a study aid for tests and quizzes. This part of the activity is to be used as an introduction to *accuracy* and *precision*. Explain that these concepts will be applied to the various measuring devices used in the scientific community.

In this activity, students will discover that measuring instruments may differ greatly in accuracy. Activate prior knowledge by *brainstorming* (view literacy strategy descriptions) with students the measuring devices used in their homes. Students can work in small groups or as a class to b*rainstorm* or share their ideas about a particular topic. It can be used to activate prior knowledge of the topic and enables them to connect their prior knowledge to that of the rest of the group. After a discussion of measuring cups, scales, measuring spoons etc., ask the students for ways in which these items are used correctly. For instance, would you use a measuring cup or a glass to measure the amount of water needed in a cake recipe? Why? Do you think that using the correct measuring device to give a small child a dose of medicine is really necessary? What would be the result of using a tablespoon if the correct dosage of medicine is a half teaspoon?

Show the students an assortment of measuring devices such as graduated cylinders, graduated beakers, graduated pipettes, a buret. Use items that your students will actually use during your labs. Be sure that students know how to

1. properly read the equipment they will be using
2. record their measurements to the correct number of significant figures.

Problem: Determine the volume of 50.0 g of water. The density of water is 1g/mL.

Instruct *each* student to

1. Write a testable question as to which measuring device will produce the most accurate result.
2. Design a procedure to test/answer their question:
    a. Include all safety issues for the procedure
    b. Identify the variables and controls
    c. List all materials needed for their procedure.
3. Have the procedure approved by the teacher.

Divide the class into groups. Instruct the students to read the procedures for each group member and select the procedure they will actually use. (Be sure all materials are available for the procedures.) Instruct the students to follow the chosen procedure and to collect and record their data in their science *learning log* (view literacy strategy descriptions) as a data table. Tell the students they are to repeat the experiment three times. On completion of the activity, they are to calculate the average of the volumes of water and to determine the precision and accuracy of their measurements. To determine the validity of the data, a conclusion is to be written describing the success (or failure) of their prediction. Tell the students that milliliters measure the same volume as cubic centimeters (cc's). These are the same cc's that doctors order when medications need to be given as injections.

Activity 4: Accuracy (SI GLEs: 4, 5; PS GLEs: 2, 3)

Materials List: graduated cylinder, metal samples, water source, rulers, string, chemistry handbook or accepted value of the density of the metal(s) used

Following a teacher demonstration of the calculation of percent error, provide students with a sample of a common metal. Each student in the group should measure the mass and volume of the metal. An average mass and volume should be calculated and used to determine the density. Students should compare the calculated value with the theoretical/accepted value for the sample obtained from a chemistry handbook. Students should calculate the percent error to determine accuracy using correct significant figures in calculations.

Activity 5: From What to What? (SI GLEs: 5, 7; PS GLEs: 1, 3, 4,)

Materials List: flashcards made of card stock or index cards, index cards with problems on each one, resealable plastic bags

$\frac{1\,meter}{100cm}$	$\frac{100\,cm}{1m}$	$\frac{1\,m}{1000\,mm}$	$\frac{1000\,mm}{1\,m}$
$\frac{1\,m}{10\,dm}$	$\frac{10\,dm}{1\,m}$	$\frac{1\,km}{1000\,m}$	$\frac{1000\,m}{1\,km}$
$\frac{1\,dm}{10\,cm}$	$\frac{10\,cm}{1\,dm}$	$\frac{1\,cm}{10\,mm}$	$\frac{10mm}{1\,cm}$
$\frac{1\,dm}{100\,mm}$	$\frac{100\,mm}{1\,dm}$		
$\frac{1\,hr}{60\,\text{min}}$	$\frac{60\,\text{min}}{1\,hr}$	$\frac{1\,\text{min}}{60\,s}$	$\frac{60\,s}{1\,\text{min}}$

Make flashcards on index cards or card stock with the facts listed above. Use matching terms on opposite sides of the cards. (See highlighted areas above) After they are made, keep in plastic storage bags for future use. Write the problem on the board: Convert 5.83 km into mm. Tell the students that for these metric conversions factors, all numbers have an infinite number of significant figures and all answers will have the same number of significant figures as the original number. Also remind students to use scientific notation where applicable. (See possible solutions on the next page.)

Create a modified science *story chain* (view literacy strategy descriptions). Put students in groups of four. Ask the first student to copy the problem on the board on an index card.

Have that student choose one of the flashcards to start the conversion process. Have the student explain to his group why he chose that card. The next student adds another card and explains his choice. Continue the process with each student until the group agrees that enough cards have been used to solve the problem. Each person in the group should copy the problem and calculate the answer using the correct number of significant figures.

Provide a set of index cards with problems to be solved using this method. The starting position should be rotated with each problem.
Once students understand the process, they are to write an explanation of the process in their own words in their science *learning logs* (view literacy strategy descriptions). Students should also include a list of all facts on the cards in their science *learning logs*. Additional conversion factors that your students will be required to use are to be added to the list as needed. Instruct the students to memorize these facts for use in various problems throughout the course.

Possible solutions:

$$\frac{5.83\,km}{} \times \frac{1000\,m}{1\,km} \times \frac{1000\,mm}{1\,m} = 5.83 \text{ X } 10^6 mm \quad \text{Or}$$

$$\frac{5.83\,km}{} \times \frac{1000\,m}{1\,km} \times \frac{10\,dm}{1\,m} \times \frac{10\,cm}{1\,dm} \times \frac{10\,mm}{1\,cm} = 5.83 X\, 10^6\, mm$$

Emphasize that the number of steps needed to solve the problem depends on their thought process.

Solving a problem that starts with a ratio:

Convert $\frac{75\,km}{hr}$ *to* $\frac{mm}{s}$. Emphasize that ratios such as miles/ hr should be written $\frac{miles}{hr}$ to make the canceling of units more visible.

Solution: $$\frac{75\,km}{1\,hr} \times \frac{1000\,m}{1\,km} \times \frac{1\,hr}{60\,min} \times \frac{1\,min}{60\,s} \times \frac{1000\,mm}{1\,m}$$

Using unfamiliar units, have students use the factor-label method (dimensional analysis) to convert a quantity expressed in one unit to another unit. Give students these equivalents: 1 wag = 12 zooms; 1,000 warps = 1 bam; 3 zoom = 1 bam. Demonstrate problem set-up and calculations to solve a simple conversion using these units. Have students show calculations for converting eight wags to warps. Provide at least five simple conversion problems for individual student practice. Have students solve simple conversions between U.S. units and metric units as well as simple word problems.

Solution: $$\frac{8 \text{ wags}}{} \; X \; \frac{12\,zooms}{1\,wag} \; X \; \frac{1\,bam}{3\,zooms} \; X \; \frac{1000\,warps}{1\,bam} = 32\,000\,warps$$

Sample Assessments

General Guidelines

Assessment techniques should include drawings/illustrations/models, laboratory investigations with reports, laboratory practical (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), science *learning log* entries, and paper-and-pencil tests (traditional summative assessments).

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will be given a written quiz to assess understanding of safety in the chemistry lab as well as the names of common lab equipment.
- The student will participate in a mock fire drill to reinforce evacuation procedures from the lab.
- The student will conduct a laboratory practical to assess measurement skills for determining (1) mass using a balance, (2) distances using a meter stick and metric ruler, and (3) volumes of liquids and solids using graduated cylinders.
- The student will be given a written test to evaluate student ability to perform conversions using the factor-label method of problem solving, to determine the number of significant figures in a series of measurements and to express numbers in scientific notation.
- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

Activity- Specific Assessments

- Activity 1: Set up lab stations with a variety of laboratory set ups for students to evaluate (e.g., heating a solution: a burner, ring stand with ring and wire gauze, beaker of water). Students will rotate through the stations identifying what safety issues need to be addressed and how they should to be handled.

- Activity 2: Set up lab stations with a variety of laboratory equipment such as rulers, graduated cylinders, triple beam balances and thermometers. Provide various items to measure such as different size beakers (record the mass of each) or fill the graduated cylinders with different volumes of water. Require the student to record all measurements to the correct number of significant figures. Construct a grading rubric involving students in its development. Refer to Specific Assessment Rubric BLM.

- Activity 5: Provide students with 3-5 index cards with problems of varying difficulty written on them. Students are to demonstrate their ability to solve problems using the facts in the factor-label format by solving the assigned problems on loose-leaf paper. After a specified time, students are to exchange papers for peer correction. Use metric conversions as well as word problems.

Resources

- General Chemistry Online. *Tutorial, Drill, and Quiz Index.* Available online at http://antoine.frostburg.edu/cgi-bin/senese/tutorials/sigfig/index.cgi
- NTTI. *Significant What?* Available online at http://www.thirteen.org/edonline/ntti/resources/lessons/significant This site provides a complete lesson plan dealing with accuracy and precision, significant figures, and math problems. Required materials include Video**:** World of Chemistry #3: "Measurement" and five to six Velcro-type dart board game sets per class.

Chemistry
Unit 2: Matter

Time Frame: Two weeks

Unit Description

This unit focuses on the classification, properties, and changes of matter.

Student Understandings

Students will understand the organization of matter, its chemical and physical properties, and the chemical and physical changes it undergoes. Students will demonstrate their understanding by molecular level drawings, classifying various properties and changes as either chemical or physical, and providing evidence to support their decisions.

Guiding Questions

1. Can students describe, differentiate, and provide examples of elements, compounds, and mixtures?
2. Can students describe, differentiate, and provide examples of physical properties, physical changes, chemical properties, and chemical changes?
3. Can students use their knowledge of physical properties and changes to separate an unknown mixture?
4. Can students describe, differentiate, and provide examples of solids, liquids and gases?

Unit 2 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
1.	Write a testable question or hypothesis when given a topic (SI-H-A1)
3.	Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls (SI-H-A2)
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)

GLE #	GLE Text and Benchmarks
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
15.	Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)
Physical Science	
1.	Convert metric system units involving length, mass, volume, and time using dimensional analysis (i.e., factor-label method) (PS-H-A1)
14.	Identify unknowns as elements, compounds, or mixtures based on physical properties (e.g., density, melting point, boiling point, solubility) (PS-H-C1)
21.	Design and conduct a laboratory investigation in which physical properties are used to separate the substances in a mixture (PS-H-C4)
31.	Describe chemical changes and reactions using diagrams and descriptions of the reactants, products and energy changes (PS-H-D1)

Sample Activities

Activity 1: Classification of Matter (SI GLE: 5, 7)

Materials List: card stock, Card Sort Template 1 and 2 BLMs, Sample Concept Map BLM, scissors**,** plastic storage bags, newsprint, markers, masking tape to hang student work on wall

Part 1: Copy Card Sort Template 1 BLM onto card stock, making one set per group. Cut the words apart to make individual cards. Place the cards into a plastic storage bag marked Bag 1. Distribute a set of the cards to each group. Students should be instructed to *brainstorm* (view literacy strategy descriptions) descriptions of the terms used from common knowledge. Brainstorming involves more than one person discussing a common idea. Tell the students to develop a concept map *graphic organizer* (view literacy strategy descriptions) on matter, making sure that all of the connecting words/phrases are included. The concept map should then be drawn on newsprint or other large paper sheets using a marker. The entire concept map should be the same color. (refer to the unshaded part of the Sample Concept Map BLM*)*

Part 2: Copy Card Sort Template 2 BLM onto card stock, making one set per group. Cut the words apart to make individual cards. Mark the back of these cards with an X or make this set of cards a different color. This will help to place the cards in the correct bag when the activity is completed. Place the cards into a plastic storage bag marked Bag 2. Distribute a set of the cards to each group. Students should be instructed to *brainstorm* (view literacy strategy descriptions) and determine where to place this set of terms within the previous concept map. The words should be added to the concept map using a different color marker. Connecting words/ phrases should be included. (refer to the shaded part of the Sample Concept Map BLM)

When the groups are finished with the cards, they are to separate the cards and place them in the appropriate bag. Both bags of cards can then be placed in a larger storage bag for future use.

Part 3: Each group should make a presentation in front of the class, being sure to explain why they made the connections illustrated on their map. After each presentation, give the other groups an opportunity to agree or disagree with any of the connections. An explanation of what they agree/disagree on and why should be given. When all presentations have been made, the teacher should draw a concept map *graphic organizer* (view literacy strategy descriptions) or use one of several computer programs that will generate a concept map format, refer to Sample Concept Map BLM, to reemphasize the actual connections between these terms. This will prevent misconceptions from being reinforced and clarify the classification of matter. The student generated materials can be taped to the wall (if allowed) and be referred to as needed.

Activity 2: Identifying Elements, Compounds and Mixtures (SI GLE: 7; PS GLE: 14)

Materials List: beakers, salt, copper shot, jar, water, can of soda, Sample Word Grid BLM

Activate prior knowledge of the three types of matter—elements, compounds, and mixtures—by displaying a beaker of salt, a jar of copper shot, and a beaker of water. Pour some of the salt and water into a fourth beaker. Pour some of the copper and water into a fifth beaker. In small student groups, instruct students to discuss the items and make a *word grid* (view literacy strategy descriptions) (See Sample Word Grid BLM) to compare and contrast the items. Tell students to determine whether each material is an element, a compound, or a mixture. Discuss their lists. Hopefully, one group will determine that the helium in the balloon is an element, the salt is a compound, copper and water form a mixture, and the soda is a solution. Ask the students to list items found in their homes and identify them as elements, compounds, and mixtures. The students are to include reasons for their choices. Give students time to quiz each other over the information in the grid in preparation for tests and other class activities.

The website http://www.chem.purdue.edu/gchelp/atoms/elements.html shows a molecular level animation of the particles of gaseous elements, compounds, and mixtures in motion as well as providing descriptions of the terms.

Activity 3: Separation of a Mixture (SI GLEs: 3, 10; PS GLE:14, 21)

Materials List: film canisters or other type of container, water, spoons, filter paper, funnels, magnets (covered with some type of material such as plastic wrap to make it easy to remove the iron filings), pieces of cheesecloth or plastic screens or wire gauze, balance, forceps, salt, sand, poppy seeds, iron filings or mossy zinc pieces, burners, ring stands (hot plates), strikers, evaporating dishes, goggles, aprons, science *learning logs.*

The objective of this activity is for students to use their previous knowledge of physical properties to separate a mixture. Students are to write a step-by-step procedure for separating the components using the available equipment. All safety issues must be addressed. Students should be familiar with lab safety, filtering apparatus, and using a lab burner with a ring stand (or hot plate) before starting.

Provide premixed samples of sugar or salt, sand, poppy seeds (they will float), and iron filings or pieces of mossy zinc and place the materials in a film canister, beaker or other appropriate container. A tablespoon of the mixture should be enough. Describe to the class the mixture they will separate. Students should be assigned to group of 3-4 students. Provide a list of all available equipment and the premixed sample to each group. Allow time for the students to explore the physical properties of each component to determine the method of separation. Instruct each group they are to write a step-by-step procedure for separating the mixture using the available equipment. In their science *learning logs* (view literacy strategy descriptions), students are to supply the following information: purpose, hypothesis, material list, and procedure. Instruct the students to gather the materials listed and perform their experiment. Students should record their results. Instruct the students to include in their reports, a list of the physical properties of each material that was used to separate it from the mixture and what technique was used for the separation of each material. The teacher should assist the students to develop a conclusion if this has not been done previously.

If electronic balances and/or probe ware are available, they should be incorporated into this activity.

Note: If time is a factor, the iron filings can be omitted and mossy zinc added. The zinc can easily be removed with the forceps.

Activity 4: States of Matter (SI GLEs: 1, 5, 7)

Materials List: Three Worlds of Chemistry BLM, science *learning logs*

Activate the students' prior knowledge of the states of matter by having them, in groups, *brainstorm* (view literacy strategy descriptions) what they know about the states of matter. Review the states of matter and changes of state. Explain to students the difference between the macroscopic world, the molecular world and the symbolic world using the Three Worlds of Chemistry BLM. An overview of the difference between the macroscopic world, the molecular world, and the symbolic world can be found at http://www.doe.state.la.us/lde/uploads/2007.pdf .

Ask students if changing states is a physical or chemical change. Have students do a molecular level drawing of a solid substance changing states. Drawings are to be done in their science *learning logs* (view literacy strategy descriptions). Plasma should be mentioned as a high energy state of matter that is a mixture of positive ions and electrons. It is the most abundant state of matter in the universe but not on Earth. A drawing of the substance in the plasma state can also be included. Students are to include a written description of the movement of the particles in each state.

Examples:

Molecular Level Drawings of the States of Matter

The following link has an excellent microscopic view of the motion of the particles in the gaseous, liquid, and solid states. An explanation of the arrangement and motion of the particles of the various states of matter as well as a table that summarizes the properties and identifies the behavior responsible for each property are also included on this website: http://www.chem.purdue.edu/gchelp/liquids/character.html

Activity 5: Density Discovery (SI GLEs: 4, 5, 7; PS GLE: 1)

Materials List: various shaped objects of different materials that are not soluble in water, rulers, string, balance, water source, and graduated cylinder, Density BLM

Make a transparency of the Density BLM. Place the transparency on an overhead projector. Activate prior knowledge by asking the students to respond, in their science *learning logs* (view literacy strategy descriptions), to the question *Each box has the same volume. If each ball has the same mass, which box would weigh more? Why? (The box that has more balls has more mass per unit of volume. Mass per unit of volume is an intensive property of matter called density.)*

Gather enough objects of the same material (plastic, metallic or wooden) to distribute three objects of one material to each group. Try to collect various shapes such as cylinders, spheres, cubes, rectangles, etc. Calculate the density of each material before handing out the objects and record the data. This data will be needed to insure the densities that the students calculate are correct.

Divide the class into groups. Distribute three different sized or shaped objects of one type of material to a group. Students are to measure the mass and volume (by water displacement or by using the appropriate mathematical volume formula) of each item. The density of each sample should be calculated and averaged. The density value should be a constant.

Have each group list their findings in chart form, according to the material and record on the board. Instruct the students to construct a line graph using their group's data. The graph should show a direct relationship between the masses and volumes.

Discuss *intensive* (properties that depend on the amount of matter in the object such as length) and *extensive properties* (properties that not depend on the amount of matter in the object such as density or color). Refer the students to the graphs, and ask students if density is an extensive or intensive property. The students should realize that density is an intensive property because regardless of the size of the sample, the density of the material is a constant. Give students the densities of water, oil, or any other liquid they may be familiar with. Ask which, if any, object(s) used in the activity will float in these various liquids. Discuss how the concept of specific gravity, which is a ratio of the density of the substance with the density of water, does not have units because they cancel in the ratio.

$$\text{specific gravity} = \frac{\text{density of substance (g / cm}^3\text{)}}{\text{density of water (g / cm}^3\text{)}}$$

Teacher-generated worksheets should provide problems which require the students to use factor- label to convert a variety of larger and smaller units into the standard g/mL density units.

Activity 6: Chemical and Physical Changes Lab Carousel (SI GLEs: 4, 5, 7, 9, 15, PS GLE: 31)

Materials List: aprons, goggles, water, beaker, hot plate, effervescent tablet, graduated cylinder, plastic cup, water soluble transparency pen, dry ice, light sticks or any materials readily available to the teacher, Split-Page Notetaking BLM

Set up lab stations with different materials that can be used by the students to perform various chemical and physical changes.
Example:

- small container of dry ice (sublimation)
- effervescent tablet to be placed in water (production of bubbles)
- unactivated light sticks to be activated by breaking inner tube of chemicals
- pieces of paper to cut and then burn
- a dot of transparency pen ink on a piece of filter paper and a pipet of water to be dispensed drop-wise on the ink (for chromatography)

Provide specific directions for each station along with all safety issues involved with the procedure. Students should perform the activity and record all observations. Using *split-page notetaking* (view literacy strategy descriptions) students should identify what type of change is observed at each station based on the observed chemical and physical properties. Split-page notetaking is a logical organization of information and ideas. It helps to separate big ideas from supporting details. Tell the students to draw a line from top to bottom approximately 2 to 3 inches from the left edge on a sheet of notepaper. Model the approach by using the Split-Page Notetaking BLM as a guide. Evidence of chemical reaction should be recorded where applicable. Students should describe the reactions in terms citing evidence of chemical changes in the reactants, products formed, and energy changes. On the left side of the page, describe the original material; on the right-hand side, describe the properties of the material after the activity. Encourage students to study from their notes in preparation for tests and other class activities by covering the information in one column and using the information in the other to prompt their recall.

Sample Assessments

Assessment techniques should include drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), writings in their science *learning logs*, group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

General Guidelines

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

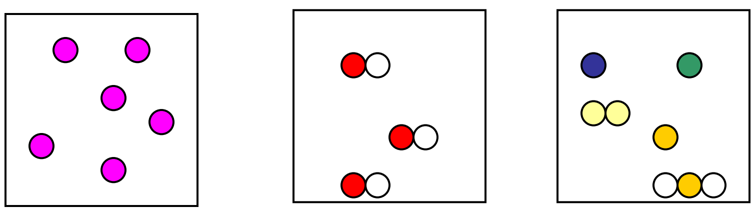
General Assessments

- The student will provide the sequence of separating a mixture of known materials based on physical properties.
- The student will explain why the phrase *heterogeneous substance* is inaccurate.
- The student will list additional chemical and physical changes besides the ones observed in any of the listed activities.
- The student will construct a concept map after completing all activities that will be graded with a rubric.

Activity- Specific Assessments

- Activity 2: Discuss any safety issues before beginning the lab assessment. Set up lab stations with various samples of elements, compounds and mixtures. Students rotate through the stations identifying the type of material as an element, compound, or mixture. Students should provide supporting evidence for their choices.

- Activity 3: Have students do molecular level drawing of elements, compounds, and mixtures in *science learning logs*.



Element Compound Mixture

- Activity 5: Magic Popcorn Density Demonstration Assessment

  Materials List: Clear colorless container large enough for all students to see well from their seats, enough un-popped popcorn to fill the container half-full, 2 ping pong balls, BBs, piece of tape, marker, science *learning log.*

  Advance Preparation: Poke a small hole in one of the balls. Fill the ball about half full with BBs. Cover the hole with a small piece of tape. Using the marker, make large dots all over the BB filled ball. Pour the popcorn into the container. Take the plain ping pong ball and push it under the popcorn in the center of the container so that it cannot be seen (about 2-3" down). Place the BB ball slightly to the side of the position of the marked ball on top of the popcorn with the tape side down.

Procedure:

1. Place the prepared container on a desk or table in the front of the class.
2. In their learning logs, ask the students to write their observations and to predict what will happen when you shake the container,
3. Instruct the students to watch what you do with the "Magic Popcorn" and be ready to write an explanation of what they think happened.
4. Carefully pick up the container and gently shake it from side to side. (As you shake the container, the BB ball will begin to sink into the popcorn and the plain ping pong ball will rise to the surface, giving the appearance that the BB ball has been changed by the Magic Popcorn.) Be sure to practice before you do this demonstration.
5. When the demonstration is completed, allow time for the students to record their observations and explanations.
6. Collect the science *learning logs* to be graded.
7. Facilitate a discussion of what actually occurred.

This demonstration assessment works well as a follow-up to the study of density. Ask guiding questions to lead students to the realization that the ping pong ball that rose to the top of the popcorn must be less dense than the one that sank into the popcorn. The movement of the popcorn can be compared to the behavior of fluids (the popcorn kernels tumble over and around one another like liquid and gas particles do), so materials of different densities can move throughout the system.

Resources

- *Elements, Compounds, and Mixtures*. Available online at http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch2/mixframe.html
- *SMILE Program Chemistry Index*. Available online at http://www.iit.edu/~smile/cheminde.html
- Popcorn activity courtesy of *Chemical Concepts and Connections*, (C_3 Program) Louisiana Tech, Ruston, Louisiana. http://c3.latech.edu

Chemistry
Unit 3: Atoms and the Periodic Table

Time Frame: Approximately four weeks

Unit Description

This unit focuses on the development of the modern atomic theory, atomic structure and the periodic table.

Student Understandings

Students will understand the history of the development of the atomic theory and the periodic table. They will understand how atomic and electron structure affect the periodic trends. They will understand how periodic trends can be used to predict whether an element is a metal, nonmetal, or metalloid as well as predicting ion formation and bond type based on an element's location on the periodic table. Atomic timelines, models, and documentation throughout the activities will provide evidence of students' understanding of these items.

Guiding Questions

1. Can students trace the development of the atomic theory through modern times?
2. Can students represent the structure of the atom using a variety of models?
3. Can students predict the physical properties and chemical properties of an element based on its location on the periodic table and provide the rationales for the predictions?
4. Can students differentiate between mass number and atomic mass and relate these terms to isotopes of elements?
5. Can students identify the types of radiation and radioactive decay and give an example of each?
6. Can students explain what is meant by *half-life* of a radioactive substance?
7. Can students describe the benefits of using radioactive substances?

Unit 3 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
2.	Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)

GLE #	GLE Text and Benchmarks
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
8.	Give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected (SI-H-A5)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
11.	Evaluate selected theories based on supporting scientific evidence (SI-H-B1)
13.	Identify scientific evidence that has caused modifications in previously accepted theories (SI-H-B2)
14.	Cite examples of scientific advances and emerging technologies and how they affect society (e.g., MRI, DNA in forensics) (SI-H-B3)
16.	Use the following rules of evidence to examine experimental results: (a) Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability? (b) Has the technique or theory been subjected to peer review and publication? (c) What is the known or potential rate of error of the technique or theory when applied? (d) Were standards and controls applied and maintained? (e) Has the technique or theory been generally accepted in the scientific community? (SI-H-B5) (SI-H-B1) (SI-H-B4)
Physical Science	
8.	Analyze the development of the modern atomic theory from a historical perspective (PS-H-B1)
9.	Draw accurate valence electron configurations and Lewis dot structures for selected molecules, ionic and covalent compounds, and chemical equations (PS-H-B1)
10.	Differentiate among *alpha, beta*, and *gamma* emissions (PS-H-B2)
11.	Calculate the amount of radioactive substance remaining after a given number of half-lives has passed (PS-H-B2)
12.	Describe the uses of radioactive isotopes and radiation in such areas as plant and animal research, health care, and food preservation (PS-H-B2)
13.	Identify the number of bonds an atom can form given the number of valence electrons (PS-H-B3)
15.	Predict the physical and chemical properties of an element based only on its location in the periodic table (PS-H-C2)
16.	Predict the stable ion(s) an element is likely to form when it reacts with other specified elements (PS-H-C2)
17.	Use the periodic table to compare electronegativities and ionization energies of elements to explain periodic properties, such as atomic size (PS-H-C2)

Sample Activities

Activity 1: Atomic Theory Timeline (SI GLEs: 2, 6, 8, 11, 13, 16; PS GLE: 8, 12, 16)

Materials List: poster board, paper strips or software, library books or other reference materials

The teacher should explain to the students that scientists conduct investigations for various reasons such as inquisitiveness (Newton), to address a societal need (Pasteur, Edison, Salk), to validate or invalidate another scientists findings (atomic theory), the challenge (Watson & Crick), or for money such as pharmaceutical testing today.

Students will do a web quest (or use library books) of scientists involved with the development of the atomic theories. Scientists to be included: Leucippus, Democritus, Aristotle, Thomson, Bohr, Rutherford, Dalton, Einstein, Millikan, Planck, Geiger, Chadwich, and Moseley. Information to be gathered: dates of birth and death, major contributions to the atomic theory, if they followed a scientific method (if applicable), a description of their model of the atom (if applicable), a picture of the man/model, etc. This information is to be developed into a timeline on paper strips or poster board or using available software in a creative manner and shared with the class. Students should realize that a literature search and description, such as they are doing in this activity, is also an investigation. Students should include a summary using their timelines to give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected and to identify scientific evidence that has caused modifications in previously accepted theories. The students should also explain the reasons why the various scientific investigations were conducted.

Instruct students to evaluate one of the scientists in terms of the ideas presented in the theory. Use the following rules of evidence to examine experimental results:

- Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability?
- Has the technique or theory been subjected to peer review and publication?
- What is the known or potential rate of error of the technique or theory when applied?
- Were standards and controls applied and maintained?
- Has the technique or theory been generally accepted in the scientific community?

Activity 2: Isotopes of Pennies (SI GLEs: 4, 5, 9)

Materials List**:** goggles, balance, an empty 35 mm film canister, six pennies made before 1982 and seven made after 1982 , ten pennies to place in the film canister

The purpose of this activity is to demonstrate that isotopes of an element have different masses, that isotopes are atoms of the same element that have different numbers of neutrons, and that atomic mass is the weighted average of the naturally occurring isotopes of an element.

The directions, student worksheet, and assessment tool can be found at the website http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=4&DocID=176. This website activity is the first of three that deals with isotopes, radioactive decay and the nucleus. The radioactive decay part of the lesson at this website will be used in Activity 6 of this unit.

Activity 3: The Periodic Table (SI GLE: 13; PS GLE: 15)

Materials List: card stock, Exploring the Periodic Table BLM, color printer or markers, resealable plastic bags or envelopes, scissors, periodic table

Copy the Exploring the Periodic Table BLM onto card stock. If a color printer is available, make enough copies for each group. If a color printer is not available, simply outline each group of elements with different colored markers. Cut the pieces apart and put pieces into a container such as a sealable plastic bag or envelope. Remove the Ga and Ge cards from each set of cards and place in a separate bag or envelope.

- **Part 1**
  Instruct the students to arrange the cards into some type of order and write a summary explaining why the arrangement was chosen. They are to copy the arrangement into their science *learning logs*(view literacy strategy descriptions). Ask the students if there is anything unusual about their arrangement? (There may be a hole in the chart.) List all answers on the board. Guide them to the holes in the pattern and ask them to predict the properties of the missing cards and, using a periodic table, identify the missing elements. If this identification is correct, give them the missing cards. Explain Mendeleev's periodic table: how it was arranged and why. Include the fact that he predicted the properties of the missing elements with great accuracy and used atomic mass and properties to arrange the elements.

- **Part 2**
  Tell the students to arrange their charts in numerical order (atomic masses are given) if they have not already done so. Ask them to identify any problems they may have with this arrangement. Guide them to the Te and I cards. Explain that this was a problem for Mendeleev also. Refer the students back to the Activity 1

timeline and determine the name of the scientist responsible for the atomic number of the element (Mosely). Explain that this discovery rearranged all of the elements in order of properties and took care of the mass problems also.

- **Part 3**
  Assign each row of students a particular representative group of elements. Assign each student in the row a particular element in the group to research. Information to include: name, group number, period number, atomic number, mass number, chemical and physical properties (such as chemical reactivity, melting points, etc), and number of valence electrons. Once all the information has been gathered, put the row of students into a group and compile a list of similarities, differences, and trends for the group of elements assigned.
  - *Tell each row of students they will be called on randomly to come to the front of the room to be a team of* "professor know-it-alls" *(view literacy strategy descriptions) about their particular group of elements. Have groups prepare by thinking up questions about their research in order to compare their data to that of the other groups. For example*
    - *What is the general trend in atomic number for your group of elements? (*increases down the group)
    - *What is the trend in mass for your group of elements*? (increases down a group)
    - *What is the trend in reactivity down the group?*(groups 1-3,14 activity generally increases for groups 15-18 activity generally decreases)
    - *What is the trend in melting and boiling points down a group*?(for the halogens, melting and boiling points increase)
    - *For groups 1and 2 and 15-18, , what is the most stable ion formed?(*review the charges on the ions formed by elements in these groups)

Call on a group of students to come to the front of the room. Ask students to stand shoulder to shoulder. Invite questions from the other groups. Demonstrate how you would like to the *professor know-it-alls* to answer each question. First, they should huddle as a team to talk about the answer, then return to their positions and give answer in complete sentences. After answering all questions, ask a new group of *professor know-it-alls* to take their place in front of the class, and continue the process of students questioning students. This should be done until all groups have had a chance to serve as *professor know-it-alls*. The teacher should also ask questions to each of the groups. Students asking the questions should hold the *professor know-it-alls* accountable for the correct answers. Compile all lists to see a sample of the variety of patterns exhibited on the periodic table. Students should be able to identify elements as metals, nonmetals, or metalloids by examining the trends. Tie this in with the zigzag line on the periodic table. Students should be able to use this information to determine the physical and chemical properties of an element based on its location on the periodic table when assigned a specific representative element.

This activity should be repeated using the elements in the same period.

Activity 4: Periodic Table Trends (SI GLE: 5, 9; PS GLE: 9, 17)

Materials List: periodic table or reference materials that list electronegativity, ionization energy, and atomic radii values, GISTing BLM

Provide students with a copy of the periodic table that includes electronegativity values, ionization energy values, and atomic radius. After a discussion of these terms, conduct a think-pair-share activity by having students work independently to study the values and write down five observations of trends or patterns they see. Have students pair with a partner, share observations, and compile a list. Have pairs of students join other pairs to compile larger lists. Conclude by compiling a class list of observations and periodic trends. The student will graph the values for electronegativity values, ionization energy values, and atomic sizes either on paper, using a graphing calculator or marker board. Discuss with students the relationships among atomic size, ionization values, and electronegativity values. Relate all three values to the predicted type of bonding of the element. Have students predict bonding tendencies from the position of elements on the periodic table and predict the ion formed when selected elements react with other specific elements. Students will use a modified *GISTing* (view literacy strategy descriptions) to summarize the stated periodic trends. *GISTing* is an excellent strategy for helping students paraphrase and summarize essential information. Students are required to limit the gist of a paragraph to a set number of words. Individual sentences from a paragraph are presented one at a time while students create a gist that must contain only the predetermined number of words. By limiting the total number of words students can use, this approach to summarizing forces them to think about only the most important information in a paragraph, which is the essence of comprehension.

The first step in teaching *GISTing* the teacher selects appropriate paragraphs on which to write gists. It's best to start with relatively short paragraphs of no more than three to five sentences that are easily understood. Second, the teacher establishes a limited number of spaces to represent the total number of words of the gist, say 15 or so. Third, students read the sentences of the paragraph and, using only the spaces allowed, write a statement in those spaces capturing the essential information of the sentences. This is the beginning of their gist. Fourth, the teacher has students read the second sentence of the paragraph and, using the information from the first and second sentences of the paragraph, they rewrite their gist statement by combining information from the first sentence with information from the second. Again, the students' revised gist statement should be no more than the allotted number of spaces. This process continues with the remaining sentences of the paragraph. As students read each succeeding sentence they should rework their gist statement by accommodating any new information from the sentence into the existing gist statement, while not using any more than the allotted number of spaces. Finally, students should share their gists for comment and critique. Refer to the GISTing BLM as a guide.

A discussion of electron configuration should follow this activity. Electron configuration can then be used to explain the arrangement of the modern periodic table. Emphasize that the properties are periodic (repeating) because of similar outer electron configuration.

Activity 5: A Date with Chemistry (PS GLEs: 13)

Materials List: copies of WebElements.com's Periodic Table to be downloaded and printed from http://www.webelements.com/, copies of Chemical Elements.com's Periodic Table to be downloaded and printed from http://www.chemicalelements.com/, pens/pencils, paper, copies of "Sometimes, the March of Science Goes Backward" from the website http://sanacacio.net/118_saga/essay.html, resources for researching the elements (science and chemistry textbooks, encyclopedias, books on the elements, computers with Internet access)

In this activity, students will research certain elements and then analyze their potential bond formation with other elements in a dating game, where the dating pool is composed of the elements featured on the periodic table. The printer friendly version of the entire lesson, including complete instructions and links to all necessary websites can be found at http://www.nytimes.com/learning/teachers/lessons/20020723tuesday_print.html.

Activity 6: Nuclear Chemistry (SI GLEs: 6, 14; PS GLEs: 10, 11, 12)

Materials List: Radioactive Decay: A Sweet Simulation of Half-life student sheet—one copy for each student from the website http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=4&DocID=178, For each pair of students, 80 small candies such as plain M&M's® or Skittles®; paper towels, cups

Ask students what they think of when they hear the word *radiation*. Take all responses from students. Students may mention many negative ideas. Radioactivity *can be* very dangerous and it must be treated with care and respect. However, it can also be very useful. Ask students to name any positive uses for radioactive materials. Take all responses from students. Point out practical uses that students do not mention, such as carbon dating, X-rays, nuclear power production, cancer treatment, and medical tracers. Return to the applications at the end of the activity as closure tasks.

Have students develop a timeline of significant discoveries with regard to radioactivity, discussing how theories and knowledge evolved with each new discovery. Discuss the role of technology in advancing the work of scientists. Provide instruction and illustrations on alpha, beta, and gamma radiation. Conclude this task by having students organize information regarding radioactivity, types of radiation, and types of radioactive decay.

Have students write or diagram nuclear reactions for each type of radioactive decay. Conclude with a discussion in which guiding questions are used to lead students to describe negative effects of radiation for humans, safety considerations, and practical, positive uses for radioactive isotopes and disposal of radioactive material.

Following the discussion on the negative aspects of radiation, implement the lesson, *Radioactive Decay: A Sweet Simulation of a Half-life* found at http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=4&DocID=178. This activity is a continuation of Activity 1.

Sample Assessments

Assessment techniques should include drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

General Guidelines

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will calculate the average mass of a given element given the relative abundance and atomic masses of the element.
- The student will determine the age of the fossil given the half-life of a selected radioactive isotope, the amount of that isotope in a living organism, and the amount of the specific isotope remaining in a fossil.

Activity-Specific Assessments

- Activity 1: Develop a rubric in conjunction with the students for use in evaluating student work on the atomic theory timeline.

- Activity 2: Make a chart similar to this:

Symbol	Atomic number	Mass number	# of p+	# of n^0	# of e-	Atom or ion
$^{64}_{30}Zn$						
Zn-65						
			7	7	6	

Fill in minimal information and have students complete the rest of the chart.

- Activity 6: Have students assume that one minute equals 100 years and that the sample needs to decay to 1/16 of its original amount to be considered safe. Have them explain (1) how many years you would have to be concerned about the radioactivity of the sample, and (2) how you would dispose of this material. Be sure students justify their responses.

Resources

- *Chemical Elements*. Available online at http://www.chemicalelements.com/
- *The Isotopes Project Homepage*. Available online at http://isotopes.lbl.gov/ip.html
- Item HE 1325, SCASS Science Assessment Resource CD-ROM by Council of Chief State School Officers
- Science NetLinks. *Isotope Pennies*. Available online at http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=4&DocID=176
- *Smile Program Chemistry Index*. Available online at http://www.iit.edu/~smile/cheminde.html
- *WebElements*. Available online at http://www.webelements.com/

Chemistry
Unit 4: Chemical Bonding and The Formation of Compounds

Time Frame: Approximately four-weeks

Unit Description

The focus of this unit is bonding, molecular shape, intermolecular forces, and chemical formulas.

Student Understandings

The student will understand how to predict the type of chemical bond in a compound by using the periodic table and Lewis dot structures to model bond type. The student will be able to understand how to predict the shape of simple molecules by drawing Lewis Structures showing the correct molecular geometry. The student will understand intermolecular forces of attraction and their impact on the physical and chemical properties of substances by writing a *RAFT*ing paragraph.

Guiding Questions

1. Can students predict the bond type of a compound?
2. Can students predict the molecular geometry of simple compounds?
3. Can students predict the physical and chemical properties of a substance based on the type of bond and intermolecular forces present in the substance?
4. Can students write formulas and name compounds?

Unit 4 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)

GLE #	GLE Text and Benchmarks
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
Physical Science	
5.	Write and name formulas for ionic and covalent compounds (PS-H-A2)
9.	Draw accurate valence electron configurations and Lewis dot structures for selected molecules, ionic and covalent compounds, and chemical equations (PS-H-B1)
15.	Predict the physical and chemical properties of an element based only on its location in the periodic table (PS-H-C2)
16.	Predict the stable ion(s) an element is likely to form when it reacts with other specified elements (PS-H-C2)
22.	Predict the kind of bond that will form between two elements based on electronic structure and electronegativity of the elements (e.g., ionic, polar, nonpolar) (PS-H-C5)
23.	Model chemical bond formation by using Lewis dot diagrams for ionic, polar, and nonpolar compounds (PS-H-C5)
24.	Describe the influence of intermolecular forces on the physical and chemical properties of covalent compounds (PS-H-C5)
46.	Identify and compare intermolecular forces and their effects on physical and chemical properties (PS-H-E1)

Sample Activities

Activity 1: Prediction of Bond Type Using the Periodic Table (SI GLEs: 5, PS GLEs:15, 22)

Materials List: periodic table, Vocabulary Self-Awareness BLM

Vocabulary self- awareness (view literacy strategy descriptions) charts should be used to activate prior knowledge of the terms to be used in this unit. Provide a list of words to students at the beginning of this part of the unit and have them complete a self-assessment of their knowledge of the words using the Vocabulary Self-Awareness BLM. Do not give students definitions or examples at this stage. Ask students to rate their understanding of each word or law with either a "+" (understand well), a "✓" (limited understanding or unsure), or a "-" (don't know). Over the course of the readings and exposure to activities throughout the unit, students should be told to return often to the chart and add new information to it. The goal is to replace all the check marks and minus signs with a plus sign. Because students continually revisit their vocabulary charts to revise their entries, they have multiple opportunities to practice and extend their growing understanding of key terms related to the topic of chemical and physical properties of matter. If after studying these key terms, students still have checks or minuses, the teacher should be prepared to provide extra instruction for these students. Use the Vocabulary Self-Awareness BLM as a guide.

Review the significance of groups/families (number of valence electrons) and the significance of periods (number of electron energy shells). Other concepts to be reviewed are prediction of chemical and physical properties of an element based on its periodic table location, electronegativity values and trends, atomic size trends, ionization energy values and trends, and types of bonds.

Provide a brief description of ionic bonding (electrons are transferred from cation to anion), covalent bonding (electron pairs are shared between atoms) and metallic bonding (attraction between positive metallic ions and the surrounding mobile electrons). Use the general rule of thumb that ionic bonds form between metals (low electronegativity values) and nonmetals (high electronegativity values). Covalent bonds form between nonmetallic atoms and metallic bonds form between adjacent metal atoms. Covalent bonds can be polar (unequal sharing of the electron pair occurs because one atom has a higher electronegativity value than the atom that is going to bond with it) or nonpolar (equal sharing of the electron pair because the electronegativity values of both bonding atoms are very similar).Refer students to their *vocabulary self-awareness charts* to add any additional terms as they are introduced. Provide a guided practice session to predict the bond type (ionic, nonpolar covalent, polar covalent) between a variety of element pairs using the periodic table as a reference.

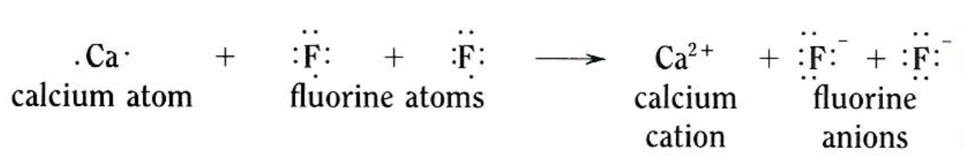
For review or reinforcement, students could visit the following Web site to study the differences in chemical bonding, including, ionic, covalent polar, and covalent nonpolar (pop-up window simulations of the synthesis of sodium chloride, hydrogen, and water are presented): www.visionlearning.com/library/module_viewer.php?mid=55. A video of the actual reaction can be seen at http://jchemed.chem.wisc.edu/jcesoft/cca/cca0/Movies/NACL1.html

Activity 2: Modeling the Formation of Ionic Compounds (SI GLEs: 7, PS GLEs: 5, 9, 16, 23)

Materials List: Ion Cards BLMs, card stock, resealable plastic bags, student handout, periodic table

Begin the activity by using Lewis dot structures to model the transfer of electrons from metallic ions to nonmetallic ions. A demonstration of ionic bonding using valence electron configurations should also be done. Guided practice should be provided to master these types of models.

Example:



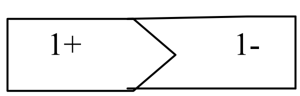
Preparation for the activity:
Each point on the left side of the cards represents an electron that is lost. Each indentation on the right side is an electron gained. Use the patterns in BLM to make ion cards on card stock. Duplicate each sheet at least twice for each group. Have the students cut them out and place the pieces in a resealable plastic bag. These cards will be uses for writing and naming compounds, writing and balancing equations, and demonstrating the law of conservation of mass. Prepare a set to be used on an overhead projector to model the activity for the students. The ion cards can be done (or outlined) with different colors for a better contrast for visual learners.

Teacher: Make a handout (for each group of students) with a list of ions to be made into compounds such as

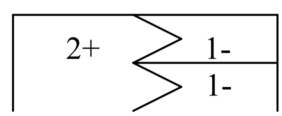
1. sodium + chlorine
2. aluminum + oxygen
3. magnesium + phosphate
4. calcium + fluorine

Distribute a handout, a bag of ion cards, and a periodic table to each student group. Students are to use the periodic table to determine the charge on each ion in the list. They should then choose the appropriate ion card to represent that charge. They are to build each compound, write its formula, and name it correctly.

For example, given the name sodium chloride, students should use the periodic table to determine that sodium has a 1+ charge and chlorine has a 1- charge. Each student should pick a 1+ card and a 1- card and put them together. If all points and indentations match, it represents a formula unit of the compound. Notice that in the compound calcium fluoride, it takes two 1- cards for all points and indentations to match.



sodium chloride



calcium fluoride

Once the student has mastered writing formulas, instruct the students how to name compounds that are ionically bonded. Have the students correctly name the compounds formed in this activity.

Provide teacher demonstrations of how to use elemental symbols, charges, and subscripts to write chemical formulas when given the name of a compound. Provide compound names and have students write the chemical formulas. Provide written formulas and have students use the rules of chemical nomenclature, including Stock (roman numeral) system, to determine the name of the compound represented. Allow time for guided and individual practice prior to assessment.

Activity 3: Molecular Compounds (SI GLEs: 7, PS GLEs: 5, 9, 23)

Materials List: Chemical Formulas and Nomenclature I & II with answers BLMs; minimum of 2 pink, 5 blue, 9 red, 14 green , 15 yellow balloons (all the same size), minimum13 larger white balloons; string to hang finished models; Molecular Geometry of Simple Molecules Student Sheets 1 and 2 BLMs; Molecular Geometry of Simple Molecules Answer Sheet

Part 1: Chemical Formulas and Nomenclature of Molecules

Guide the students to use Lewis dot structures to model covalent bonding, emphasizing that they are pairs of electrons being shared between the two atoms. Include a discussion of single and multiple bonds, as well as co-ordinate covalent bonds (one atom shares a lone pair of electrons with another atom). Explain the difference between molecular formulas and structural formulas. Provide guided practice to demonstrate student understanding of using Lewis dot structures for covalent bonding.
Provide teacher demonstrations of how to use elemental symbols and subscripts to write chemical formulas when given the name of a binary molecular compound. Provide compound names and have students write the chemical formulas. Provide written formulas and have students write the name of the compound represented. Refer to the Chemical Formulas and Nomenclature BLMs for sample worksheets.

Part 2: Shapes of Molecules (Molecular Geometry)

Balloons (helium quality is best) of various colors will be used to model molecular geometry of electron pairs and used to explain molecular shape using the valence shell electron-pair repulsion (VSEPR) theory.

To assemble the balloon models: Distribute the balloons for students to inflate. All colored balloons should be inflated to the same size. The white balloons, which represent lone pairs, should be inflated to a larger size. Once all of the balloons are inflated, like colors for each model should be tied together and the white balloons should be tied together as needed. To assemble the models, twist the colored balloon groups and the white balloon groups. The balloons will assume the shape of the molecule. You may have to adjust some of the balloons in order to see the structure better. Hang the balloon models from the ceiling (if possible) to be used as references as needed.

Either copy the Molecular Geometry of Simple Molecules Student Sheets 1 and 2 BLMs for each student or have students make the chart in their science *learning log* (view literacy strategy descriptions). Students will fill in the chart as the various models are discussed.

These websites can be used for explanations and reinforcement of molecular geometry:

- http://www.chem.uncc.edu/faculty/murphy/1251/slides/C19a/sld001.htm
- http://www.up.ac.za/academic/chem/mol_geom/mol_geometry.htm

- http://www2.wwnorton.com/college/chemistry/gilbert/tutorials/chapter_07/vsepr/index.html has models that can be examples that can be rotated along the x, y, and z axes.

After a discussion of Lewis structures and resonance, introduce students to the VSEPR theory used to determine the shape of molecules.

- VSEPR (Valence Shell Electron-Pair Repulsion) theory: valence shell electron pairs spread as far apart as possible to minimize repulsion, shapes of molecules are determined by electron pair geometry, the number of atoms attached to the central atom and the number of lone pairs on the central atom. Lone pairs repel electrons more than bonding pairs.

Using the balloon models, explain the following:

- colored balloons represent bonding pairs with atoms attached to the outer edge
- white balloons represent lone pairs
- a central atom is located where the balloons are tied in the center of the model

Activate prior knowledge of electron pair geometry by asking students

1. Two points lie on either side of a central point. What is the bond angle between the two points?(180°)
2. Three points on a circle are equidistant from each other. What is the bond angle between two adjacent points? (120°)

Using the appropriate one-colored balloon models, marked * on the BLM, explain the various basic electron pair geometries: linear, trigonal planar, tetrahedral, triangular bipyramidal, and octahedral. Explain that electron pair geometry is the starting point for determining the shape of simple molecules. First draw a Lewis structure for the compound. Then determine the electron-pair geometry. Next determine the molecular geometry. The shape of the molecule is vital to determining the polarity of a molecule. Refer back to the use of electronegativity values to determine bond polarity. Explain that nonpolar bonds will form nonpolar molecules. A molecule will only be polar if it contains polar bonds and its shape is not symmetrical.

Activity 4: Experimental Indicators of Bond Types (SI GLEs: 9, 10)

- Materials List: test tubes, thin stem pipettes, iron ring and stand, candle with foil holder, small foil pie pan, calcium chloride, citric acid, phenyl salicylate, potassium iodide, sodium chloride, sucrose, Chemical Bond Type Lab BLM, safety goggles, aprons, conductivity testers (if available)

All safety issues should be identified by the students and addressed before starting this activity.

Complete instructions for this activity are found on the Chemical Bond Type Lab BLM. Note: The data table can be omitted and replaced with a student-generated table.

Provide student groups with six samples labeled 1-6 (sodium chloride, potassium iodide, calcium chloride, sucrose, phenyl salicylate, citric acid), a foil pie plate, candle, ring stand, and ring clamp. Have students describe and record the physical appearance of each substance. Have students place a sample of each on the pie pan, making sure that samples are approximately the same size and that the samples are not touching. They are to place the pan with samples on the ring clamp that is attached to the ring stand at a sufficient height for a candle flame to heat the pan without touching the pan. Light the candle and note the order in which the substances melt. Next, the students are to determine if the samples are soluble in water. Students will also check the conductivity of each sample. Students will analyze the data to determine which substances are likely to contain ionic bonds, polar covalent bonds, and nonpolar bonds.

Activity 5: Intermolecular Forces (SI GLEs: 5 ; PS GLEs: 24, 46)

Materials List: pennies, pipettes, water, rubbing alcohol, microplates, capillary tubes, microscope slide, safety goggles, lab aprons, distilled water, and metric rulers

The teacher should use direct instruction to discuss the intermolecular forces of attraction between molecules commonly referred to as van der Waals forces. This discussion should include dipole-dipole forces, London dispersion forces, and hydrogen bonding. The website http://antoine.frostburg.edu/chem/senese/101/liquids/faq/h-bonding-vs-london-forces.shtml has animations showing dipole-dipole forces and dispersion forces.

Many of the characteristics of pure substances, such as their boiling or melting points, can be explained by the attraction between the particles of which they are composed. Characteristics of liquids, such as volatility and surface tension, can also be explained by the interactions between the molecules in the materials. This activity is designed to study some of these phenomena. Students are to create a data table, record data, and explain observations by using knowledge of the nature of the bonds contained in the substances. They are to include drawings showing the point(s) of molecular attraction.

- To explore surface tension of liquids due to intermolecular forces, students are to use a pipette and count the number of drops of distilled water that can be placed on the surface of a penny. Record results in the table, then repeat with rubbing alcohol (2-propanol).
- To extend observations regarding surface tension, students are to predict whether water or 2-propanol will rise to the same height in capillary tubes. If not, which will rise higher? Students should record their predictions and reasons for the predictions in the table. Then have students place a small amount of distilled water in a well in a micro plate. Place a small amount of 2-propanol in a second well. Place a capillary tube in the well of distilled water. Record the height the water rises above the surface of the water. Do the same

with 2-propanol. Record the results and provide possible explanations for the observations. Next, have students predict the capillarity of a mixture of 1:1 water and 2-propanol. Students are to record their predictions and rationale, then mix and test their hypothesis. In addition to recording their results, the students are to explain the differences in surface tension characteristics of water and 2-propanol.

- To explore the volatility of the liquid, students should simultaneously place one drop of water and one drop of 2-propanol at opposite sides of a microscope slide. Make sure that the drops are the same size. Predict which will evaporate first and why. Students are to observe what happens to the drops on the microscope slide and record which liquid evaporates first.
- Students are to compare and contrast the types and strengths of intermolecular forces in water and 2- propanol based on the experimental data from this activity.

A class discussion should be conducted to refocus the students on the different types of intermolecular forces and their effect on the states and properties of matter. Misconceptions can also be identified and corrected to insure student understanding of these concepts.

Activity 6: Predicting Properties (PS GLEs: 22, 23)

Materials List: periodic table, *RAFTing* BLM

Have students consider the following compounds: magnesium chloride, methanol, methane, sodium sulfate, ammonia, glucose, and potassium iodide. Have students use the periodic table and electronegativity values to determine whether the compound is ionic, covalent, or polar covalent. Students are to draw Lewis dot notations, name the shape, and determine if the molecule is polar or nonpolar. For all compounds, students should predict their states at room temperature (solid, liquid, or gas) and predict whether or not the compound will dissolve in water. Students will compile information in chart form. Conclude with a class discussion revealing and explaining correct responses.
As a culminating activity for this unit, have the students do *RAFT writing.* Challenge students to create a want ad for one of the states of matter. Begin with a *RAFT*ed writing assignment (view literacy strategy descriptions). Once students have acquired new content information and concepts they need opportunities to rework, apply, and extend their understandings. This form of writing gives students the freedom to project themselves into unique roles and look at content from unique perspectives. From these roles and perspectives, RAFT writing has been used to explain processes, describe a point of view, envision a potential job or assignment, or solve a problem (Fisher & Frey, 2003). It's the kind of writing that when crafted appropriately should be creative *and* informative. See the example in the BLM. RAFT is an acronym that stands for

R – Role (role of the writer)
A – Audience (to whom or what the RAFT is being written)
F – Form (the form the writing will take, as in letter, song, etc.)
T – Topic (the subject focus of the writing)

Allow students to share their RAFTs with a partner or the class. Students should listen to make sure the RAFT is accurate and logical.

Sample Assessments

Assessment techniques should include drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

General Guidelines

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will describe the difference between an ionic bond, a covalent bond, and a polar covalent bond.
- The student will explain why water "beads" on a waxed car surface but spreads out on an unwaxed surface.
- The student will explain the reason for the abnormally high melting point and boiling point of water.
- The student will differentiate between intramolecular and intermolecular bonding.

Activity-Specific Assessments

- <u>Activity 3</u>: Students will be given a list of compounds. For each compound on the list, the students are to predict the type of molecule, the electron pair geometry, the molecular shape, the number of bonds formed and the number of lone pairs.
- <u>Activity 4</u>: Students will be given a list of compounds. For each compound on the list, the students are to draw the Lewis dot structure and indicate whether

the bonds are polar or non-polar and whether the molecule is polar or non-polar.

- Activity 5: Given a physical description and formulas of various molecules, students are to determine the intermolecular forces of attraction acting among the particles.

Resources

- *Chromatography of Markers*. Available online at http://science.csustan.edu/tutorial/
- *Formation of Water Simulation*. Available online at www.visionlearning.com/library/module_viewer.php?mid=55
- *MicroScale Labs*. Available online at http://dwb.unl.edu/Chemistry/MicroScale/MScale00.html - Anchor-The-3800
- *Predicting Bond Type—Ionic vs. Covalent*. Available online at http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch2/mixframe.html
- *Smile Program Chemistry Index*. Available online at http://www.iit.edu/~smile/cheminde.html
- *Tyndall Effect*. Available online at https://www.freyscientific.com/resources/lessonPlans/high/chem_mixtures.html

Chemistry
Unit 5 Moles, Reactions and Stoichiometry

Time Frame: Approximately six weeks

Unit Description

This unit focuses on chemical changes; the mole; the law of conservation of matter; writing, interpreting, and balancing equations; plus the quantitative relationships among these concepts and the substances involved

Student Understandings

Students will understand the mole concept and its relationship to formulas and equations by examining data collected and solving mathematical problems. Students will understand how and why reactions occur. They will also be able to write, balance, classify, and interpret chemical equations by using experimental data and guided practice. An understanding of composition and reaction stoichiometry changes during reactions will be demonstrated by solving stoichiometry problems relating to formulas (percentage composition and empirical and molecular formulas problems) and equations (mass-mass, mass-volume, volume-volume, and mole-mole problems).

Guiding Questions

1. Can students describe the mole as a counting word/quantity and demonstrate the ability to solve mole conversion problems?
2. Can students experimentally determine a chemical formula of a compound?
3. Can students mathematically determine the chemical formula of a compound?
4. Can students express chemical reactions using correct, balanced formula equations?
5. Can students identify the basic types of chemical reactions?
6. Can students write balanced chemical equations?
7. Can students predict the products of simple reactions, oxidation/reduction, and formation of precipitates?
8. Can students explain the law of conservation of matter in ordinary chemical reactions?
9. Can students use balanced equations to solve mass/mass, mass/volume, volume/volume, mole/mole problems, and limiting reactant problems?
10. Can students discuss environmental issues related to the use and storage of chemicals?

Unit 5 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
3.	Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
Physical Science	
5.	Write and name formulas for ionic and covalent compounds (PS-H-A2)
6.	Write and name the chemical formula for the products that form from the reaction of selected reactants (PS-H-A2)
7.	Write a balanced symbolic equation from a word equation (PS-H-A2)
31.	Describe chemical changes and reactions using diagrams and descriptions of the reactants, products, and energy changes (PS-H-D1)
34.	Describe chemical changes by developing word equations, balanced formula equations, and net ionic equations (PS-H-D3)
35.	Predict products (with phase notations) of simple reactions, including acid/base, oxidation/reduction, and formation of precipitates (PS-H-D3)
36.	Identify the substances gaining and losing electrons in simple oxidation-reduction reactions (PS-H-D3)
38.	Relate the law of conservation of matter to the rearrangement of atoms in a balanced chemical equation (PS-H-D5)
39.	Conduct an investigation in which the masses of the reactants and products from a chemical reaction are calculated (PS-H-D5)
40.	Compute percent composition, empirical formulas, and molecular formulas of selected compounds in chemical reactions (PS-H-D5)
41.	Apply knowledge of stoichiometry to solve mass/mass, mass/volume, volume/volume, and mole/mole problems (PS-H-D5)
45.	Give examples of common chemical reactions, including those found in biological systems (PS-H-D7)
47.	Assess environmental issues related to the storage, containment, and disposal of wastes associated with energy production and use (PS-H-G4)

Sample Activities

Activity 1: How Large Is a Mole? (SI GLEs: 5, 9)

Materials List: 5 different types of dried beans (40 beans of each type/group), container (plastic cups or beakers), balance, How Large is a Mole? BLM, How Large is a Mole? Answer Sheet BLM, safety goggles, problems for students to work from text or other teacher-provided resource

Note: This activity is vital to meeting the PS GLEs **20, 31, 34, 38, 39, 40, 41** that will be addressed in future activities.

Review all safety issues. Provide each student group with a copy of the How Large is a Mole? BLM.

This activity is designed to help students understand the concept of the mole as a definite number of particles. Using five varieties of different type beans, students will determine the relative mass of each type of bean and express the relative masses in grams.

- Have students work in groups and provide each group with five sets of 40 beans per cup and a balance. Each cup will contain only one type of bean.
- Have students determine the total mass of each type of bean in the cup. Enter the data into the table provided.
- Using a ratio, students are to calculate the relative masses of the other beans by dividing the mass of the beans by the mass of the smallest bean.

Using the data in the relative mass column, find out how many *whole* beans are needed to get a mass in grams equal to the relative mass for each type of beans. Refer to the How Large is a Mole? Answer BLM sheet for sample calculations.

Students should write and defend a conclusion about the relationship among the number of particles, containers, and mass based on logical analysis of the data obtained from this activity.

This idea will then be extended to atoms in the periodic table. Explain to the students that atoms have the same relationship between their gram atomic mass and a mole. That is, the relative mass of any element expressed in grams has the same number of atoms: 6.02×10^{23} atoms. This number of particles is referred to as a mole. Students should then be able to work calculations by referring to sample calculations on the BLM. This skill is necessary to solving stoichiometric problems.

Students will participate in a guided practice session to solve quantitative problems involving mole conversions using the factor-label method. These should include the following types of problems:

Convert to:	**Mole**	**Representative particles**	**Mass**	**Volume**
Mole	X	✓	✓	✓
Representative particles(atoms, ions, formula units, molecules)	✓	X	✓	✓
Mass	✓	✓	X	✓
Volume	✓	✓	✓	X

Example: Convert 5.78 g Na to moles. Solution: $5.78\,\cancel{g\ Na} \times \frac{1\,mole\ Na}{23.0\,\cancel{g\ Na}} = 0.251\,mole\ Na$

Mole Day is a national celebration of chemistry education and an ideal time to engage families with the science education process. It is observed from 6:02 a.m. to 6:02 p.m. on October 23 (6:02, 10/23). Why? The mole is a unit of measurement based on work done almost 200 years ago by Amadeo Avogadro as he studied gas behavior. His work led to the association of the number (6.02×10^{23}) with the mole; hence it is often referred to as Avogadro's number. Similar to the dozen, a mole is a unit of matter that allows particles to be "counted." The major difference between the concept of the mole and the dozen is that the mole is much bigger! Form groups of four to six students and have each group design and conduct a Mole Day activity.

Activity 2: Determining Empirical Formulas for Ionic Compounds (SI GLEs: 5; PS GLEs: 5, 40, 41)

Materials List: aprons, safety goggles, crucibles, magnesium ribbon, sandpaper, laboratory burner, balance, learning logs, problems for students to work from text or other teacher provided resource, crucible tongs, ring stand, pipestem triangle

Review all safety issues, especially the correct handling of the hot crucible.

Direct instruction of calculating empirical formulas, molecular formulas, and percentage composition should be provided prior to this activity. Students should participate in a guided practice session to solve quantitative problems involving these calculations before they do the activity.

Students will quantitatively determine the empirical formula of an ionic compound. Have the students make a data table in their science *learning logs* (view literacy strategy descriptions) in which to enter all data collected.

1. Issue crucibles to student groups or pairs and have them measure and record the mass of the crucible.
2. A sample of magnesium metal ribbon (lightly sanded with sandpaper) will be placed in the crucible and the total mass of the crucible and magnesium should be recorded.
3. Have students calculate the mass of the magnesium ribbon and record the mass.
4. The crucible will be heated, allowing the magnesium metal to react with oxygen from the air.
5. Students will measure and record the mass of magnesium oxide formed.
6. Using the periodic table, students will predict the empirical formula of magnesium oxide.
7. Knowing the mass of magnesium used and the amount of magnesium oxide produced, the amount of oxygen reacted can be determined.
8. Students will determine the number of moles of magnesium and oxygen used, thus allowing them to predict the empirical formula of magnesium oxide.

Percentage composition of each element should also be found. Students will describe the chemical change that occurred (including descriptions of the reactants, products and energy changes) and write a word equation for the reaction. [$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$]

Activity 3: Observing Chemical Reactions (PS GLEs: 5, 6, 31, 45)

Materials List: precut pieces of copper wire, 0.2 M silver nitrate solution, mossy zinc, 0.1M hydrochloric acid, sodium chloride solution, acetic acid (vinegar), sodium hydrogen carbonate (baking soda), small beaker, microplate, test tubes, plastic spoon, test tube racks, pipettes, safety goggles, lab apron, Observing Chemical Reactions BLM, water, phenolphthalein, large beakers, vinyl gloves, science learning logs, problems for students to work from text or other teacher provided resource

All safety issues must be discussed with the students prior to beginning this activity. Be sure to address the proper handling of acids and silver nitrate solution, including their disposal.

Activate prior knowledge of chemical reactions by asking students to discuss photosynthesis, enzyme action, and other chemical processes they learned in biology or previous science courses. Ask students for examples of chemical reactions around their homes. Some examples could include the reaction of gasoline in a car engine, using chemicals to remove a bathtub ring, lighting a gas burner on a stove or propane tank to cook food, or digestion of food.

Set up lab stations with the listed materials. Complete directions for each of the 5 lab stations and individual lab station cards are on the Observing Chemical Reactions BLM. Copy one lab station card for each station set up. Students will rotate through the stations, recording observations at each station. The large beakers are to be used to empty all waste at each station

Instruct students to record their observations in their science *learning log* (view literacy strategy descriptions), including a description of the reactants and products. Have them cite evidence, such as color change, gas produced, and/or precipitate formed, to indicate that a chemical reaction has occurred. Make a class list of all the observations gathered.

Be sure to have students put on lab aprons and safety goggles before beginning the activity.

To conclude this activity, guide students through the process of writing and balancing the equation for some of the reactions from the activity.

Reaction 1: $Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$ (solid formed)
Reaction 2: $Zn(s) + HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ (gas produced)
Reaction 3: $NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$ (precipitate formed)
Reaction 4: $HC_3H_3O_2(aq) + NaHCO_3(aq) \rightarrow NaC_2 H_3O_2(aq) + H_2O(l) + CO_2(g)$ (gas produced and color change occurred)

Activity 4: Classifying Reactions (SI GLEs: 3, 10; PS GLEs: 7, 31, 34)

Materials List: materials dependent upon the reactions chosen by the students, lab aprons, safety goggles, Split-Page Notetaking BLM, problems for students to work from text or other teacher-provided resource

To activate prior knowledge on the types of chemical reactions, divide students into five groups. Each group will be assigned a type of reaction: synthesis, decomposition, single replacement, double replacement, or neutralization. Students should research and determine two simple reactions that can be performed as a demonstration to the class (or the teacher can assign specific reactions using the available chemicals). An explanation of solubility rules (for double replacement reactions) and the use of the activity series (for single replacement reactions) should be included in the student presentations.

Have students plan their lab set-up, procedures, presentations of information, and safety issues on the type of reaction they selected. Once the teacher approves the students' plan, instruct them to describe the reaction type, conduct demonstrations, and guide their classmates in writing balanced equations for the reactions. Ask students to observe the equations and notice commonalities and differences to identify a pattern for each type of reaction.

Split-page notetaking (view literacy strategy descriptions) logically organizes information and ideas from multiple sources; it helps separate big ideas from supporting details; it promotes active reading and listening; and it allows inductive and deductive prompting for rehearsing and remembering the information. *Split-page notetaking* should be used to develop a class description of the pattern for each type of reaction. Refer to the sample on the Split-Page Notetaking BLM. Given the reactants, students will participate in a guided practice session to write balanced equations, including phase notations, and classify the type of reaction. Examples of the four basic types of reactions and the basic forms or patterns can be located online for teacher use at http://www.chem.vt.edu/RVGS/ACT/notes/Types_of_Equations.html. This site provides concise descriptions of the types of reactions as well as numerous examples of each. It also explains using the activity series of the elements, the solubility rules, and ionic equations. Practice predicting the products of reactions is also included. Demonstrate for students how they can study from their notes by covering one of the columns and, using information in the other, try to recall the covered information. Students can also quiz each other over the content of their notes in preparation for tests and other class activities.

Activate prior knowledge of chemical changes by asking students what indications to look for as evidence that a chemical change has occurred (formation of bubbles when a gas is produced, unexpected color change, energy in the form of heat and/or light produced, formation of a precipitate). Using direct instruction, instruct students how to write ionic and net ionic equations to predict the formation of precipitate, gas produced, or water molecules formed. Provide practice problems for the students.

Activity 5: **Stoichiometry and Conservation of Mass (SI GLE: 5; PS GLEs: 38, 41)**

Materials List: large container of different colored paper clips, problems for students to work from text or other teacher-provided resource

Students will use paper clips to model chemical reactions.

Give each group of students several paper clips of two different colors. Instruct the students they are to use the clips to model reactant A with one color clip and reactant B_2 with two of the same color clips hooked together, as many times as they can. (Place any extra clips on the side.)

Next, they are to use the clips to *make* as many models of the product AB as possible, tracking how many A clips and how many B_2 clips are used and how many AB sets are formed. When they are finished, have students write a balanced equation using their data.

For example, given 13 blue clips (A) and 8 red clips (B): 8 A and 4 B_2 sets can be formed and 5 blue clips will be left over and removed. (These can be introduced as excess (XS) reactants!). The sets of the red clips must be unhooked. 8 blue clips and 4 red clip sets will combine to form 8 blue/red combinations. The equation will be $8A + 4B_2 \rightarrow 8AB$. This can be reduced to $2A + B_2 \rightarrow 2AB$.

The teacher should lead a discussion that shows that the total number of blue clips and red clips used as reactants equals the total number of blue and red clips used for the

products. This activity should be followed by students writing a brief statement that tells how this activity supports the law of conservation of matter (the amount and color of clips used as reactants = the amount and color of clips produced.)
An equation such as 2 Na + $Cl_2 \rightarrow$ 2 NaCl could be used to calculate the mass of each reactant and product to mathematically prove the law of conservation of mass. This equation could also be used to demonstrate mass-mass, mass-volume, and mole-mole problems.

Ask students for examples of stoichiometric relationships in their daily lives. For example: baking a cake by following the directions on the cake mix box or mixing oil and gasoline in the correct proportions for two stroke gasoline engines (some gas weed trimmers, chain saws, outboard motor engines.) Students should explain the consequences of not following the cake mix directions (cake does not taste good or does not rise properly) or incorrectly mixing the oil and gasoline for two stroke gasoline engines (engine will seize up).

Provide practice worksheets for the students.

Activity 6: Can You Make Two Grams? (PS GLE 35, 39, 41)

Materials List: goggles and aprons, calcium acetate monohydrate, magnesium sulfate heptahydrate, potassium carbonate, silver nitrate, sodium carbonate, zinc sulfate heptahydrate, balance, funnel, filter paper, two beakers, stirring rod, wash bottle, heat lamp or drying oven (if available), Can You Make Two Grams**?** Answer Sheet BLM

This activity will use the skills of writing and balancing equations, predicting products, using a solubility chart to predict the formation of a precipitate, and solving stoichiometry problems.
Following instruction on solubility rules, have students choose two of the chemicals listed in the Materials list and write a balanced chemical equation using the selected chemicals. They are to use solubility rules to predict if the selected chemicals will form a precipitate and calculate the amount of each reactant required to produce exactly 2.00 g of the precipitate. They will be given the chemicals and should measure the calculated masses, dissolve the reactants in water, and mix the two solutions to form the precipitate. The precipitate will be collected by filtration. The mass of the precipitate will be measured; percent error will be calculated.

Complete instructions including various charts can be found at www.msu.edu/~santalam/chemistry/Documents/**Can**%20**You**%20**Make**%202.doc.
Possible combinations, balanced chemical reactions, and calculations are found on the Can You Make Two Grams**?** Answer Sheet BLM

Activity 7: An Introduction to Oxidation-Reduction Reactions (SI GLEs: 10; PS GLEs: 34, 36)

Materials List: zinc shot, copper shot, lead shot, O.1 M solutions of zinc nitrate, copper nitrate and lead nitrate, microplate per group, lab aprons, safety goggles, Introduction to Oxidation-Reduction Reactions BLM, Introduction to Oxidation-Reduction Reactions Answer Sheet BLM, Vocabulary Self-Awareness BLM, problems for students to work from text or other teacher-provided resource

Vocabulary self-awareness (view literacy strategy descriptions) charts should be used to activate prior knowledge of the terms presented in this activity. Provide a list of words to students at the beginning of this part of the unit and have them complete a self-assessment of their knowledge of the words using the Vocabulary Self-Awareness BLM. Do not give students definitions or examples at this stage. Ask students to rate their understanding of each word or law with either a "+" (understand well), a "✓" (limited understanding or unsure), or a "-" (don't know). Over the course of the readings and exposure to activities throughout the unit, students should be told to return often to the chart and add new information to it. The goal is to replace all the check marks and minus signs with a plus sign. Because students continually revisit their vocabulary charts to revise their entries, they have multiple opportunities to practice and extend their growing understanding of key terms related to the topic of chemical and physical properties of matter. If after studying these key terms, students still have checks or minuses, the teacher should be prepared to provide extra instruction for these students. Use the Vocabulary Self-Awareness BLM as a guide.

Provide instruction on oxidation-reduction (redox) reactions prior to the following activity. Provide examples of common oxidizers and reducers, such as silver tarnishing in the presence of sulfides and iron rusting in air. Allow students to practice writing and balancing net-ionic equations. The teacher should then demonstrate balancing a redox equation by half-reactions.

In this investigation, students will experimentally determine the relative electron-gaining tendency of three metallic ions. Students will enter their observations in a student-generated data table. Prior to entering the lab, describe the experiment and have the class describe appropriate safety measures to be observed in this lab. Lead a class discussion of findings of the groups. Compare the results of the activity to the activity series of the elements referred to under single replacement reactions on the Activity 4, Split-Page Notetaking BLM.

Complete instructions for this activity can be found on the Introduction to Oxidation-Reduction Reactions BLM.

Activity 8: Chemicals in the Home and Community (PS GLE:45, 47)

Materials List: poster board or newsprint

Students will work in groups to determine the types and natures of household chemicals in their homes. Use student suggestions to compile a class list of common reactions that occur in their every-day environment, such as baking powder and water reacting to make biscuits rise, drain cleaners acting, and the combustion of gasoline or natural gas. Have students select (or assign) one common chemical and have them research proper storage methods as well as proper disposal methods. They should develop a safety tip sheet that could be placed on poster board or newsprint as a ready reference to household members. Students should present and share their tip sheets with the rest of the class.

Ask the students how their family discards the used oil from an oil change, unwanted paint cans, used cooking oil, etc. The students should research how their community handles the disposal of these items. Some cities and parishes have a household hazardous materials pickup day or pickup site. Students could research to find out if their city\parish participates.

Brainstorm (view literacy strategy descriptions) with students various types of businesses, manufacturers, and service providers (e.g., hospitals) in their community and/or state that generate chemicals or energy production waste by-products, radioactive medical wastes, and oil sludge at refineries that must be considered for proper disposal. After students review state and federal regulations for waste disposal, they are to select one type of business, service provider, or manufacturer to research its disposal methods. Students are to assume they are the leaders of those companies. Students are to use *RAFT* writing (view literacy strategy descriptions) to develop a brochure. RAFT writing has been used to explain processes, describe a point of view, envision a potential job or assignment, or solve a problem. It's the kind of writing that when crafted appropriately should be creative *and* informative.

RAFT is an acronym that stands for
R – Role (role of the writer)
A – Audience (to whom or what the RAFT is being written)
F – Form (the form the writing will take, as in letter, song, etc.)
T – Topic (the subject focus of the writing)

Students are to develop a brochure emphasizing that they are a "good neighbor" in the community. The Role should be the leader of a business or manufacturer. The Audience can be the public, community, or Chamber of Commerce. The Topic could be the company's waste disposal needs and strategies that are being used to address those needs. The Form should be a brochure. Students should also include current concerns/hot issues and strategies being explored to address those concerns/hot issues. Allow students to share their RAFTs with the class, while the other students listen for accuracy and logic.

This would also be a wonderful opportunity to have guest speakers from local government, industry, and business to come to class and address these issues with the students. Websites that can be useful for this activity are included in the resources at the end of the unit.

Sample Assessments

Assessment techniques should include drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

General Guidelines

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will write correctly-balanced chemical equations for reactions and classify the types of reactions encountered in laboratory work or assignments.
- The student will be able to solve mole/mole, mole/mass, and mass/mass problems, expressing answers with the correct number of significant figures.
- The student will research and journal the proper use of and disposal of the chemicals used in the experiments performed in this unit.

Activity Specific Assessments

- Activity 1: A written test will be given to show mastery of working mole problems. This is an important concept that will be used throughout the rest of the units.

- Activity 3: Students will write and balance equations including providing evidence that a chemical reaction did occur, such as the formation of a precipitate or the presence of bubbles, where applicable.

- Activity 4: Following instruction and teacher demonstrations, students will solve practice problems to classify word equations according to type of reaction and to write balanced equations for these word equations. The teacher should evaluate their performance to determine mastery or decide if re-teaching is necessary.

Resources

- *Flinn Chemical and Biological Catalog/Reference Manual*, 2004.
- Intel Education. *Lights, Camera, Reaction!* Available online at http://www97.intel.com/en/ProjectDesign/UnitPlanIndex/LightsCameraReaction/index.htm
- *Types of Equations*. Available online at http://www.chem.vt.edu/RVGS/ACT/notes/Types_of_Equations.html
- National Mole Day Foundation online at www.moleday.org
- Website on chemical waste or clean up methods online at http://www.deq.louisiana.gov/portal/tabid/2446/Default.aspx , http://nonpoint.deq.louisiana.gov/wqa/default.htm , http://www.epa.gov/epaoswer/hazwaste/id/id.htm , http://appl003.lsu.edu/PubSafety/oes.nsf/$Content/Hazardous+Waste+Disposal?OpenDocument , http://www.superpages.com/yellowpages/C-Hazardous+Waste+Disposal/S-LA

Chemistry
Unit 6: States of Matter, Energy Changes, and LeChatelier's Principle

Time Frame: Approximately six weeks

Unit Description

This unit focuses on developing a quantitative understanding of the behavior of gases and energy changes that occur during the substance phase changes and chemical reactions. Additional focus is placed on understanding the shift in equilibrium and LeChatelier's Principle.

Student Understandings

Students will develop an understanding of the relationships between temperature, pressure, volume, and moles of gases by solving gas law problems. Students will also comprehend state changes at the molecular level and exothermic and endothermic processes by reading and interpreting graphs, as well as doing the various lab activities of this unit. Students will be able to predict the direction of a shift in equilibrium in a system as a result of stress by using LeChatelier's principle in a lab activity, as well as solving problems.

Guiding Questions

1. Can students predict the behavior of a known quantity of gas using Boyle's law, Charles's Law, Gay Lussac's Law, Avogadro's Law, Dalton's Law, and the Ideal Gas Law?
2. Can students describe the experimental study known as calorimetry and how it incorporates specific heat and latent heat of fusion or vaporization?
3. Can students compare the amount of activation energy for an endothermic reaction and an exothermic reaction?
4. Can students produce and interpret a temperature-time graph as a substance passes through phase changes?
5. Can students predict the direction of a shift in equilibrium in a system as a result of stress by using LeChatalier's principle?

Unit 6 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
1.	Write a testable question or hypothesis when given a topic (SI-H-A1)
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
15.	Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)
Physical Science	
29.	Predict the properties of a gas based on gas laws (e.g., temperature, pressure, volume) (PS-H-C7)
30.	Solve problems involving heat flow and temperature changes by using known values of specific heat and latent heat of phase change (PS-H-C7)
31	Describe chemical changes and reactions using diagrams and descriptions of the reactants, products, and energy changes (PS-H-D1)
37	Predict the direction of a shift in equilibrium in a system as a result of stress by using LeChatalier's principle (PS-H-D4)
42.	Differentiate between activation energy in endothermic reactions and exothermic reactions (PS-H-D6)
43.	Graph and compute the energy changes that occur when a substance, such as water, goes from a solid to a liquid state, and then to a gaseous state (PS-H-D6)
44.	Measure and graph energy changes during chemical reactions observed in the laboratory. (PS-H-D6)

Sample Activities

Activities 1 - 3: Gas Laws (SI GLEs: 5, 6, 10; PS GLE: 29)

Materials List:
Activity 1: Cartesian diver apparatus, safety goggles, aprons, clear 2 liter soda bottle with cap, eye dropper or pipette, hex nut, water, paper towels, tweezers if students make their own Cartesian divers, Boyle’s law apparatus (if available), science learning logs, graph paper, problems for students to work from text or other teacher-provided resource

Activity 2: balloons, flask, ice water bath or access to freezer, graph paper, manometer (if available), problems for students to work from text or other teacher-provided resource

Activity 3: pressure cooker (if available), problems for students to work from text or other teacher-provided resource, glass, container of water, straw, problems for students to work from text or other teacher-provided resource

Begin this unit with a review of the kinetic-molecular theory. As a pre-assessment, have students illustrate and describe the motion of the particles of a material in the solid, liquid, and gaseous states in their science *learning logs* (view literacy strategy descriptions).

Students should identify safety issues to consider after they have been provided an overview of the investigation. Activate students' prior knowledge of the gas laws as they apply to their everyday lives by asking where applications of these laws can be found. Examples might include hot air balloons, propane tanks being used for cooking foods, opening soda cans or bottles, and scuba diving.

If internet access is available, the site http://intro.chem.okstate.edu/1314F00/Laboratory/GLP.htm provides simulations of the relationship among pressure, volume, temperature, and moles. Access to the instructions on how to use the software, as well as examples of guided inquiry and open-ended inquiry activities, is provided by a link on the site.

Activity 1: Boyle's Law: The teacher can illustrate Boyle's Law by using a Cartesian diver and having students observe the results of pressure changes. The teacher should present the demonstration without explanation, allowing time for the students to think about what they are observing. If available, have students use Boyle's Law apparatus to study the relationship of the pressure and volume (inversely proportional) of a specified amount of gas at constant temperature.

An alternative to the teacher demonstration is to supply the materials necessary for the students to construct their own Cartesian diver and write an explanation of observations, providing molecular level drawings of what is occurring to the gas inside the diver as the pressure changes. Materials needed and directions for constructing the diver can be found at http://www.usc.edu/org/cosee-west/MidwaterRealm/11CartesianDiver.pdf. Students will then construct a pressure-volume graph from collected or teacher-provided data and write conclusions about the relationship. Conduct guided and individual practice in solving word problems using the formula $P_1V_1 = P_2V_2$.

Activity 2: Charles's Law: Demonstrate Charles's Law by having students blow up two identical balloons with warm air, leaving one at room temperature and placing the second in a freezer overnight or ice bath for at least 15 minutes. Place the two balloons side by side and compare their volumes. Lead students to a description of the relationship between temperature and gas volume (directly proportional) with guiding questions. If available, have students use a manometer, flask, and water bath to study the relationship of the volume and temperature of a specified amount of gas at constant pressure. An alternative is to use a scenario with illustrations and have students observe data to determine the relationship. Conclude by having students construct a volume-temperature graph from recorded data and write their conclusions about the relationship. Follow up by having students solve word problems using the following formula: $V_1 / T_1 = V_2 / T_2$.

Activity 3: Gay-Lussac's Law: Display a pressure cooker and ask students if they are familiar with this type of cooking pot. If someone has seen one in use, ask them what it was used for and how it works. Write the formula, $P_1 / T_1 = P_2 / T_2$, on the board or a transparency and have students silently write a description of the relationship (directly proportional) described by this formula. Call on students to provide their responses, and discuss correct descriptions so that all students can gain an understanding of the relationship between temperature and pressure in gases. Assign word problems and have students practice solving the problems using the formula provided previously.

Use guiding questions to allow students to combine Boyle's, Charles's, and Avogadro's principle to derive the Ideal Gas Law. An ideal gas is an imaginary gas that follows all of the assumptions of the kinetic molecular theory. These assumptions are

1. Gases are composed of a large number of tiny particles that are in constant, random motion.
2. These particles move in a straight line until they collide with another particle or the walls of the container.
3. There are no forces of attraction or repulsion between gas particles or between the particles and the walls of the container.
4. Collisions between gas particles or collisions with the walls of the container are perfectly elastic. An elastic collision is one in which none of the energy of the gas particles is lost during these collisions.
5. The average kinetic energy of the gas particles is directly proportional to the temperature of the gas.

Real gases act like ideal gases at high temperatures and low pressures.

Boyle' Law $V \propto \frac{1}{P}$: Charles' Law ; Avogadro $V \propto n$ therefore $V \propto \frac{1}{P} \times T \times n$ A proportionality can be changed to an equality with a constant, k: $V = k \times \frac{1}{P} \times T \times n$ or $V = \frac{knT}{P}$. The constant, k, has the same value for all gases that behave like an ideal gas. R is substituted for k and is called the ideal gas constant. The previous equation can be rearranged to obtain the ideal gas law equation PV = nRT. Instruct students to use the relationship 1 mole(g) = 22.4 L at STP to calculate the value of R. Different pressure units can be used to derive the various values of R. Assign problems for students to work from text or other teacher-provided resource.

Instruct students to combine Charles and Boyle's and Gay-Lussac's Laws to derive the combined gas law. Assign word problems and have students practice solving the problems using the formula $P_1V_1/ T_1 = P_2V_2/ T_2$.

Dalton's Law of Partial Pressure can be explained and used to work problems that involve collecting a gas over water. An easy demonstration can be performed by inverting a glass filled with water in a glass container of water and having a student (a gas producing experiment) blow into a flexible straw inserted into the glass. Explain that some of the water evaporated and the total pressure inside the glass is $P_{(g)} + P_{H2O(g)}$. Assign word problems and have students practice solving the problems, including "gases collected over water" as part of Boyle's and combined gas law problems.

The gas laws provide an excellent opportunity to use the Internet for interactive investigations. Suggested website: http://www.chm.davidson.edu/ChemistryApplets/GasLaws/index.html for the following gas laws: Boyle's, Charles's, Avogadro's, Dalton's and Ideal gas

Students should use *split-page notetaking* (view literacy strategy descriptions) to compare and contrast the various gas laws covered above. *Split-page note taking* is done by drawing a straight line from top to bottom of a piece of paper (preferably a sheet of normal-sized, lined notebook paper) approximately 2 – 3 inches from the left edge. The page should be split into one-third/two-thirds. In the left column big ideas, key dates, names, etc. should be written and supporting information in the right column. Students should be urged to paraphrase and abbreviate as much as possible.

Sample of *split-page notetaking*

Gas Laws	
Boyle's Law	1. Deals with V and P if T and n are constant 2. V and P are inversely proportional a. If V is doubled, P is halved 3. $V_1P_1 = V_2P_2$
Charles's Law	1. deals with V and the Kelvin T if P and n are constant 2. V and T are directly proportional only if Kelvin T is used. (DOES NOT work with T in Celsius) 3. $\frac{V_1}{T_2} = \frac{V_2}{T_2}$

Activity 4: Inter-State Matters: Exploring Phase Transitions of Gases, Liquids, and Solids (SI GLEs: 1, 5, 6; PS GLEs: 30, 43)

Materials List: safety goggles, apron, ice, heat source, beakers, thermometers, Heating Curve BLM, Phase Diagrams BLM, science learning logs, probes and graphing calculators (if available)

Safety caution: Address all safety issues before beginning this activity.

Students should explore the phase and temperature changes that occur as ice changes to water and steam. The students should predict what the heating curve (a graphical representation of the energy changes when a substance is heated—a plot of temperature vs. time) for these changes will look like before doing the activity. Have students set up an apparatus to melt a known quantity of ice in a beaker, then heat the resulting water and allow it to boil for two minutes while monitoring the temperature throughout the process. Have students make a temperature-time graph from the recorded data and compare it to their prediction. The students should try to explain any discrepancies between the predictions and graphs. The teacher should then guide the students through the calculations of the energy changes through transitions. Conclude with a discussion of the reason the temperature remains stable even when additional energy is being added when phase changes occur (intermolecular forces of attraction between the H_2O molecules must be weaken or broken). This is an excellent activity to use with probes and graphing calculators. Use the Heating Curve BLM and instruct students to draw a sample heating curve in their science *learning logs* (view literacy strategy descriptions).

Copies of the Phase Diagrams BLM should be made and handed out. All points on the diagrams should be explained. It should be explained that the phase diagram of H_2O is the only one with a negative slope between the solid and liquid phases. Provide students with copies of the Phase Diagrams BLM to accompany the discussion of how to read and interpret the diagrams. An excellent explanation can be found online at the website http://www.chemguide.co.uk/physical/phaseeqia/phasediags.html. Students should compare and contrast heating curves and phase diagrams in their science *learning logs* (view literacy strategy descriptions).

Activity 5: Heat of Fusion of Ice (SI GLEs: 5, 15; PS GLE: 30)
Materials List: ice, graduated cylinder, thermometer, foam cup, source of hot water

Safety caution: Address all safety issues before beginning this activity.

Provide students with ice, a graduated cylinder, thermometer, foam cup, and source of hot water. Have students fill the cylinder with hot water. Allow the cylinder to stand for one minute. Pour the water into the sink. Use the graduated cylinder to measure 70 ml of hot water. Pour it into the foam cup. Record the temperature of the water. Add a small cube of ice to the water and gently swirl the cup. Measure the temperature of the water immediately after the ice cube has completely melted. Pour the water from the cup into the graduated cylinder and measure the volume. Determine the heat of fusion of ice (kJ/mol) by dividing the heat given up by the water by the moles of ice melted. (Determine the mass of ice melted by subtracting the difference between the volume before the ice was added and the volume after it has melted.) Students are to respond in writing to the following: The heat of fusion of ice is 6 kJ/mol. What is your percent error? Why do you think there was a difference, if any? How could you make this activity more error proof?

Activity 6: Exothermic and Endothermic Reactions (SI GLEs: 6; PS GLE: 31, 42)

Materials List: safety goggles, aprons, citric acid solution, baking soda, foam cup, thermometer, stirring rod, baby food jar, steel wool, vinegar, Exothermic and Endothermic Energy Diagrams BLM, Energy Diagram (with activation energy) BLM, probes and graphing calculators (if available), matches, match box, dominoes

Activate prior knowledge by asking students to define the terms *endothermic* (a change that absorbs heat), *exothermic* (a change that releases heat), *activation energy* (minimum energy needed to start a chemical reaction, abbreviated E_a; allows the activated complex to form), *activated complex* (an unstable combination of molecules in which bond breaking and new bond formation occur. The collision theory should be discussed prior to this activity. (Particles must collide in order for reactions to occur. The particles must collide with enough energy and with the correct orientation to break the bonds of the reactants [called an effective collision].)

Provide copies of the Exothermic and Endothermic Energy Diagrams BLM for the students. Facilitate a discussion of the energy diagrams.

Safety caution: Address all safety issues before beginning this activity.

Complete instructions for this activity can be found at http://chemistry.about.com/cs/howtos/ht/endothermic.htm and http://chemistry.about.com/cs/howtos/ht/exothermic.htm.

Endothermic reaction: Combine citric acid and baking soda and note the temperature change.

Exothermic reaction: Soak steel wool in vinegar and note the temperature change.

This would be a good activity to collect data with probes and graphing calculators, if available.

After the activities are done, refer the students back to the Exothermic and Endothermic Energy Diagrams BLM. Ask the students how the activities relate to the BLM. Exothermic reaction: heat was given off to the surroundings causing the temperature of the system to increase; the reactants had more energy than the products and the extra energy was given off; ΔH is negative

Endothermic reaction: heat was absorbed from the surroundings causing the temperature of the system to decrease; the products have more energy than the reactants; ΔH is positive

Next, the teacher should pass a match lightly over the striking surface so that the match does not ignite. Ask the students why the match did not light (didn't strike it hard enough). Strike the match hard enough for it to light. Ask guiding questions about why the match did light (supplied enough energy to start the reaction-activation energy) and what energy changes occurred (light and heat were given off).

Use different positions of a domino to illustrate the two energy states. When the domino is standing on one small end, it has the most potential energy (representing the unburned match). When it is lying flat, it has less potential energy (representing the burned match). Ask why the domino does not fall down spontaneously. The students will suggest that you need to tap the domino to make it fall.

Line up several dominoes. Tapping too lightly rocks the domino but does not knock it over. Tapping the domino adds energy. A certain minimal amount of energy is needed; this corresponds to the activation energy. This additional energy can be shown on the graph as the "hump" of activation energy.

The endothermic reaction can also be illustrated with the domino. The domino can be moved from the flat position (lower potential energy) to the on-end position (higher potential energy) only by applying a continuous push or pull.

Provide copies of the Energy Diagram (with activation energy) BLM for the students. Facilitate a discussion of the energy diagram. Relate the domino analogy to BLM. Conduct a class discussion to ensure that all students have the opportunity to understand the correct responses.

Activity 7: Calorimetry (SI GLEs: 1, 6, 7, 10; PS GLE: 30)

Materials List: safety goggles; aprons; balance; foam cups with lids; thermometers; stirrers; ice; source of hot water; ionic compounds such as NH_4Cl, $NaC_2H_3O_2$, KCl, KOH, NaCl, NaOH or NH_4Cl; metal samples such as Al, Cu, Fe, Ag, or Pb; probes and graphing calculators (if available); problems for students to work from text or other teacher-provided resource

Safety caution: Address all safety issues before beginning this activity.

To develop an understanding of the fundamentals of calorimetry, students will learn how to manipulate and set up the necessary equipment. Provide students with foam cups or calorimeters with aluminum inside cups, stirrers, thermometers, balances, hot plates, and ice cubes. Using calculators or computers with probes, if available, is an excellent way to collect the data and graph the results. Give students the opportunity to identify appropriate safety measures that should be considered for this investigation.

Ask the students to write a testable question regarding what will happen when an ionic solid is dissolved in water or when a hot metal is placed in cold water. This question will be investigated by using a calorimeter that the student constructs or the teacher provides. The calorimeter can also be used to find the heat of solution or the specific heat of a metal.

The activity can be found at the website http://www2.hn.psu.edu/faculty/dmencer/calorimetry/Coffee1.htm. This activity includes how to construct and calibrate a coffee cup calorimeter. It includes a worksheet that includes the calibration instructions as well as directions for finding the heat of solution and specific heat of metals. The heat of solution and specific heat of metals can be done in the lab or online as a virtual lab once the calorimeter is calibrated.

Students should solve problems involving heat flow and temperature changes by using known values of specific heat and latent heat of phase change.

Ask students what happens when a spoon is placed in a cup of hot chocolate (the energy of the hot chocolate is transferred to the spoon) or when a glass of cold water is left out on a counter. (energy is transferred from the warmer room to the water) Ask what happens to these systems if they are left on a counter while the student has to go and answer the door? (The systems will reach room temperature) Ask what direction the flow of energy takes? (Heat flows from the warmer object to the cooler object) Ask the students why they sit in front of a fireplace in the winter. (To get warm… the heat energy of the fire is being transferred to the student!)

Activity 8: Heat of Reaction (PS GLE: 44)

Materials List: safety goggles, aprons, 0.5 M $HC_2H_3O_2$, 0.5 M NaOH, flask, thermometer, foam cup, stirring rod, stopwatch or watch with second hand, problems for students to work from text or other teacher-provided resource

Safety caution: Address all safety issues before beginning this activity.

The student groups are to place 50 mL of 0.5 M $HC_2H_3O_2$ into a flask. Record the temperature of the acid. Add 50 mL of 0.5 M NaOH solution into a foam cup and record the temperature of the base. Pour the acid solution into the cup containing the NaOH solution and stir with a stirring rod. Record the temperature every 30 seconds until the highest reading has been reached and the temperature starts to drop.

Instruct the students to

Write a balanced equation for the reaction.

Calculate the

- change in temperature (T_f - T_i)

- mass of the solutions (Assume 1mL of solution = 1g)
- heat gained by the solutions (J)
- number of moles of water produced
- heat of the reaction ($\frac{\text{total heat evolved}}{\text{moles of product}}$)

A graphical interpretation of the experiment should be completed by each student. Ask students where they use heat of reaction in their lives. They should be guided to mention heat and cold packs used for sports or by hunters.

Provide guided practice of heat of reaction problems followed by individual problem solving.

Activity 9: Heat of Combustion of Mg (SI GLEs: 15; PS GLEs: 31)

Materials List: safety goggles, aprons, 1.0 M HCl, MgO, Mg ribbon, coffee cup calorimeter, thermometer, straw, problems for students to work from text or other teacher-provided resource

Safety caution: Address all safety issues before beginning this activity.

The intent of this activity is to give students an appreciation of how simple multiple reactions can be added to give the energy change for a net reaction that is difficult to measure directly. They will also see an example of Hess's law (the energy change for an overall reaction is equal to the energy changes for all steps of the reaction). In this case, they will determine the energy released in kJ/mol of MgO formed from the elements. Be sure to address all safety issues associated with this activity.

Students will add 25 ml of 1.0 M HCl solution into a coffee cup calorimeter. A coffee cup calorimeter consists of a foam cup, with a thermometer and a straw (to be used as a stirrer) inserted through the lid, inside of another foam cup. After recording the initial temperature, they will add 0.25 of MgO to the HCl solution and carefully stir and record the highest temperature reached. They are to discard the solution and dry the cup.

Students will again add 25 ml of 1.0 M HCl solution into the coffee cup calorimeter and add a 0.25 g sample of clean Mg ribbon. They are to record the temperature of the acid solution before and after the reaction. Be sure there are no open flames as H_2 gas is produced in this reaction.

Guide students through the process of using the following reactions to write answers to the questions:

(1) $Mg + \frac{1}{2} O_2 \rightarrow MgO$
(2) $MgO + 2\ HCl \rightarrow MgCl_2 + H_2O$
(3) $Mg + 2\ HCl \rightarrow MgCl_2 + H_2$
(4) $H_2 + \frac{1}{2} O_2 \rightarrow H_2O$

This activity is a heat of combustion reaction demonstrating Hess's Law. Hess's Law states that the change in energy of the overall chemical reaction is equal to the energy changes for the individual steps of the reaction.

Assume that 4.184 J of energy is needed to raise the temperature of one ml of solution one degree Celsius.

- Combine equations 2, 3, and 4 to obtain equation 1.
- Calculate the change in temperature for reactions 2 and 3.
- Calculate the energy released (in kJ) for each reaction.
- Calculate the energy in kJ/mol of MgO.
- Use this information to calculate the heat of reaction 1 in kJ/mol of MgO.
- Compare your experimental result with the value given in a table of molar heats of formation.
- Does your data support agree with the known value?
- Write a conclusion for the activity using the data in these steps.

Provide guided practice of heat of combustion and Hess's Law problems, followed by individual problem solving.

Activity 10: Chemical Equilibrium and Le Chatelier's Principle (SI GLEs: 4, 9, 10, 15; PS GLE: 37)

Materials List: 0.1 M potassium chromate, 0.1 M potassium dichromate, 12 well microplate (or any size available), 1.0 M NaOH, pipettes, 1.0 M HCl, 0.1 M barium nitrate, problems for students to work from text or other teacher-provided resource

Lead a discussion of equilibrium (rate for two opposing processes in a closed system are equal) and LeChatelier's Principle (When a stress is applied to a system at equilibrium, the system will tend to shift its equilibrium position to reduce the effect of the stress.) The stress can be a change in temperature (adding heat favors the endothermic reaction), concentration (adding more reactants will favor the product side of the reaction and vice versa) or pressure (increasing the pressure on a gaseous system shifts the equilibrium to the side with fewer moles of particles). Chemical equilibrium occurs when the rates of opposing chemical reactions are equal. Example: Using the Haber process for the production of ammonia **(**$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$**)**, chemical equilibrium is established when the rate of the forward reaction equals the rate of the reverse reaction).

Safety caution: Address all safety issues before beginning this activity.

Students will investigate Le Chatelier's Principle using the chromate-dichromate equilibrium. Students will test the effect of various reagents on the equilibrium state of the chromate-dichromate system and write net ionic reactions for the changes that occur. In addition, the chemicals used in this experiment will be a basis for a discussion on lab safety and proper disposal methods. Use approximately 10 drops of each reagent unless otherwise indicated.

A. Students will obtain 0.1 M potassium chromate and 0.1 M potassium dichromate in separate wells of a 12 well microplate and observe the color of each solution. They will add 1.0 M NaOH solution, a drop at a time, alternately to each solution until a color change is noted in one of the wells. Again, students are to record observations in a student-generated data table. This microplate will be kept for a later test.

B. Students are to place potassium chromate and potassium dichromate in separate wells in another 12 well microplate but will add 1.0 M HCl solution alternately to each solution until a color change occurs. After recording the observations, the students are to add 1.0 M NaOH, drop by drop, to either of the wells until a change is observed and record observations.

Students are to return to the Part A microplate and add 1.0 M HCl, drop by drop, to either of the wells until a change is noted.

Students are to write their conclusions about the relationships among chromate, dichromate, and an acid solution and their conclusions about the relationships among chromate, dichromate, and a basic solution. Guide students through writing a balanced equation by adding the proper number of hydroxide ions and water molecules to the appropriate side of the equation.

C. Into one well of the microplate, students are to add 0.1 M potassium chromate, two drops of 1.0 M NaOH, and then add 0.1 M barium nitrate solution, a drop at a time, until a change is noted. They are to record results.

They are then to add 1 M HCl, drop by drop, to the well until 10 drops have been added and again record observations.

D. Into one well of the microplate, students are to add 0.1 M potassium dichromate, two drops of 1.0 M HCl, and then 10 drops of 0.1 M barium nitrate. They are to record results.

They are then to add 1.0 M NaOH, drop by drop, to the well until 10 drops have been added and again record observations. Is there a way to reverse the changes and reactions just observed? Have students test their ideas. Do the same for Part C.

E. Students are to add 0.1 M potassium dichromate in one well and the same amount of 0.1 M potassium chromate in another well. They will add a few drops of 0.1 M barium nitrate to each and record observations. They should describe the relative amounts of product formed.

Students are each to write a paragraph explaining how their results demonstrated Le Chatelier's Principle and should identify the stress applied and how the system reacted to relieve the stress. Students are to be placed in groups. Modified r*eciprocal teaching* (view literacy strategy descriptions) should be used to demonstrate mastery of chemical equilibrium and LeChatelier's principle. Reciprocal teaching is a strategy in which the teacher models and the students use summarizing, questioning, clarifying, and predicting to better understand content concepts. First, model each of these four roles for students using another related principle. Provide students a summary statement about the principle and talk about how the summary was formed; ask relevant questions about the principle; predict expected outcomes based on the principle; and clarify key concepts in the principle. Next, place role cards on each table for students to determine who will fulfill each role—summarizer, questioner, clarifier, and predictor. The summarizer summarizes the main points of equilibrium systems. The questioner asks what stresses affect an equilibrium system. The clarifier explains the effect of the stresses on an equilibrium system. The predictor makes a prediction of the shifts caused by specific stresses on a given equilibrium system. Monitor group work and provide additional modeling of the four processes of reciprocal teaching as needed.

Guided practice should be used to facilitate student understanding of LeChatelier's Principle.

Sample Assessments

Assessment techniques should include drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

General Guidelines

- Students should be monitored throughout the work on all activities via teacher observation of their work and learning log entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will interpret phase change diagrams.
- The student will provide everyday applications for each of the gas laws.
- The student will interpret energy diagrams.

Activity Specific-Assessments

- Activities 1-3: Students will graph the data from collected or teacher-provided data and write conclusions about the mathematical relationships between pressure, volume, and temperature. Students should be able to solve gas law problems, showing all steps in their work.

- Activity 4: The student is to graph the data from the activity and write conclusions about the energy changes that occur as H_2O is heated and changes state. Explanations of what is occurring on the molecular level from the initial temperature reading to the final temperature reading should be included in the student's writing.

- Activity 6: Given graphs, have the student determine if the reaction for the graphical data is exothermic or endothermic. Students will work additional problems and identify the reactions as exothermic or endothermic by interpreting the answers to the problems.

Resources

- *Gas Laws*. Available online at http://www.chm.davidson.edu/ChemistryApplets/GasLaws/index.html
- *Simulations of the relationship between pressure, volume, temperature and moles*. Available online at http://intro.chem.okstate.edu/1314F00/Laboratory/GLP.htm
- *Smile Program Chemistry Index*. Available online at http://www.iit.edu/~smile/cheminde.html
- *Constructing a Cartesian Diver*. Available online at http://www.usc.edu/org/cosee-west/MidwaterRealm/11CartesianDiver.pdf
- *Assumptions of theKinetic Molecular Theory*. Available online at http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch4/kinetic4.html
- *Phase Diagrams explanations* Available online at http://www.chemguide.co.uk/physical/phaseeqia/phasediags.html
- *Endothermic and Exothermic Iinvestigations* Available online at http://chemistry.about.com/cs/howtos/ht/endothermic.htm and http://chemistry.about.com/cs/howtos/ht/exothermic.htm.
- *Coffee Cup Calorimetry* Available online at http://www2.hn.psu.edu/faculty/dmencer/calorimetry/Coffee1.htm

Chemistry
Unit 7: Solutions and Acids and Bases

Time Frame: Approximately six weeks

Unit Description

The focus of this unit is solutions, colligative properties, and acid-base chemistry.

Student Understandings

The student will understand solutions, including the effect of the action of solute particles on the properties of the solvent, by solving math problems and investigating the change in freezing points and boiling points of sugar and salt water solutions. The student will understand the relationship between acids, bases, salts, pH, and titration by investigating the properties of acids and bases and their reactions with various acid-base indicators. Titrations, both experimentally and mathematically, will be used to explain the connection between acids, bases, and pH.

Guiding Questions

1. Can students explain the difference between mixtures and solutions?
2. Can students demonstrate their knowledge of various concentration units through problem solving that involves real and hypothetical solutions?
3. Can students predict and determine the conductivity, freezing point, and boiling point from the known concentration of a solution?
4. Can students explain the chemical and physical properties of acids and bases?
5. Can students explain the meaning and use of pH?
6. Can students demonstrate knowledge in calculations involving pH, pOH, $[H^+]$, and/or $[OH^-]$?
7. Can the students describe the process of acid-base titrations and demonstrate knowledge application through experimental calculations?
8. Can students describe the role of indicators in acid-base titrations?

Unit 7 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)

GLE #	GLE Text and Benchmarks
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
Physical Science	
14.	Identify unknowns as elements, compounds, or mixtures based on physical properties (e.g., density, melting point, boiling point, solubility) (PS-H-C1)
18.	Given the concentration of a solution, calculate the predicted change in its boiling and freezing points (PS-H-C3)
19.	Predict the conductivity of a solution (PS-H-C3)
20.	Express concentration in terms of molarity, molality, and normality (PS-H-C3)
21.	Design and conduct a laboratory investigation in which physical properties are used to separate the substances in a mixture (PS-H-C4)
32.	Determine the concentration of an unknown acid or base by using data from a titration with a standard solution and an indicator (PS-H-D2)
33.	Calculate pH of acids, bases, and salt solutions based on the concentration of hydronium and hydroxide ions (PS-H-D2)
35.	Predict products (with phase notations) of simple reactions, including acid/base, oxidation/reduction, and formation of precipitates (PS-H-D3)

Sample Activities

Activity 1: Mixtures as Solutions or Colloids (SI GLEs: 9; PS GLE: 14)

Materials List: safety goggles, aprons, plain gelatin, hot water, beakers, table salt, a cup, black construction paper, masking tape, teaspoon, flashlight, three jars or large test tubes, distilled water, cornstarch, sodium hydrogen carbonate, Vocabulary Self- Awareness BLM

Review all safety issues concerning this activity.

A *vocabulary self- awareness* (view literacy strategy descriptions) chart should be started with this activity and added to continuously throughout the rest of the unit. Distribute to each student a copy of the Vocabulary Self-Awareness BLM to work on, and remind them to return to the chart regularly to add and make any changes as their vocabulary knowledge increases for these specific terms. The goal is for students to have pluses for all the words by the conclusion of the unit.

Activate prior knowledge of the Tyndall effect that the students have probably experienced (headlight in fog, for example). Begin with a teacher demonstration of the Tyndall effect for colloidal mixtures. Shine the beam of a flashlight through a colloidal mixture (plain gelatin dissolved in a beaker of hot water) and a salt water solution in a beaker to show the difference between a solution and a colloid. (The colloid will scatter the light due to the large size of the gelatin particles. The solution will not scatter the light because of the extremely small size of the ions in solution).

Follow this demonstration by having students classify mixtures as solutions or colloids by virtue of the Tyndall effect. Provide each group with a cup, black construction paper, masking tape, teaspoon, flashlight, three jars or large test tubes, distilled water, cornstarch, and sodium hydrogen carbonate. Have students carry out the following steps: With the construction paper, make a cone and tape it to fit over the lens of the flashlight. Make a paste by mixing a quarter teaspoon of cornstarch with four teaspoons of water in a cup. Fill Jar 1 with distilled water. In Jar 2, put a quarter teaspoon of sodium hydrogen carbonate (baking powder), fill with water, and mix. In Jar 3, put in the cornstarch paste and fill with water and mix. Turn out the lights in the room. Shine the flashlight at each of the jars and document your observations. Respond to the following: (1) Was the light beam visible in any of the jars? (*yes*) Which one(s)? (*cornstarch mixture*) Why not in all? (*Light will only be visible in the colloid. The Tyndall effect can be used to distinguish between a solution and a colloid.*) (2) Predict what you would observe if you were to replace the sodium hydrogen carbonate with sugar.

Students should be able to visually identify true solutions and colloids after this activity and write a conclusion based on the experimental data from this activity as to the difference between a solution and a colloid. Evidence should be cited to support and defend the conclusion. (A beam of light is not visible in a true solution and is visible in a colloid.)

Activity 2: Chromatography of Markers (SI GLEs: 4; PS GLEs: 14, 21)

Materials List: safety goggles; aprons; chromatography paper strips or strips cut from coffee filters; large beaker; water-soluble markers; assorted ink pens; selected solvents such as alcohol, water, vinegar, mineral spirits

Review all safety issues concerning this activity with students.

Distribute supplies for this activity to each pair of students. Activate prior knowledge by asking students to name ways of separating mixtures (distillation, crystallization, and chromatography). Construct a concept map, a type of *graphing organizer* (view literacy strategy descriptions), on the board as students respond. Guide students to the concept of chromatography as a technique used by scientists to separate the components of solutions, mainly using the principle of polarity. The mixture will be carried along the stationary phase by a mobile phase. The parts of the mixture will move at different rates based on polarity. Illustrate examples and explain the concept of polar molecules to develop student understanding. Point out that different dyes have different polarities. Some colors will travel along with the water if their polarity is close to that of water. This means that the more polar a dye molecule is, the further it will travel up the surface of the paper. Remind students that polar substances require polar solvents and nonpolar substances require nonpolar solvents for dissolution and separation.

Cut four strips of chromatography paper (or four strips that are 2 cm wide from a coffee filter.) The strips should be long enough to fold over the edge of the beaker when the edge of the strip is just immersed in the solvent. Using a different marker or pen, draw a line about 2 cm above the bottom of each of the four strips. Add the first solvent (water) to the beaker until it is about 1 cm deep. Arrange the strips around the edge of the beaker with the bottom edge just immersed in the solvent. Fold the top of the strips over the edge of the beaker to hold them in place. Wait about five minutes and remove the strips. Compare chromatograms (the pattern of the separated components of the mixture). Repeat the process using different markers and/or solvents.

Ask the students how they know that some of the inks used were mixtures, based on their results. Which inks were water soluble and why? Which inks did not dissolve in water and why? What is the stationary phase? What is the mobile phase? Have the students write a conclusion based on the answers to these questions.

Relate this activity to current television shows with a forensic theme such as CSI.

Activity 3: Expressing Solution Concentrations (SI GLE: 5; PS GLE: 20)

Materials List: problems for students to work from text or other teacher-provided resource, Solution Concentrations BLM

After instruction on the meaning of molarity (moles of solute/ liter of solution), molality (moles of solute/ kilogram of solvent), and mole fraction (moles of solute /total moles of solute and solvent), have students construct a comparison matrix of the three concentration terms. Direct the students to participate in guided practice and individual practice in solving problems pertaining to the preparation of solutions of a specified concentration and expressing concentrations, given values of a solute and solvent.

Examples of concentration problems can be found on the Solution Concentrations BLM.

Activity 4: Investigation of Electrolyte and Non-Electrolyte Solutions (SI GLEs: 6; PS GLE: 19)

Materials List: safety goggles; aprons; a conductivity apparatus; a source of electricity; appropriate volumes of the following solutions: 1.0 M HCl, 1.0 M NaOH, distilled water, solution of sugar and water, vinegar

Safety Caution: To prevent electrical shock, emphasize to students not to touch the electrodes of the conductivity apparatus at any time. After a discussion of the activity, students should identify the appropriate safety measures.

Provide students with a conductivity apparatus, a source of electricity, and appropriate volumes of the following solutions: 1.0 M HCl, 1.0 M Na_2CO_3, distilled water, solution of sugar and water, and vinegar. Ask students to explain how they might complete the circuit so that the conductivity apparatus registers a current, such as indicated on a meter reading or by a glowing light bulb. Ask students to suggest materials that they think conduct electricity. Ask students to predict if a current will flow when electrodes are placed in a beaker of (A) 1.0 M HCl, (B) 1.0 M NaOH, (C) distilled water, (D) solution of sugar water, and (E) vinegar. Class discussion should include asking students to explain the following:

- What type of bonding does each compound exhibit?
- Why did a current flow when the electrodes were immersed in solutions A, B, and E but not C and D?
- Why did solutions A and B demonstrate greater conductivity (larger value on meter or bulb glowed brighter) than solution E?
- Why is it dangerous to use electrical appliances in wet areas (e.g., a hairdryer while sitting in the bathtub)?

Students should be able to identify electrolytes as sources of free ions and nonelectrolytes as molecular substances that do not ionize in water solutions. Students should also write a conclusion based on experimental evidence describing differences noted in conductivity and the causes for these differences.

Popular sports drinks that are advertised as sources of electrolytes can be tested also. A comparison of various brands could be conducted to determine which drink is the best electrolyte. Use the conductivity apparatus with the various sport drinks and record observations.

Activity 5: Freezing Point Depression and Boiling Point Elevation Calculations (SI GLEs: 5; PS GLE: 18)

Materials List: safety goggles; aprons; balance; ice; sucrose and sodium chloride; test tubes; a thermometer; large beakers; a graduated cylinder; stirring rods; hot plates or Bunsen burner; ring stand; test tube clamps; probeware (if available), problems for students to work from text or other teacher-provided resource; Ice Cream Recipe BLM; 1 gal whole milk; 1 pint half & half; 6 cups sugar; 6 t vanilla; several boxes of ice cream salt; roll of duct tape; Per student: 1 pint size freezer zip top bag, 1 gallon size freezer bag, ice, several pages of newspaper, plastic bag from grocery or discount stores, mixing bowl, spoon, large pot

(If available, this is an excellent activity to use probeware instead of traditional laboratory collection techniques.) The purpose of this portion of the activity is to determine quantitatively the effects of solutes at the freezing point and boiling point of water. Divide the class in half. One-half of the class will conduct the Freezing Point Depression Experiment, and the other half will conduct the Boiling Point Elevation Experiment. After receiving the directions for their assigned portion of this activity, students are to design their own data tables.

Review all safety issues concerning this activity.

For the Students Conducting the Freezing Point Depression Experiment

Provide student groups with ice, sucrose, sodium chloride, test tubes, a thermometer, large beakers, a graduated cylinder, and stirring rods. Have students identify the safety measures involved, including the fact that they should not eat the contaminated ice.

<u>Preparation of Ice Bath</u>
Students are to fill the large beaker 3/4 full with ice. They are to cover the ice with 1/4 to 1/2 an inch of table salt and stir the ice-salt mixture with a stirring rod and make sure the temperature drops to at least -10°C.

<u>Determination of Freezing Points of Solutions</u>

- Students are to place a test tube that is half full of water in the ice bath and stir the water in the test tube gently while keeping track of the temperature with a thermometer. When the first ice crystals appear on the inside wall of the test tube, record the temperature. This should be the freezing point of the liquid. (In this activity, water is the pure solvent.) They are to record the temperatures on a data collection table that they prepared prior to entering the laboratory.
- Students are to prepare a solution of sodium chloride by adding 5.8 grams of sodium chloride to 100 ml of water and mixing until all of the crystals dissolve. They are to place a test tube that is half full of the solution in the ice bath and stir the solution in the test tube gently while keeping track of the temperature. When the first ice crystals appear on the inside wall of the test tube, record the temperature. This should be the freezing point of the solvent.
- Students are to prepare a solution of sucrose by adding 34 grams of sucrose to 100 ml of water and mixing until all of the crystals dissolve. They will repeat the same process for the sucrose solution as for the sodium chloride solution.
- Students are to calculate the molalities of the sodium chloride and sucrose solutions.

Using the equation $\Delta T = (K_f)(m)(i)$, lead students through the process of determining the value of i, where i is the number of particles produced per formula unit and K_f for water = $1.86°C/m$.

For the Students Conducting the Boiling Point Elevation Experiment

Provide student groups with water, sucrose, sodium chloride, hot plates or Bunsen burner, ring stand, test tube clamps, test tubes, a thermometer, a graduated cylinder, and stirring rods.

Preparation

Students are to attach a test tube clamp to a ring stand so that the test tube will be positioned above the tip of their Bunsen burner.

Determination of Boiling Points of Solutions

- Students are to place a test tube that is half full of water in the test tube clamp and heat to boiling. They are to stir the water in the test tube gently as it heats while keeping track of the temperature with a thermometer at regular intervals. When bubbles are steadily released, students are to record the temperature. This should be the boiling point of the liquid. They are to record the temperatures on a data collection table that they prepared prior to entering the laboratory. (In this activity, water is the pure solvent. Depending on atmospheric pressure, the boiling point of water may not be exactly 100.0 ^{o}C.)
- Students are to prepare a solution of sodium chloride by adding 5.8 grams of sodium chloride to 100 ml of water and mixing until all of the crystals dissolve. They are to fill a test tube about half full of the solution and place the test tube in test tube clamp. They are to stir the solution in the test tube gently as it heats while keeping track of the temperature at regular intervals. When the bubbles begin to be steadily released, they are to note and record the temperature. (This should be the boiling point of the solvent.) They should continue to take readings for two more minutes. They are to note what happens to the temperature as the solution continues to boil.
- Next, students are to prepare a solution of sucrose by adding 34 grams of sucrose to 100 ml of water and mixing until all of the crystals dissolve. They are to repeat the same process for the sucrose solution as for the sodium chloride solution.
- Students are to calculate the molalities of the sodium chloride and sucrose solutions. Using the equation $\Delta T = (K_b)(m)(i)$, determine the value of ***i***, where *i* is the number of particles produced per formula unit and K_b for water = 0.512 °*C/m*.

Follow laboratory activities with guided questions and class discussion to assure student understanding of the following:

- Student groups will pair up and share procedure and results with each other. Each group is to have a thorough understanding of each experiment. The groups should compare calculated results of molality and note that they are the same for sodium chloride and the same for sucrose.
- The addition of a solute to a solvent raises the boiling point and lowers the freezing point of a solvent.

- Colligative properties of solutions depend on the concentration of solute particles.
- The freezing points of water solutions are always lower than that of pure water and boiling points are always higher.

Some properties of a solution are different from the properties of the pure solvent. These include freezing point and boiling point as well as vapor pressure and osmotic pressure. These properties are determined by the number of solute particles in the solution. Colligative properties depend on the *number* of solute particles but not the identity of the solute.

Because colligative properties depend on the number of particles in solution, a one-molal solution of an electrolyte (sodium chloride), which dissociates in water, lowers the freezing point and elevates the boiling point more than a one-molal solution of a nonelectrolyte (sucrose). Molality is used for the concentration because it does not change its value with temperature changes.

Provide guided and individual practice solving colligative properties problems.

Ask the students how the activity would relate to making ice cream. Have them apply\use the principles from the activity by making ice cream. Recipes and directions can be found on the Ice Cream BLM.

Activity 6: Investigating the Properties of Acids and Bases (SI GLEs: 4, 10; PS GLE: 35)

Materials List: safety goggles; aprons; Zn, Mg, Fe, Cu shot or small samples; microplate; 1M HCl; 6M $HC_2H_3O_2$; 1M NaOH; household ammonia solution; small test tubes; wood splints and flint strikers; science learning logs

Arrhenius, Brønsted-Lowry, and Lewis Acid/ Base theories should be explained prior to this activity.

Theory	Acid definition	Base definition
Arrhenius (traditional)	Substance that contains hydrogen and ionizes in water to produce H^+ ions	Substance that contains hydroxide ions and ionizes in water to produce OH^- ions
Brønsted-Lowry	Proton donor	Proton acceptor
Lewis	An electron- pair acceptor in a covalent bond	An electron- pair donor in a covalent bond

Provide the students with an overview of the activity. Instruct the students to identify the appropriate safety measures.

All observations should be recorded in the science *learning logs* (view literacy strategy descriptions). Data tables should be student generated.

Procedure: Place a piece or two of each metal shot in separate wells on the left side of the microplate and on the right side of the microplate. On the left side of the microplate, add enough HCl to cover the shot in each of the four wells. Record observations.

On the right side of the microplate, add enough $HC_2H_3O_2$ to cover the shot. Record observations.

After disposing the materials in a waste beaker, the microplate should be washed and rinsed with distilled water. This part of the activity should be repeated with 0.5 M NaOH and ammonia solutions. Observations should be recorded.

Place a small amount of Zn in a separate well. Cover with HCl. Hold an inverted test tube over the reaction for about a minute. Remove the test tube, making sure it remains inverted. Insert a burning splint into the inverted test tube. Record observations.

The teacher should lead a discussion in which the students compare observations and draw conclusions comparing and contrasting the properties of acids and bases from the activity. The student is to write balanced equations for the reactions that do occur. Students should use *split-page notetaking* (view literacy strategy descriptions) to compare and contrast the various acid-base theories covered above. *Split-page note taking* is done by drawing a straight line from top to bottom of a piece of paper (preferably a sheet of normal sized, lined notebook paper) approximately 2 – 3 inches from the left edge. The page should be split into one-third/two-thirds. In the left column big ideas, key dates, names, etc. should be written and supporting information in the right column. Students should be urged to paraphrase and abbreviate as much as possible.

Sample of *split-page notetaking*

Acid- Base Theories	
Arrhenius	4. Acid must contain hydrogen 5. Base must contain hydroxide ions. 6. Very limiting definitions of acids and bases.
Lewis	4. Deals with electron behavior instead of proton (H^+)transfer 5. Hydrogen ions and hydroxide ions are not necessary at all. 6. broadest definition of acids and bases Note: amphoteric substances have the ability to act as either as acid or base

Demonstrate for students how to review their split-page notes by covering one column and using the information in the other to recall the covered information. Students should be allowed to quiz each other over the content of their notes in preparation for tests and other class activity.

Activity 7: pH (SI GLEs: 5, 6; PS GLEs: 32, 33)

Materials List: safety goggles; aprons; microplate; red and blue litmus paper; universal indicator; phenolphthalein; other indicators if available; stirring rod; vinegar; distilled water; 0.1 M KOH solution; household ammonia; colorless soda; 0.1 M HCl solution; pH paper or pH meter; problems for students to work; pH Lab Carousels BLM

Review all safety issues concerning this activity.

Activate prior knowledge of pH by asking students about the care of pools or aquariums. Ask if they have experienced heartburn and the purpose of antacids medications. Students can also research common items such as shampoo or antiperspirants to see the effect of different pH levels on these products.

Explanation and direct instruction of pH and pH problems should be conducted prior to this activity.

Set up the lab carousels found on the pH Lab Carousels BLM. Students should have time to complete both activities in one class period. Demonstrate the correct way of using indicator paper before beginning the activities. Observations should be recorded on a student generated data table.

Students should respond in their laboratory reports/journals to the following:

- How do you explain the change of pH when you mix an acid with a base?
- When you mix an acid and a base, you *neutralize* the solutions. Why do you think this term is used?
- List the materials you tested in order from most acidic to the most basic.
- Which has more hydrogen ions, a solution with a pH of 10 or a pH of 8?
- Which has more hydroxide ions, a solution with a pH of 10 or a pH of 8?
- What is the pH value of a neutral solution?

Following a teacher demonstration, have students participate in a guided practice session to solve quantitative problems regarding the pH, pOH, $[H^+]$, and/or $[OH^-]$ of strong acids and strong bases. Sample problems include the following:

- Calculate the pH of 0.00255 M HCl.
- Calculate the pH of a 0.084 M $Ca(OH)_2$.
- If 2.00g of solid NaOH are dissolved in 250.0 mL of H_2O, what will be the pH of the resulting solution?
- If the pH of an HNO_3 solution is 3.50, find the $[H^+]$ and $[OH^-]$.
- Find the pH, pOH, and $[OH^-]$ of 0.002 M HCl.

Conclude the activity by having students solve additional pH problems.

Activity 8: Acid-Base Titration (SI GLEs: 5, 10; PS GLEs: 32, 33)

Materials List: safety goggles, aprons, 0.1 M HCl, 0.5 M NaOH, burets, double buret clamps, ring stand, Erlenmeyer flask, phenolphthalein

The purpose of the activity is to determine the concentration of a solution of hydrochloric acid using acid-base titration. In this experiment students will titrate a measured volume of HCl with a standardized solution of NaOH of known concentration. The acid and the base react with one another according to the equation

$$HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$$

Provide student groups with two burets, a double buret clamp, a ring stand, an Erlenmeyer flask, beakers, a standardized solution of NaOH with molarity labeled, a phenolphthalein indicator, and an unknown solution of HCl. Demonstrate the procedure and lead the class to develop a list of appropriate safety measures for this experience.

The HCl is placed in the Erlenmeyer flask, and phenolphthalein indicator is added. The NaOH solution is added from a buret into the flask containing the acid. During the first stages of the titration, the NaOH will be completely neutralized, and an excess of acid will remain. However, eventually there will be a point, the theoretical endpoint, at which the acid and the base have neutralized one another exactly, and no more base should be added to the flask. The phenolphthalein indicator is used to determine experimentally the point, called the experimental endpoint, at which the base has neutralized the acid. Phenolphthalein is colorless in an acid solution. It turns pink when the acid is completely neutralized and a slight excess of base is present. In this titration, a successful endpoint is achieved if one drop of base turns the solution in the flask from colorless to pink. Ask students why they think they are to use two separate burets for the acid and the base. (The answer is to deal with overshooting the end point.) An additional measured volume of acid can be added, neutralizing the excess base and turning the solution acidic again; then more base can be added to reach a new endpoint.

Students will record all volume measurements and complete calculations by applying their knowledge. Both the concentration in molarity (mol/L) and the volume in ml that can be converted to L of the NaOH hydroxide is known and can be used to calculate the moles of base used. At the endpoint, the number of moles of HCl used equals the number of moles of NaOH used as indicated in neutralization equation. Therefore, the number of moles of HCl in a measured volume of acid is now known, and the concentration of the HCl can be calculated.

Titration experiences may also be completed in the microscale by using well plates with pipettes to drop an acid of known concentration into known quantity and concentration of a base.

Guided and individual practice should be conducted to ensure that students understand titration problems.

Students are to be placed in groups. Modified r*eciprocal teaching* (view literacy strategy descriptions) should be used to demonstrate mastery of solutions, colligative properties, electrolytes, pH, and titrations. *Reciprocal teaching* can be done after each individual activity or as a concluding activity for the unit. *Reciprocal teaching* is a strategy in which the teacher models and the students use summarizing, questioning, clarifying, and predicting to better understand content concepts. First, model each of these four roles for students using another related principle. Provide students a summary statement about the principle and talk about how the summary was formed; ask relevant questions about the principle; predict expected outcomes based on the principle; and clarify key concepts in the principle. Next, place role cards on each table for students to determine who will fulfill each role—summarizer, questioner, clarifier, and predictor. The summarizer summarizes the main points of equilibrium systems. The questioner asks what stresses affect an equilibrium system. The clarifier explains the effect of the stresses on an equilibrium system. The predictor makes a prediction of the shifts caused by specific stresses on a given equilibrium system. Monitor group work and provide additional modeling of the four processes of reciprocal teaching as needed

Activity 9: Titrations with Technology (SI GLEs 5, 6; PS GLEs: 32, 33)

Materials List: safety goggles, aprons, data collection device with graphing calculator and pH probe, 0.1 M NaOH, buret, graduated cylinder, ring stand, buret clamp, beakers, hot plate/stirrer with magnetic stirrer, regular and diet cola soft drinks

This activity will focus on student understanding of titrations, equivalence points, and acid-base concepts, as well as how to interpret data by exploring an everyday beverage acid content using technology and probeware.

To activate prior knowledge, open the activity by focusing on the chemistry behind a titration. Use a *graphic organizer* (view literacy strategy descriptions), focus formative assessment on the concepts of acids, bases, acid-base equations, pH, and molarity as an expression of solution concentration. Move to an overview of the experiment by having students read cola cans to determine the acids contained in the cola. They should note citric, carbonic, and phosphoric acids. Share with students that the phosphoric is the strongest acid listed and the one that will be of main concern in the experiment. Tell students that as part of the procedure, the colas will be gently boiled. Ask students to predict why (to eliminate an acid) and which acid will be eliminated (carbonic acid, which can vary greatly from cola to cola). Discuss pertinent safety precautions and have students begin laboratory work.

Provide each group of students with these materials: data collection device with graphing calculator and pH probe, 0.1 M NaOH, buret, graduated cylinder, ring stand, buret clamp, beakers, hot plate/stirrer with magnetic stirrer, regular and diet cola soft drinks.

Have students rinse and fill a clean buret with 0.1 M NaOH. Measure about 50 ml of a cola into a beaker. Take the pH of the cola before it boils and record it. Gently boil the cola on a hot plate for ten minutes, and then allow it to cool to room temperature. Transfer 30 ml of the boiled cola to a clean beaker. Place the pH probe into the solution, add a magnetic stirrer, place the beaker on the hotplate/stirrer, and turn on the stirrer. Students should look over the set-up carefully for problems, think of the interactions and the basic workings of the equipment and solutions, and then summarize in their lab reports/journals what will be happening during the experiment. Make sure the technology and probeware are set to collect 30 readings at regular intervals. Take an initial pH reading of the boiled cola, and then begin. Add the base in 1 to 2 ml increments until you observe a sharp increase in pH. Add the base in 0.1 to 0.2 ml increments to define more clearly the equivalence point of the titration. After the equivalence point is reached, add more base in 1 to 2 ml increments. Take several readings. After all 30 sample points are taken, a STAT PLOT of the collected data can be displayed. Discard the solution and conduct at least two more trials on the same cola. Prepare the second cola sample according to the original instructions. Through class discussion, summarize the concepts used during the experiment. Have students review the titration plots for the two types of cola. Ask them to record in their lab reports/journals any differences or similarities. Students are to determine the exact endpoint of the titration to calculate the phosphoric acid concentration in each.

Students can also research the health risks of ingesting too much carbonation and/or phosphoric acid from sodas.

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Sample Assessments

Assessment techniques should include drawings/illustrations/models, laboratory investigations with reports, laboratory practicals (problem-solving and performance-based assessments), group discussion and journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

General Guidelines

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will conduct a crime scene investigation of an unknown clear liquid and/ or ransom note.
- The student will write a report summarizing pH and its importance in his daily life. The results of the pH activities in this unit will be used to show an understanding of these items.

Activity Specific Assessments

- Activity 2: Write several "ransom notes" using a variety of ink pens and felt tip pens. Have several pens that could possibly have been used to write the notes available. Give different notes to each group. Students are to apply the concepts of chromatography to determine which pen was used to write their particular note. The site http://www.kids.union.edu/fsnChromatography.htm provides background information, activity directions, questions and explanations for determining who wrote a note canceling class and left the note on the door. Students use chromatography to solve the mystery. This activity can be easily modified for the individual classrooms and used in place of the ransom notes.

- Activity 6: Students should use the data collected in their experiment to determine the reactivity of the metals with the acids.

	With HCl	***With $HC_2H_3O_2$***
Mg	*Very fast*	*Slow*
Zn	*Fast*	*Very slow*
Fe	*Slow*	*No apparent reaction*
Cu	*No apparent reaction*	*No apparent reaction*

- Activity 7: Students should use the data collected to determine the pH of the solutions and the color changes with the indicators.

	Red litmus	*Blue litmus*	*phenolphthalein*	*pH paper*
Vinegar	*No effect*	*Turns red*	*Colorless*	*3*
Distilled water	*No effect*	*No effect*	*Colorless*	*7*
KOH solution	*Turns blue*	*No effect*	*Turns pink*	*13*
Antacid solution	*Turns blue*	*No effect*	*Turns pink*	
Ammonia solution	*Turns blue*	*No effect*	*Turns pink*	*10*
Milk	*No effect*	*Turns red*	*Colorless*	*6*
HCl solution	*No effect*	*Turns red*	*Colorless*	*1*

- Activity 8: Students will work problems involving titration data and solve for the unknown volume or the molarity of the acids or bases involved.

Resources

- *Smile Program Chemistry Index*. Available online at http://www.iit.edu/~smile/cheminde.html
- *Acid-Base Titration*. Available online at http://educ.queensu.ca/~science/main/concept/chem/c10/c10lamo6.htm
- *Acid Stomach*. Available online at http://www.sciencenetlinks.com/lessons.cfm?DocID=380
- *Neutralizing Acid and Basic Solutions*. Available online at http://educ.queensu.ca/~science/main/concept/chem/c10/C10LALG1.HTM
- *Titration Illustrations*. Available online at http://www.dartmouth.edu/~chemlab/techniques/titration.html
- *Titration Using Probes and Computers for Analysis*. Available at http://www.calpoly.edu/~cbailey/125LabExperiments/Titration/Titration.html

Chemistry
Unit 8: Carbon and Its Compounds

Time Frame: Approximately two weeks

Unit Description

This unit focuses on a basic understanding of organic compounds. The unit allows students to explore how carbon forms bonds, the structural formulas of carbon compounds, and how carbon compounds are classified based on their functional groups and structures.

Student Understandings

The student understands that carbon-based substances or organic materials form the basic compounds that are found in living systems, energy sources (oil and gas), alcohols, etc. The student demonstrates his/her understanding of the basics by classifying, naming, and drawing simple carbon compounds and the reactions they undergo.

Guiding Questions

1. Can students explain the differences between diamonds and graphite?
2. Can students describe the hybridization of the carbon atom to explain single, double, and triple bonds as well as molecular shapes?
3. Can students classify, name, and draw structural formulas for carbon compound molecules?
4. Can students classify, name, and draw structural formulas for carbon compounds with different functional groups?

Unit 8 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
14.	Cite examples of scientific advances and emerging technologies and how they affect society (e.g., MRI, DNA in forensics) (SI-H-B3)

Physical Science	
25.	Name selected structural formulas of organic compounds (PS-H-C6)
26.	Differentiate common biological molecules, such as carbohydrates, lipids, proteins, and nucleic acids by using structural formulas (PS-H-C6)
27.	Investigate and model hybridization in carbon compounds (PS-H-C6)
28.	Name, classify, and diagram *alkanes*, *alkenes*, and *alkynes* (PS-H-C6)

Sample Activities

Activity 1: Allotropes of Carbon (SI GLEs: 6, 7; PS GLE: 25)

Materials List: diagrams or models of graphite and diamond, toothpicks and foam balls or molecular model kits

Activate prior knowledge of covalent bonding (sharing of electron pairs) and the hybridization of the valence orbitals of carbon. The 2s and three 2p orbitals of carbon atoms hybridize (combine and rearrange) to form 4 new identical orbitals of equal energy. Each of these new orbitals will have a bond angle of 109.5˚ and give a tetrahedral molecular geometry to carbon compounds with single bonds.

Define *allotropes* (different forms of the same element) and, as an example, explain the difference in the crystalline structures of diamond (each carbon atom is bonded to 4 other carbon atoms in all directions) and graphite (each carbon atom is bonded to 5 carbon atoms in a ring in layers).

An Internet lesson adapted from *Science Netlinks* resources is available online at http://www.sciencenetlinks.com/lessons.cfm?DocID=154 . If Internet access is available, instruct the students to follow the directions on the website for this activity. Next, have students view graphite and diamond on the *Reciprocal Net Common Molecules* web site: http://www.reciprocalnet.org/recipnet/showsample.jsp?sampleId=27344423 and http://www.reciprocalnet.org/recipnet/showsample.jsp?sampleId=27344170. Be sure to have students click and drag on the structures to rotate them. Ask students to describe how the animations demonstrate that diamond is hard and graphite is soft.

If the Internet is unavailable, provide diagrams of the crystal structures of graphite and diamond. These diagrams are usually found in the commonly used chemistry textbooks. Instruct the student to contrast the two carbon structures.

Ask students to make a list of ingredients for several products they use in their daily lives. This should be done as a homework assignment. They should be given some examples such as acetaminophen in pain medications or cyclohexanediamine found in some dishwashing liquids. During a class discussion of their findings, compile a list of the most common ingredients identified. Draw attention to the endings of these names such as n-alkyl dimethyl benzyl ammonium chloride (found in many bathroom cleaners) or pseudoephedrine HCl (found in sinus medications). Ask how these names compare to the ionic names (sodium chloride) and molecular names (carbon dioxide). (These names are much more complex and are usually carbon based.) Explain that many of these ingredients found in plastics, medicines, cleaning products, etc. are examples of organic compounds.

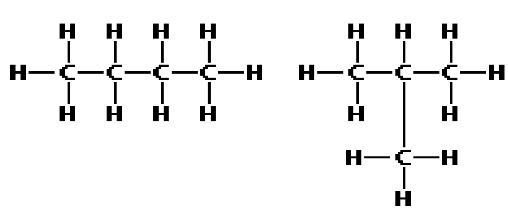
It should be noted that carbon monoxide, carbon dioxide, and compounds containing the polyatomic ion carbonate are not considered organic compounds, even though they contain carbon.

To accommodate kinesthetic learners, have students construct model molecules for selected organic compounds from structural formulas using toothpicks and small foam balls of various colors or plastic model components. Models can be constructed for the rest of the activities in this unit.

Activity 2: Alkanes, Alkenes and Alkynes (SI GLE: 7; PS GLEs: 25, 27, 28)

Materials List: toothpicks and small foam balls or molecular model kits, Alkanes BLM, Alkanes Answer Sheet BLM

Distribute copies of the Alkane BLM to the students. The Alkane BLM can be used as a guide to naming and drawing structural formulas as they do this activity. Use toothpicks and small foam balls of various colors or plastic model components and have students construct molecules for selected organic compounds. Explain what hydrocarbons are. Explain that the hybridization of C atoms is used to explain the single and multiple bonds that can be formed between C atoms and between C atoms and the atoms of other elements. Begin constructing models of alkanes starting with methane, CH_4. Add additional CH_2 groups, naming each model in turn. Tell students they are building straight-chain alkanes. Point out that straight-chain means having no branches. The actual models will have a zigzag shape due to the bond angle of the carbon atoms. For methane through propane, ask students if the models can be constructed in any different fashion. (No, they have only one isomer each.) Have students construct the straight chain model for butane. Ask if there is any other way of bonding the carbons together. Explain that butane has two isomers (compounds with the same molecular formula but different structures.) Explain that a structural formula indicates the number and types of atoms in the molecule as well as showing how the atoms are bonded together. For example, Butane C_4H_{10} is the molecular formula. The structural formulas are



n-butane   isobutane
also called methylpropane

Structural isomers can have different physical or chemical properties. Students should be able to name compounds up to 10 carbons. They should be able to draw structural formulas for all of the straight chain compounds and be familiar with the rules for IUPAC names for these alkanes. They should also be able to recognize and draw several isomers of a given compound.

Once students have mastered alkanes, cycloalkanes (carbons atoms are connected to each other in rings) can be discussed. In naming cycloalkanes, the carbons in the ring are numbered to give the substituents (branches) the lowest numbers. The properties and uses of alkanes should be discussed.

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Alkenes (hydrocarbons that have at least 2 carbon atoms connected by a double bond), alkynes (hydrocarbons that have at least 2 carbon atoms connected by a triple bond), and aromatic compounds (hydrocarbons that contain the benzene ring) should be discussed. Systematic names, properties, and uses of these hydrocarbons should be addressed. A web quest can be developed to help students understand these ideas.

Activity 3: Functional Groups for Organic Structures (PS GLEs: 25)

Materials List: textbook, library books or internet sites, teacher-generated worksheet

Using the textbook or other resources, students should use *split-page notetaking* (view literacy strategy descriptions) to list the various functional groups. Additional information for each functional group should include its general formula, the name of the characteristic group, ending of compound name, and an example of each class of compounds. *Split-page note taking* is done by drawing a straight line from top to bottom of a piece of paper (preferably a sheet of normal-sized, lined notebook paper) approximately 2 – 3 inches from the left edge. The page should be split into one-third/two-thirds. In the left column big ideas, key dates, names, etc. should be written and supporting information in the right column. Students should be urged to paraphrase and abbreviate as much as possible. Groups to include: halocarbons, carboxylic acids, aldehydes, ketones, esters, amines, amides, amino acids, nitriles, and nitro compounds

Sample of *split-page notetaking*

Functional Groups	
Alcohols	General formula: R-OH -OH is the hydroxyl group (not hydroxide ion!) ending –ol ex.: CH_3OH methanol Additional info: alcohols with 4 or more C atoms are not soluble in water

Ethers	General formula: R-O-R -O- ending: -oxy- ex.: CH_3-O-CH_2CH_3 methoxyethane (methyl – oxygen-ethane) or methyl ethyl ether Additional info: diethyl ether (ethoxyethane) was used as an anesthetic; extremely flammable, only slightly soluble in water

After all functional groups are addressed, develop a worksheet with various condensed structural formulas representing the various functional groups. Students are to use their notes to name the compounds. Guided practice should be used before individual practice is done. Remind students how to study from their notes by covering one column and using the information in the other to recall the covered information. Also, allow students time to quiz each other over the content of their notes in preparation for tests and other class activities.

A teacher-generated worksheet with samples of compounds containing the various functional groups should be given to the students. The students should underline or circle the functional group(s) in each compound and name the group. The compound should be classified according to the group. For example, given the formula C_3H_5OH, the students should circle or underline the -OH group. The group is called the hydroxyl group. This functional group would identify the compound as an alcohol.

Activity 4: The Carbon Compounds of Life (SI GLEs: 7, 14; PS GLEs: 25, 26)

Materials List: textbook or other resource materials

Activate prior knowledge of organic chemistry from previous biology classes by asking students about the importance of carbon. Students should recall that carbon is a necessary element for all living things.

Begin the activity by using illustrations and issuing structural formulas for selected carbohydrates, lipids, amino acids, nucleic acids, and proteins. Emphasize that biochemical organic compounds can be identified by the functional groups they contain. For example, amino acids contain a carboxyl group (-COOH) and an amino group (-NH_2), both attached to the same carbon atom. The carbon will also have a hydrogen atom attached. Use DNA as an example of a polymer. Ask students what they know about DNA and its uses in society today. Explain how DNA can be used to prove or disprove parenthood and innocence or guilt in a crime and how it is used in forensics. Lipids (fats), as saturated and unsaturated fats, can also be related to the current trend to remove saturated fats from our diets.

Have students write molecular formulas from the structural formulas and examine the ratios of carbon and hydrogen or carbon, hydrogen, and oxygen in selected compounds to differentiate among types of organic compounds.

Sample Assessments

Assessment techniques should include drawings/illustrations/models, group discussion, journaling (reflective assessment), and paper-and-pencil tests (traditional summative assessments).

General Guidelines

- Students should be monitored throughout the work on all activities via teacher observation of their work and journal entries.
- All student-developed products should be evaluated as the unit continues.
- Student investigations should be evaluated with a rubric.
- When possible, students should assist in developing any rubrics that will be used.
- For some multiple-choice items on written tests, ask students to write a justification for their chosen response.

General Assessments

- The student will identify the type of carbon compound (e.g., alkane, alcohol, acid, etc.), given a set of structural formulas for organic compounds.
- The student will write structural formulas and name organic compounds, given the molecular formulas.

Activity-Specific Assessments

- Activity 2: Given the name for heptane, the student will write the structural formula for the nine isomers of heptane. Each isomer should be named under its structural formula.

- Activity 3: Given a card sort of structural formulas and molecular formulas representing the various classes of compounds each represents (in random order), the student is to identify the functional group in each and identify the type of class of compounds. A concept map can be developed from the cards and information.

- Activity 4: Given a card sort of structural formulas and molecular formulas representing various compounds, the student is to identify each as a carbohydrate, lipid, amino acid, nucleic acid, or protein.

Resources

- *Carbon Structure Matters*. Available online at http://www.sciencenetlinks.com/lessons.cfm?DocID=154
- *Graphite and Diamond*, the Reciprocal Net Common Molecules. Available online at http://www.reciprocalnet.org/recipnet/showsample.jsp?sampleId=27344423 http://www.reciprocalnet.org/recipnet/showsample.jsp?sampleId=27344170
- *Is Carbon Hard or Soft?* Available online at http://www.lbl.gov/MicroWorlds/MaterialWorld/
- *The Mineral Gallery*. Available online at http://mineral.galleries.com/minerals/by-name.htm
- *The Reciprocal Net. A Database for Crystallographers*. Available online at http://www.reciprocalnet.org/
- 3-*D Molecular Structures.* Available online at http://www.nyu.edu/pages/mathmol/library/