The College of St. Scholastica
School of Education

Middle/Secondary Education Program
Recommendation for Admission to Student Teaching

Department/Licensure Area: Chemistry

Student: Complete Items 1-4

Student Name: ____

1. Indicate your grade in these courses required for licensure in Chemistry. If you are currently enrolled in a course, indicate “in progress”.

COURSE	CR	GRADE	COURSE SUBSTITUTION
CHM 1110 General Chemistry I	4		
CHM 1120 General Chemistry II	4		
CHM 2200 Organic Chemistry I	4		
CHM 2210 Organic Chemistry II	4		
CHM 3000 Analytical Chemistry	4		
CHM 3240 Biochemistry I	4		
CHM 3460 Physical Chemistry I	4		
CHM 4020 Inorganic Chemistry	4		
BIO 1104 Life Science	4		
PSC 2001 Physics 1	4		
PSC 2002 Physics II	4		
PSC 4150 Science & Culture	4		
NSC 3333 Science Methods	4		
NSC 3335 Science Methods Field Exp	1		
PSC 1202 Cosmic Systems	4		
MTH 2221 Calculus I	4		
CHM 4999 Independent Research	4		

2. Self-evaluate your attainment of the General Science and Chemistry licensure standards included with this form.

3. Ask your department chair to complete the recommendation section that follows.

4. Submit this form with your application for student teaching.

Department Chair: Complete items 1-3

1. Review the student's grades in their major and identify any courses substituted in place of the Board of Teaching approved curriculum.
2. Evaluate attainment of General Science and Chemistry licensure standards included with this form.
3. Make a recommendation below regarding admission to student teaching for this student.

☐ I recommend admission to student teaching for this student.

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☐ I recommend admission to student teaching for this student ***with the following reservations***:

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☐ I do not recommend admission to student teaching for this student ***for the following reasons:***

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Signature ____ ____________________

Department Chair Date

Minnesota Administrative Rules
Chapter 8710, Teacher and Other School Professional Licensing
8710.4750 TEACHERS OF SCIENCE

Subp. 3. Subject matter standards for science in grades 5 through 8. A candidate for licensure as a teacher of science in grades 5 through 8 must complete a preparation program under subpart 2, item C, that must include the candidate's demonstration of the knowledge and skills in items A to F.

A. A teacher of science must demonstrate science perspectives, including:
(1) understanding and conducting science inquiry as evidenced by the ability to:
(a) ask appropriate theoretical or empirical questions about a given system or event that build on current scientific knowledge and can be answered scientifically;
(b) design and conduct, using appropriate methods, technology, and mathematical tools, a scientific investigation to answer a given question;
(c) develop, using appropriate sources of information, qualitative and quantitative solutions to problems;
(d) communicate clearly and concisely, using words, diagrams, tables, graphs, and mathematical relationships, the methods and procedures, results, and conclusions for a given empirical question or problem;
(e) justify a scientific explanation of a given system or event, compared to alternative explanations, based on the available empirical evidence, current scientific understanding, and logical arguments; and
(f) criticize, using knowledge of common errors of evidence and logic, a given science-related claim or argument; and
(2) understanding the history and nature of scientific knowledge as evidenced by the ability to:
(a) describe the evolution of scientific knowledge in a given historical context in terms of the contributions of male and female individuals from various cultures; the influence of society, culture, and personal beliefs of the scientists involved; and the accumulating empirical evidence and logical arguments used to develop the new knowledge;
(b) explain why scientists disagree on a given contemporary controversy in terms of the different assumptions made by the scientists, the different values the scientists place on a particular piece of evidence, and the limitations of the available data or theories, or both; and
(c) explain, using knowledge of the role of empirical evidence and logical argument in science and the assumption that the universe is a vast single system in which the basic rules are everywhere the same, why a given contemporary or historical belief is nonscience.

	Attained	Not Attained	In Progress
Student Self Evaluation			
Faculty Evaluation			

B. A teacher of science must have the knowledge and ability to make conceptual connections within and across the domains of science and between science and technology. The teacher of science must understand:
(1) connections across the domains of science as evidenced by the ability to:
(a) describe, using words and diagrams, a given technological, biological, physical, earth, or space system in terms of its components, inputs, outputs, and control or feedback;
(b) describe, using a specific example, the use of a given unifying theme or principle in the physical sciences, life sciences, and earth and space sciences; and
(c) explain, using unifying scientific principles, a given set of seemingly unrelated systems or events, both within a science domain and across science domains;
(2) connections between science and technology as evidenced by the ability to:
(a) describe the similarities and differences between the goals and processes of scientific inquiry and the goals and processes of technological design;
(b) explain how the availability of new technology influenced the development of scientific knowledge in a given contemporary or historical context and how the development of new scientific knowledge led to technological advances in a given contemporary or historical context;

(c) explain and predict the possible unexpected benefits and the negative side effects and unintended consequences of a given technological advance;
(d) explain why the contributions of individuals from different scientific disciplines and of technology were necessary for the success of a given contemporary or historical scientific investigation; and
(e) design a modification or use of a system to meet certain needs or criteria in either chemistry, earth and space science, biology, or physics; and

(3) connections between science and other school subjects as evidenced by the ability to:
(a) communicate clearly and precisely, using words, physical models, computer models, demonstrations, diagrams, flow charts, numbers, tables, graphs, and appropriate mathematical relationships, the observations, methods and procedures, results, and conclusions for a given empirical question or problem; explanations of how or why something happens; predictions of what will happen when a change is made; the design for modifying or using a system; and the evaluation of the design against the needs or criteria it was designed to meet;
(b) interpret a given text, physical or computer model, demonstration, diagram, flow chart, set of numbers, table, graph, and appropriate mathematical relationships;
(c) use computer software or graphing calculators to display and analyze data and to model solutions to a prediction or design problem;
(d) explain how mathematics influenced the development of scientific knowledge in a given contemporary or historical context, and how the development of new scientific knowledge led to new mathematics in a given contemporary or historical context; and
(e) describe the impact on society and culture of a given historical development of scientific ideas.

	Attained	**Not Attained**	**In Progress**
Student Self Evaluation			
Faculty Evaluation			

C. A teacher of science understands how knowledge of concepts and principles of science and technology and knowledge of factors influencing personal and community health, population growth, natural resources, environmental quality, and natural and human-induced hazards influence decisions about personal and societal issues. The teacher of science must:
(1) predict the scientific, economic, political, and ethical factors that could influence a course of action to address a given personal issue or local, national, or global challenge;
(2) design, using the systematic approaches of science and scientific knowledge, a course of action to address a personal issue or a given local, national, or global challenge; and
(3) justify and defend a given design for a course of action in terms of an assessment of alternatives, risks, costs, and benefits, and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them.

	Attained	**Not Attained**	**In Progress**
Student Self Evaluation			
Faculty Evaluation			

D. A teacher of science must be able to understand and apply fundamental principles, laws, and concepts of earth and space science, life science, and physical science. The teacher of science must:
(1) know and apply the fundamental principles, laws, and concepts of earth and space science including understanding:
(a) the components and evolution of the Earth system as evidenced by the ability to:
i. describe, using words, diagrams, pictures, and graphs, the physical properties of a given Earth material;
ii. explain, from observation of its composition, texture, and physical state using physical, geological, or biological processes, a plausible way in which a given rock formed through time;

iii. explain, in terms of environmental changes, structural events, plate tectonics, and sedimentary, igneous, metamorphic, and biologic processes, how observed differences within a given rock sequence are related to the various processes that may have formed the rocks;
iv. explain, in terms of environmental changes, structural events, plate tectonics, and sedimentary, igneous, metamorphic, and biologic processes, a plausible way in which a given rock sequence formed through time;
v. explain, in terms of the physical processes that formed it, the origin and development of a given Earth structure;
vi. predict, in terms of known rock sequences, how a given geologic or biologic event might be recorded in a rock sequence; and
vii. explain, using the fossil record and decay rates of radioactive isotopes, how the age of a given rock is determined;

(b) matter and energy in the Earth system as evidenced by the ability to:
i. explain, using convection, conduction, and radiation, how matter is transported and how energy drives the process of transportation of matter within and between given Earth subsystems or structures;
ii. explain, using convection, conduction, radiation, and conservation of energy, how energy is transmitted and transformed within and between given Earth subsystems or structures;
iii. design a simple physical model that mimics the behavior of a given Earth system; and
iv. describe, using words, diagrams, and chemical equations, the processes involved in the movement of chemical elements or compounds among different given chemical reservoirs in the Earth;

(c) the Earth in the solar system and the universe as evidenced by the ability to:
i. explain how the properties and organization of galaxies provide evidence that the universe is continuously changing;
ii. explain qualitatively, using fundamental processes of chemical, physical, and geological change, how processes of change on a given solar system object are different or similar to Earth;
iii. describe, using words, diagrams, and physical models, the motion of objects in our solar system; and
iv. explain qualitatively, using Earth's axial rotation, tilt of its rotational axis, and changing position with respect to the sun, the seasonal variations in the length of a day and sun angle at various latitudes on Earth; and

(d) human interactions with the earth system as evidenced by the ability to:
i. describe, using words, diagrams, pictures, graphs, historic records, and physical models, the scientific basis for predicting the occurrence of a given environmental hazard on a human time frame;
ii. describe, using words, diagrams, pictures, maps, and physical or computer models, the observed changes in a given Earth system that are due directly or indirectly to human activity; and
iii. predict, using words, diagrams, pictures, maps, and physical or computer models, the probable movement of pollutants in a given Earth system;

(2) know and apply the fundamental principles, laws, and concepts of life science including understanding:

(a) structural and functional relationships in living systems and environments as evidenced by the ability to:
i. perform observations to describe the macroscopic structures of a given common organism;
ii. describe, using words, pictures, and diagrams, the conditions required to sustain life for a given common organism;
iii. describe, using words and diagrams, the characteristics of what determines life in a given common organism;
iv. design a system to support, sustain, and continue the life of a given set of common organisms;
v. describe, using words, pictures, dioramas, and physical or computer models, the structure and function of the components of a given living system in relation to its overall function;
vi. explain, in terms of the function of the organs of that system, the structure of a given plant and animal system;
vii. explain, using structure-function relationships, how and why the structures for a given function are different in different given species;

viii. describe the origins, transmission, prevention, management, or cure of a given disease; and
ix. explain and predict, in terms of the defense mechanism and the method by which the immunity is established, how a given active or passive immunity functions in a human;

(b) molecular and cellular life processes as evidenced by the ability to:

i. perform observations to describe cellular structures and physiological processes;
ii. describe, using words, pictures, and models, the components of a given cell;
iii. explain, in terms of the structure and function of the cell components, the differences between prokaryotic and eukaryotic cells and between given eukaryotic cells;
iv. describe, using words, pictures, and diagrams, the cellular processes of a given plant or animal cell;
v. explain, using the process of photosynthesis, how plants transform solar energy into cellular energy;
vi. explain, using the process of cellular respiration, how energy stored in food molecules is released;
vii. explain, using the process of DNA replication, how proteins are synthesized in a cell;
viii. explain, using the structure-function relationships between cells, tissues, organs, and systems, how cells function as primary building blocks of an organism;
ix. describe, using words, pictures, and models, the physical changes at each given stage of cellular asexual reproduction;
x. describe, using words, diagrams, and charts, how traits are inherited and sex is determined in a given animal; and
xi. explain, using the relationships between genetic change and expression, how a mutation occurs and predict the effect an environmental change will have on the expression of a trait;

(c) diversity and biological evolution as evidenced by the ability to:

i. describe, using words, pictures, and diagrams, the range of physical and behavioral adaptations that can occur in response to environmental stresses for a given species;
ii. describe, using words, diagrams, charts, and graphs, the range of observable characteristics of a given species in a given environment;
iii. explain the speciation process in a given fossil record; and
iv. design, based only on observable structure, a classification key for a given set of organisms; and

(d) the interdependence among living things as evidenced by the ability to:

i. collect and analyze data to describe the diversity and number of species in a given ecosystem;
ii. describe, using words, pictures, and diagrams, the biotic and abiotic components of a given niche, habitat, ecosystem, or biome;
iii. explain, in terms of environmental adaptations and development, the diversity of a given species;
iv. describe, using words and diagrams, the cycling of matter and the flow of energy within a given system;
v. explain and predict the behavioral responses of an animal to a given set of environmental changes; and
vi. design, using environmental changes, an experiment to elicit a specific behavioral response from a given animal; and

(3) know and apply the fundamental principles, laws, and concepts of the physical sciences including understanding:

(a) one-dimensional and two-dimensional linear motion and forces as evidenced by the ability to:

i. perform measurements and calculations to determine the position, average speed, and direction of motion of a given object;
ii. describe, using words, pictures or diagrams, graphs, vectors, and simple mathematical relationships, the vertical and horizontal components of the motion of a given object;
iii. describe, using words and free body vector diagrams, the forces acting on an object in a given system of interacting objects, and explain qualitatively, using Newton's Second and Third Laws, the relationships between all the forces;
iv. describe, using words, energy diagrams or graphs, and simple mathematical relationships, the change of energy of a system and any transfer of energy into or out of a given system of interacting objects; and
v. explain qualitatively, in terms of balanced and unbalanced forces and the conservation of energy, the observed motion of an object in a given system of interacting objects;

(b) vibrations and wave motion as evidenced by the ability to:
- i. perform measurements and calculations to describe the wavelength, amplitude, period, and frequency of a given oscillating object or wave;
- ii. describe, using words, diagrams, and graphs, the frequency and amplitude of a given simple pendulum or vibrating object;
- iii. describe, using words, diagrams, and graphs, the wave motion of a traveling or standing wave in a given medium; and
- iv. explain qualitatively, in terms of the changes in the frequency amplitude, wavelength, or wave velocity, the observed changes in the pitch or intensity of a sound when given changes are made to the source, the medium through which the sound travels, or the relative motion of the source or detector;

(c) the behavior of light as evidenced by the ability to:
- i. explain qualitatively, using the directionality and chromatic composition of light, how we see a given object and its color;
- ii. explain and predict, using ray diagrams, the observed shadows in a simple geometrical system of objects and point or extended light sources;
- iii. describe, using words and ray diagrams, the reflection, refraction, transmission, and absorption of light when it encounters an ordinary object, a plain or curved mirror, a prism, and thin concave or convex lenses; and
- iv. explain qualitatively, using ray diagrams and the laws of reflection and refraction of light, the observed location and magnification of the real or virtual images for a given pinhole system, simple system of mirrors, or simple system of thin lenses;

(d) electricity and magnetism as evidenced by the ability to:
- i. perform measurements to determine the type of charge of a given charged object, and the north and south poles of an unmarked magnet;
- ii. explain qualitatively, in terms of the movement of electrons, observed changes in the charge of an object in a given system of interacting charged and uncharged objects;
- iii. describe, using words and diagrams, the magnetic field around a straight current carrying wire and a current-carrying solenoid; and
- iv. design a circuit using batteries, bulbs, and switches to meet given criteria for the brightness and control of the bulbs;

(e) the properties and structure of matter as evidenced by the ability to:
- i. perform measurements and calculations to describe the mass, volume, density, concentration, melting and boiling temperatures, and solubility limits of a given substance;
- ii. describe, using words and diagrams, common substances as pure elements or compounds, solutions, suspensions, or colloids;
- iii. perform procedures of distillation, precipitation, extraction, or chromatography to separate the substances in a given mixture;
- iv. describe, using words and diagrams, the basic atomic and subatomic constituents of matter;
- v. describe, using the kinetic-molecular theory or intermolecular forces, or both, the arrangement and motion of the atoms, ions, or molecules in a given gas, liquid, or solid substance, and explain the characteristic properties of the substance;
- vi. explain and predict, using the principles for filling the electron orbital of atoms and the Periodic Table, the periodic trends in electrical conductivity, ionization, and metallic character of a given set of elements;
- vii. predict, using the Periodic Table, whether the bonding in a given substance is primarily covalent, metallic, or ionic;
- viii. describe, with words and diagrams, the electrical conductivity of a given conductor, insulator, or semiconductor using periodic trends;
- ix. describe, in words and diagrams using conservation of mass and energy, the changes in matter and energy that occur in the nuclear processes of radioactive decay, fission, and fusion; and
- x. describe, with words, structural and chemical diagrams and formulas, and physical and computer models, the unique structure of carbon, and explain how that structure results in the large variety of organic molecules;

(f) chemical reactions as evidenced by the ability to:
- i. describe, using words, diagrams, physical or computer models, and a balanced chemical equation, changes in the energy and arrangement of atoms for a given chemical reaction;

ii. describe, using words, diagrams, and chemical symbols, a given chemical reaction as oxidation-reduction, acid-base, free radical, precipitation, metathesis, or a combination of these; and
iii. explain and predict qualitatively, using solubility rules, the common oxidation states of elements, the activity series of metals and nonmetals, the stability of radicals, and the properties of acids and bases, the most likely type of reaction for a given set of given reactants;
(g) thermodynamics as evidenced by the ability to:
i. describe, using words and pictures or diagrams, the characteristics of an ideal gas;
ii. describe and predict, using words, graphs, and mathematical relationships, changes in pressure, volume, or temperature of a given ideal gas;
iii. describe, using words, diagrams, and energy graphs, the changes in the enthalpy and entropy during a given chemical reaction; and
iv. explain qualitatively, using the First and Second Laws of Thermodynamics energy, changes in a given spontaneous or nonspontaneous reaction; and
(h) chemical kinetics and equilibrium as evidenced by the ability to:
i. explain, using the requirements for effective particle collisions and activation energy, why a given spontaneous reaction is fast or slow, and predict the conditions necessary to make the reaction occur more rapidly;
ii. explain, using the concept of activation energy and the requirements for effective particle collisions, how a given catalyst increases the rate of a given reaction;
iii. explain, using the kinetic-molecular model, how a given change in temperature, concentration, or particle surface area changes the rate of a given chemical reaction;
iv. describe, using words, diagrams, chemical equations, and concentration graphs, the equilibrium of a given reaction;
v. explain, in terms of changes in the number of effective collisions of the molecules in the forward and reverse reaction, why the chemical equilibrium of a given reaction is a dynamic process; and
vi. explain and predict change in the equilibrium of a given chemical reaction when the temperature changes, the pressure changes, a catalyst is added, or the concentration of reactants or products changes.

	Attained	**Not Attained**	**In Progress**
Student Self Evaluation			
Faculty Evaluation			

E. A teacher of science must have a broad-based knowledge of teaching science that integrates knowledge of science with knowledge of pedagogy, students, learning environments, and professional development. A teacher of science must understand:
(1) curriculum and instruction in science as evidence by the ability to:
(a) select, using local, state, and national science standards, appropriate science learning goals and content;
(b) plan a coordinated sequence of lessons and instructional strategies that support the development of students' understanding and nurture a community of science learners including appropriate inquiry into authentic questions generated from students' experiences; strategies for eliciting students' alternative ideas; strategies to help students' understanding of scientific concepts and theories; and strategies to help students use their scientific knowledge to describe real-world objects, systems, or events;
(c) plan assessments to monitor and evaluate learning of science concepts and methods of scientific inquiry; and
(d) justify and defend, using knowledge of student learning, research in science education, and national science education standards, a given instructional model or curriculum;
(2) safe environments for learning science as evidenced by the ability to:
(a) use required safety equipment correctly in classroom, field, and laboratory settings;
(b) describe, using knowledge of ethics and state and national safety guidelines and restrictions, how to make and maintain a given collection of scientific specimens and data;

(c) describe, using knowledge of ethics and state and national safety guidelines and restrictions, how to acquire, care for, handle, and dispose of live organisms;
(d) describe, using state and national guidelines, how to acquire, care for, store, use, and dispose of given chemicals and equipment used to teach science;
(e) implement safe procedures during supervised science learning experiences in the public schools; and
(f) develop a list of materials needed in an elementary science safety kit;
(3) how to apply educational principles relevant to the physical, social, emotional, moral, and cognitive development of preadolescents and adolescents;
(4) how to apply the research base for and the best practices of middle level and high school education;
(5) how to develop curriculum goals and purposes based on the central concepts of science and how to apply instructional strategies and materials for achieving student understanding of the discipline;
(6) the role and alignment of district, school, and department mission and goals in program planning;
(7) the need for and how to connect students' schooling experiences with everyday life, the workplace, and further educational opportunities;
(8) how to involve representatives of business, industry, and community organizations as active partners in creating educational opportunities; and
(9) the role and purpose of cocurricular and extracurricular activities in the teaching and learning process.

	Attained	**Not Attained**	**In Progress**
Student Self Evaluation			
Faculty Evaluation			

F. A teacher of science must understand the content and methods for teaching reading including:
(1) knowledge of reading processes and instruction including:
(a) orthographic knowledge and morphological relationships within words;
(b) the relationship between word recognition and vocabulary knowledge, fluency, and comprehension in understanding text and content materials;
(c) the importance of direct and indirect vocabulary instruction that leads to enhanced general and domain-specific word knowledge;
(d) the relationships between and among comprehension processes related to print processing abilities, motivation, reader's interest, background knowledge, cognitive abilities, knowledge of academic discourse, and print and digital text; and
(e) the development of academic language and its impact on learning and school success; and
(2) the ability to use a wide range of instructional practices, approaches, methods, and curriculum materials to support reading instruction including:
(a) the appropriate applications of a variety of instructional frameworks that are effective in meeting the needs of readers of varying proficiency levels and linguistic backgrounds in secondary settings;
(b) the ability to scaffold instruction for students who experience comprehension difficulties;
(c) selection and implementation of a wide variety of before, during, and after reading comprehension strategies that develop reading and metacognitive abilities;
(d) the ability to develop and implement effective vocabulary strategies that help students understand words including domain-specific content words;
(e) the ability to develop critical literacy skills by encouraging students to question texts and analyze texts from multiple viewpoints or perspectives;
(f) the ability to identify instructional practices, approaches and methods and match materials, print and digital, to the cognitive levels of all readers, guided by an evidence-based rationale, which support the developmental, cultural, and linguistic differences of readers;
(g) the ability to plan instruction and select strategies that help students read and understand science texts, including the ability to:
i. distinguish between facts based on empirical/scientific findings from opinion;
ii. relate what is read to relevant prior knowledge;

iii. use scientific knowledge to draw inferences or conclusions from facts, discern cause and effect relationships, detect fallacies in author's evidence, and support own claims with evidence;
iv. follow instructions to perform laboratory activities step by step in a disciplined fashion;
v. explain diagrams and graphs in terms of scientific content/meaning; and
vi. explain meaning of abbreviations and symbols.

	Attained	Not Attained	In Progress
Student Self Evaluation			
Faculty Evaluation			

Subp. 4. Subject matter standards for teachers of chemistry. A candidate for licensure as a teacher of chemistry in grades 9 through 12 must complete a preparation program under subpart 2, item C, that must include the candidate's demonstration of the knowledge and skills in items A to C, and subpart 3, items E and F.

A. A teacher of chemistry must demonstrate a conceptual understanding of chemistry. The teacher must:

(1) use sources of information to solve unfamiliar quantitative problems and communicate the solution in a logical and organized manner as evidenced by the ability to:
(a) describe, in terms of the known and unknown quantities, a given problem in appropriate pictorial, graphical, or written forms;
(b) describe, in terms of the relevant numerical and algebraic quantities and equations, a given problem mathematically;
(c) plan, using words, diagrams, and mathematical relationships, a solution for a given problem in terms of steps necessary to solve the problem and to verify the solution; and
(d) evaluate, in terms of unit consistency, reasonableness, and completeness of solution, the solution of a given problem;
(2) use computers to display and analyze experimental and theoretical data as evidenced by the ability to:
(a) describe data graphically using a computer; and
(b) design a mathematical model to provide a reasonable fit to a given set of data; and
(3) develop a plan to ensure a safe environment and practices in chemistry learning activities.

	Attained	Not Attained	In Progress
Student Self Evaluation			
Faculty Evaluation			

B. A teacher of chemistry must demonstrate a knowledge of chemistry concepts. The teacher must:
(1) understand the properties and structure of matter as evidenced by the ability to:
(a) explain and predict, using the principles for filling the electron orbitals of atoms and the Periodic Table, the periodic trends in electrical conductivity, atomic radii, ionization energy, electronegativity, electron affinity, and metallic character of a given set of elements;
(b) predict, using the Periodic Table and the arrangement and energies of the element's outermost electrons, whether the bonding in a given substance is primarily covalent, metallic, or ionic;
(c) explain and predict, using the periodic trends in the physical and chemical characteristics of the elements and the type of bonds, or intermolecular forces, or both, the relative magnitudes of a given property for a set of elements or compounds;
(d) predict, using existing models including the Valence Shell electron Pair Repulsion theory, the shape of a given molecule; and
(e) describe, with words and diagrams using neutron to proton ratios and binding energies, the changes in matter and energy that occur in the nuclear processes of radioactive decay, fission, fusion, and other common nuclear transformations;

(2) understand chemical reactions as evidenced by the ability to:
- (a) perform measurements and calculations to determine the chemical formulas of the products of a given chemical reaction;
- (b) explain and predict qualitatively and quantitatively, using the Periodic Table and the concept of chemical stoichiometry, the mass relationships between reactants and products for a given chemical reaction;
- (c) predict quantitatively, using the principle of state functions and Hess's Law, the molar heat of a given reaction from known values of molar heats of formation or molar heats of a series of related reactions; and
- (d) explain and predict qualitatively and quantitatively, using solubility rules, the common oxidation states of elements, the activity series of metals and nonmetals, stability of radicals, and the properties of acids and bases, the most likely type of reaction for a given set of given reactants;

(3) understand thermodynamics as evidenced by the ability to:
- (a) perform measurements and calculations to determine the molar heat energy absorbed or released in a given phase change or chemical reaction;
- (b) predict qualitatively and quantitatively, using the Ideal Gas Law, changes in the pressure, volume, temperature, or quantity of gas in a given thermally isolated ideal gas system when the gas is heated or cooled, is compressed or expanded adiabatically, or enters or leaves the system;
- (c) describe, using words, diagrams, energy graphs, and mathematical relationships, the changes in the enthalpy, entropy, and Gibb's free energy during a given chemical reaction;
- (d) explain and predict qualitatively and quantitatively, using the First and Second Laws of Thermodynamics and the relationship between Gibb's free energy and the equilibrium constant, changes in the equilibrium and Gibb's free energy for a given change in the reaction conditions;
- (e) design, using Gibb's free energy, a method for changing the direction of spontaneity of a given reaction; and
- (f) explain qualitatively and quantitatively, using Gibb's free energy, how the electrochemical potential of a given cell depends on given changes in the temperature or the concentration of ions in solution, or both;

(4) understand chemical kinetics and equilibrium as evidenced by the ability to:
- (a) perform measurements and calculations to determine the rate of a chemical reaction, the rate expression, half-life of given reaction, the activation energy of a given reaction, and the equilibrium constant of a given reaction;
- (b) describe, using words, energy diagrams, graphs, and mathematical relationships, the activation energy, enthalpy changes, and reaction rate of a given reaction;
- (c) explain and predict qualitatively and quantitatively, using the rate equation for the reaction, changes in the reaction rate for a given change in the concentration of a reactant or product;
- (d) predict, using the rate equation and the presence or absence of intermediates, a possible mechanism for a given reaction;
- (e) describe, using words, diagrams, chemical equations, concentration and rate graphs, and mathematical relationships, the equilibrium of a given reaction;
- (f) explain, in terms of changes in the number of effective collisions of the molecules in the forward and reverse reaction, why the chemical equilibrium of a given reaction is a dynamic process;
- (g) explain and predict quantitatively, using the equilibrium constant, the concentration of a reactant or product in a given gas phase or solution chemical reaction;
- (h) design, using LeChatelier's principle, a method for achieving a specified change in the equilibrium constant or the position of equilibrium of a given chemical reaction; and
- (i) design, using the rate laws and requirements for effective collisions, a method for achieving a specified change in the rate of a given chemical reaction; and

(5) understand organic and biochemical reactions as evidenced by the ability to:
- (a) perform measurements and calculations to determine the melting point, boiling point, solubility, or other common physical properties of an organic compound;
- (b) describe, using words, structural and chemical formulas, and physical and computer models, the functional groups and polarity of the molecule of a given organic compound;
- (c) describe, using words, structural and chemical formulas, and physical or computer models, a given hydrocarbon compound as aromatic or aliphatic; saturated or unsaturated; alkanes, alkenes, or alkynes; and branched or straight chains;

(d) explain and predict, using a molecular orbital model of the pi-bond, the outcomes of reactions of given aromatic, allylic and conjugated alkenes, and other delocalized electron systems;
(e) explain and predict, using functional groups, structure, and polarity, the reactivity, solubility, melting point, and boiling point of an organic compound;
(f) predict, using infrared, nuclear magnetic resonance, and mass spectra, the structure of an organic molecule;
(g) design and carry out a single step synthesis of an organic compound, purify the compound, and characterize the product;
(h) describe, using words, diagrams, structural and chemical formulas, and physical and computer models, the origin of optical activity of a given chiral organic compound;
(i) explain why the reactivity of a chiral compound depends on its stereo chemistry when acted upon by a living system, and predict whether a particular substrate enantiomer would or would not react with its enzyme;
(j) describe, using words, structural and chemical formulas, and physical and computer models, a given set of biomolecules as a carbohydrate, lipid, protein, or nucleic acid, and explain how biomolecules are made from typical chemical components by chemical reactions;
(k) perform tests and measurements to determine if a given biological substance is a carbohydrate, lipid, protein, or nucleic acid;
(l) explain, using the concepts of electrostatic attraction, repulsion, and stereochemistry in the catalytic process, how enzymes facilitate a given biochemical reaction; and
(m) design a method to use organic compounds to demonstrate a given general chemical principle.

	Attained	**Not Attained**	**In Progress**
Student Self Evaluation			
Faculty Evaluation			

C. A teacher of chemistry must demonstrate an advanced conceptual understanding of chemistry and the ability to apply its fundamental principles, laws, and concepts by completing a full research experience. The teacher must:
(1) identify various options for a research experience including independent study projects, participation in research with an academic or industry scientist, directed study, internship, or field study;
(2) select an option and complete a research experience that includes conducting a literature search on a problem;
(3) design and carry out an investigation;
(4) identify modes for presenting the research project; and
(5) present the research project in the selected mode.

	Attained	**Not Attained**	**In Progress**
Student Self Evaluation			
Faculty Evaluation			