Chemistry Program of Study

Semester 1

The study of chemistry requires the use of inquiry and technological design to solve problems and to investigate phenomena. Chemists use mathematics to describe the composition as well as the transformations of substances. The relationships between variables may be expressed as equations and can be displayed by using graphs. The Systeme Internationale (SI) units are the measurement standards used to quantify physical variables. Laboratory safety and measurement techniques are of paramount importance in the study of chemistry.

Throughout their study of chemistry, students are asked to demonstrate their knowledge of scientific inquiry by designing experiments, interpreting and analyzing data, and drawing conclusions. Mastery of these skills will be assessed on the CASE exams. Therefore, it is imperative that chemistry teachers use scientific problem-solving strategies in all coursework. These include:

- establishing safety practices and procedures that are followed pertaining to laboratory and field work;
- using an orderly approach to solving problems through controlled experimentation to produce conclusions supported by repeatable, reliable, and verifiable data;
- evaluating different information sources to add validity, unbiased reporting, and evidence to scientific claims;
- designing experiments using a wide variety of scientific instruments and methods, which are used to make observations, and for measuring and recording data from experiments;
- organizing data using tables, charts, and diagrams;
- graphing, analyzing, and interpreting data to support valid conclusions;
- applying the use of the International System of Units in data collection and in writing about research findings; and
- applying ethical standards to scientific methods and conclusions

The Chemistry Program of Study has specific content that is delineated by five underlying conceptual statements based on the Illinois State Science Goals and is intended to specify material that takes two 16-week semesters, thereby allowing time for teachers and students to investigate topics of interest, to discuss current events, to work on independent science investigations, and for enrichment or remediation activities. The time allocations are suggestions, not mandates. Adjustments must be made for each class in each school. Teachers are expected to exercise their judgment to supplement, rearrange, and substitute equivalent or more appropriate activities so that their students will have the best opportunity to achieve the Chicago Academic Standards. Because different schools have different resources, the suggested activities and resources for teachers show a range from inexpensive to high technology. An adequate budget is necessary to support quality science instruction and science department members should develop plans to secure the instructional materials that are needed and to share those that are already in place.

Note to the Teacher:

Textbooks from a variety of publishers are used in teaching chemistry. These textbooks differ in length and in the level of detail. They may also differ regarding the topics that are most emphasized as well as the sequence, thoroughness, and method of presentation of these topics. For these reasons, it is important that teachers extract information from the textbook that corresponds to the Conceptual Statements and Supporting Ideas presented in the CASE Blueprint. This might mean omitting some chapters or portions of a particular chapter or locating supplemental information. The Program of Study is organized in such a manner that the suggested activities and teacher resources are listed under an outline of the Conceptual Statements and Supporting Ideas from the Chemistry CASE Blueprint. When teachers write lesson plans, it is recommended that they correlate this document with all available resources. The suggested activities are also linked to the State Goals, Chicago Academic Standards, and Curriculum Framework Statements.

Semester 1

Conceptual Statement	Number of Supporting Ideas	Approximate Timeline
1. Properties of Matter	6	4 weeks
2. Units of Matter	10	12 weeks

Semester 2

Conceptual Statement	Number of Supporting Ideas	Approximate Timeline
3. Chemical Reactions	7	7 weeks
4. Solutions	4	4 weeks
5. Gas Laws and PVT	9	5 weeks

Although mathematics is very important to the mastery of chemistry, it is not the focus of this Chemistry Program of Study. The use of scientific calculators in the classroom and for the CASE is strongly encouraged. Students should use the same calculator during the exam that they have been using throughout the school year. The mathematical skills specified in the Algebra Blueprint are appropriate for chemistry.

Chemistry Program of Study
Semester 1

Conceptual Statement I: Properties of Matter

Matter occupies space and has mass. Understanding atomic structure is the basic foundation for investigating matter. The identification of matter is made possible through physical description.

Supporting Idea:

1. Matter is classified according to elements (atoms), compounds, mixtures, physical states (which are determined by the kinetic energy of its atoms), and physical properties (which depend on the arrangement of the atoms and their atomic structure).

Suggested Activities for Students

- Use physical and chemical properties of materials to separate components of a mixture.
- Apply standard separation techniques to purify water samples.
- Use a variety of other sources such as class notes, textbooks, on-line searches, expert sources, periodicals, etc., to collect additional information about water purification.

Resources for Teachers

- Many chemistry textbooks include activities that give students a starting place for separating components of a mixture.
- *ChemCom* has a rcommended example of a water purification separation lab.

On-line resources:

- American Institute of Chemical Engineers
- http://antoine.frostburg.edu/chem/senese/101/compounds/index.shtml
- http://library.thinkquest.org/10429/high/matter/matter.htm

SG,CAS,CFS: 11B1-14; 11C1,3,6; 12C1; 13A2,4; 13 B3; 13 C2

Supporting Idea:

2. Transfer of energy (expressed in calories or joules) during phase changes is represented by a phase diagram. An example of this is the melting of a solid to a liquid and the continuous heating of the liquid until vaporization.

Suggested Activities for Students

- Measure and observe physical changes that occur when energy is added to various substances.
- Measure temperature changes as heat is applied to various samples of H_2O in the three states (ice-water-steam).
- Organize the data, graph, and interpret the results.

Resources for Teachers

- Many chemistry texts include activities that give students a starting place for measuring and observing physical changes that occur when energy is added to various substances.
- *Science Matters* (Doubleday). Chapter 7: Atomic Architecture is written from the science literacy perspective that *the way a material behaves depends on how its atoms are arranged.*

On-line resources:

* http://wulff.mit.edu/pt/
* http://www.cemr.wvu.edu/%7Embond/index.html
* http://www.webelements.com/
* http://antoine.frostburg.edu/chem/senese/101/thermo/index.shtml

SG,CAS,CFS: 11C6; 12C3; 12D2

Supporting Ideas:

3. Trends in physical properties and their correlation to the atomic structure of elements are found in the Periodic Table.
4. Atomic structure is determined by the number of protons, neutrons, and electrons and their spatial distribution. Atoms of the same element with different numbers of neutrons result in isotopes.

Suggested Activities for Students

- Demonstrate the relationship between subatomic particles, properties of elements, and their practical uses.
- Use the Periodic Table to identify families of elements and relate families to common physical properties and trends in physical properties.
- Observe and measure physical properties (density, malleability, ductility, heat conductivity, solubility) of various elements, compounds, and mixtures.
- Measure the conductivity of water samples (tap water, deionized water, sugar water, and salt water) and use that information to discuss and explain everyday phenomenon observed.
- Use the Periodic Table to identify families of elements and relate families to common chemical properties and trends in chemical reactivity.
- Use the electron configuration of an element to identify its position in the Periodic Table, explain chemical properties, and predict ion formation.
- Collect information from class notes, textbooks, periodicals, and on-line searches. Analyze results using the results of other students in class and the expected results based on the research/data collected. Organize the information based on patterns and trends.
- Develop a periodic table of the elements based upon information gathered from observation, experimentation and research.

SResources for Teachers

- Many chemistry texts include activities that give students a starting place demonstrating the relationship between subatomic particles, properties of elements, and their practical uses.
- *Journal of Chemical Education Software: Project Seraphim*
- *Science Matters* (Doubleday).
  Chapter 4: The Atom; Chapter 7: Atomic Architecture are written from the science literacy perspective that *everything is made of atoms and the way a material behaves depends on how its atoms are arranged.*

On-line resources:

- Chemistry Hypermedia Project
- Chemistry Teaching Resources Internet Chemistry Index
- http://www.colorado.edu/physics/2000/applets/a2.html
- http://www.chemicool.com/
- http://www.creschem.com/perchart.html
- http://www.chem.uky.edu/misc/periodicquiz.html
- http://www.resource%2Dworld.net/PerTable.htm
- http://www.cemr.wvu.edu/%7Embond/index.html
- http://www.webelements.com/

- Use the Periodic Table to determine the number of subatomic particles (protons, neutrons, and electrons) in elements and their isotopes.
- Use the Periodic Table to state the atomic mass of elements.
- Design a three-dimensional model of a practical use of an element and use this structure to hold the additional information, design a brochure, design a display board, create a cartoon strip, write a poem/song in praise of the element, create a book to explain the element to another student, etc.
- Collect information about the properties of elements from experiments and other sources such as class notes, textbooks, reference sources, etc., and organize the elements according to patterns and trends.

SG,CAS,CFS: 1 A1-3; 11C6; 12C1

Supporting Idea:

5. Since the eighteenth century, the model of the atom has undergone changes and revisions as new discoveries have been made (Dalton, Thomson, Rutherford, Schrodinger, Bohr, etc.).

Suggested Activities for Students

- Use experimental and research information to discuss the origin of elements and build the current model of atomic structure.
- Build a spectroscope.
- Use a spectroscope to observe emission spectra of various elements and relate this information to the current understanding of atomic structure.
- Explain theories for the origin of elements in the nuclear furnaces of stars.
- Use class notes, textbooks, and primary historical sources to compare and contrast atomic models proposed by Dalton, Thomson, Rutherford, and Böhr.

Resources for Teachers

- Many chemistry textbooks include activities which discuss the origin of elements and information to assist students in building a current model of atomic structure.
- Students may also build their own spectroscope. Chris de Latour at Luxagon Light Box (415-647- 5275) has many lessons on light.
- *The Making of the Atomic Bomb* (Simon & Schuster) provides authentic historical perspective.
- *Cosmos* (Random House Publishing). Chapter 9: Lives of the Stars is a recommended non-textbook source for this topic.

On-line resources

- http://www.aip.org/history/electron/jjhome.htm
- http://www.watertown.k12.wi.us/hs/teachers/buescher/atomtime.html

SG,CAS,CFS: 11A1-3; 11C6; 12C1-2,6; 12D1; 12F1; 13C1,3

Supporting Idea:

6. The use of models to describe and to work with atomic structure include the Lewis Dot structures and electron configurations that are based on an understanding of atomic orbitals.

Suggested Activities for Students

- Develop and build molecular models to demonstrate an understanding of covalent bonding and molecular shape.
- Use molecular model kits to build models of common substances in the chemistry lab.
- Create molecular models using beads, marbles, Styrofoam™ balls, or other suitable materials.
- Fold paper origami structures into the three-dimensional shapes of chemical compounds.

Resources for Teachers

- Many chemistry textbooks have model building activities.
- *The Double Helix: A Personal Account of the Discovery of the Structure of DNA* (Atheneum Publishers). This is an engaging example of a major scientific breakthrough that occurred because groups of people were able to understand the significance of the relationship between bonding and molecular shape.

On-line resources:

- Chemistry Virtual Library Mathematics and Molecules
- http://library.thinkquest.org/10429/high/bonding/bonding.htm
- http://www.towson.edu/%7Eladon/shapes.html
- http://www.micro.magnet.fsu.edu/electromag/java/atomicorbitals/index.html
- http://antoine.frostburg.edu/chem/senese/101/electrons/index.shtml
- http://library.thinkquest.org/10429/high/eleconfig/electron.htm

SG,CAS,CFS: 11C6; 12C1

Conceptual Statement 2: Units of Matter

Pure matter consists of atoms in fundamental units, which may be elemental, ionic, or molecular. Communication in chemistry is carried out by using chemical formulas to write and to balance chemical equations. Chemical quantities are typically expressed in moles. The foundation for chemical equations is explained in the context of the Atomic Theory.

Supporting Ideas:

1. A chemical formula is a constant entity according to the Law of Definite Proportions, and it shows the type and number of atoms in the smallest particle of a substance.
2. The naming of compounds is based on the number of elements involved and whether the substance is ionic or molecular.
3. One method of writing formulas involves the use of oxidation numbers or ionic charges.
4. The Stock System is used to name compounds containing transition elements based on oxidation numbers or charges.
5. In a chemical reaction, according to the Law of Conservation of Mass, matter cannot be created or destroyed (it only changes form); balanced equations illustrate this law.
6. Basic chemical reactions are classified into the following types: synthesis, decomposition, single replacement, double replacement (ionic), and combustion.

Suggested Activities for Students

- Observe and characterize examples of everyday reactions and create both word and symbolic representations of standard chemical reaction types.
- Use readily available materials to observe chemical reactions (e.g., vinegar and baking soda, hydrochloric acid as a simulation of stomach acid and antacids, metal corrosion, Vitamin C and fruits, hot and cold packs, sugar combustion, petroleum combustion).

Resources for Teachers

- Many chemistry textbooks include activities that give students a starting place for observing and characterizing examples of everyday reactions and creating both word and symbolic representations of standard chemical reaction types.
- *ChemCom* is organized around issues of chemistry that apply to everyday experiences.
- The SEPUP program is designed to provide activities covering concepts of chemical reactions and combustion.

Suggested Activities for Students

- Write balanced equations given the chemical formulas for the reactants and products.

On-line resources:

- http://www.scidiv.bcc.ctc.edu/wv/4/0004%2D000%2DTOC.html
- http://antoine.frostburg.edu/chem/senese/101/compounds/index.shtml
- http://library.thinkquest.org/10429/high/balequa/balequa.htm

SG,CAS,CFS: 11B5; 11C3-4,6; 12C1,4

Supporting Ideas:

5. In a chemical reaction, according to the Law of Conservation of Mass, matter cannot be created or destroyed (it only changes form); balanced equations illustrate this law.
6. Basic chemical reactions are classified into the following types: synthesis, decomposition, single replacement, double replacement (ionic), and combustion.
7. To determine the formula of a compound, the relative amount of the elements present in the compound must be obtained. This information can then be expressed as a percent composition. Empirical formulas may be obtained from this information. If the molecular mass is given, the molecular formula may be found.
8. The empirical formula is calculated from the percent composition. Given the molecular mass, the molecular formula may be calculated.
9. A mole may be expressed as 6.02×10^{23} particles (Avogadro's Number), the molecular (molar) mass, and the molecular (molar) volume of a gas at Standard Temperature and Pressure (22.4L).
10. Inter-conversion between moles and other quantities (e.g., grams, particles, and liters) may be accomplished using dimensional analysis.

Suggested Activities for Students

- Design and conduct an experiment to determine quantitative relationships in chemical reactions.
- Experimentally determine the percent composition of a simple compound such as magnesium oxide.

Resources for Teachers

- Many chemistry textbooks include activities that give students a starting point for designing and conducting experiments to determine quantitative relationships in chemical reactions.
- For many students, stoichiometric relationships are a difficult concept to grasp. A teacher demonstration of the electrolysis of water is a recommended place to introduce this discussion.
- *Chemistry in the Environment*, p.68, (Woodrow Wilson National Fellowship Foundation). The Micro-Hindenberg activity will give students data that permits them to determine mole ratios.

On-line resources:

- http://antoine.frostburg.edu/chem/senese/101/moles/index.shtml
- http://library.thinkquest.org/10429/high/chemcomp/chemcomp.htm
- http://library.thinkquest.org/10429/high/stoich/stoich.htm

SG,CAS,CFS: 11B1-14; 11C6; 12C1,4