8710.4750 Teachers of Science: Chemistry 9-12	**Course ID Number**	**Any and all referenced experiences must be verifiable in the course syllabi submitted. Use specific references to activities* in the syllabi that evidence learning opportunities & assessments that align to the standard. (*readings, activities, topics of discussion, assignments, experiences, etc.)**	**THIS COLUMN IS FOR REVIEWER USE**
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.			
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;	CHE-270	A graphical method for analysis of acid-base equilibria is a fundamental part of CH270. This is developed in the text written by the instructor and in class. Projected images are used. Goal is to develop chemical understanding rather than solve algebraic equations. Word problems are solved in cooperative learning exercises. At least one question appears on every exam requiring a short narrative response.	Met
(b) describe, in terms of the relevant numerical and algebraic quantities and equations, a given problem mathematically;	CHE-270	This is a major component of 270. A major goal is to help students cast chemical equilibrium problems in mathematic terms. Cubic and higher order equations are considered and analyzed by successive approximations methods as well as graphical methods. Basic concepts from calculus such as derivatives and gradients, integrals and areas, are used and tested in chemical contexts. Assessed on every exam.	Met
(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	CHE-270	Instructor uses thought experiments in units involving charge balances, material balances, and proton conditions. Planning how to lay out a problem is stressed in Bronsted Acid-base, solubility, complexation, spectrophotometry (sets of linear Beers Law equations). Students are always taught to estimate an answer after doing a calculation to test plausibility. They are also taught to test simplifying assumptions in complex equilibrium calculations. Assessed on every exam.	Met
(d) evaluate, in terms of unit consistency, reasonableness, and completeness of solution, the solution of a given problem;	CHE-107 CHE-270	Consistency of units and proper recognition of appropriate units for scientific quantities is critical to all calculations in this course. Every problem handed in is evaluated in part on the proper use of units. Assessed on every exam, homework set and laboratory report This stressed in every phase of problem solving. Students are always asked to comment on	Met

		reasonableness in class, and are given partial credit on exam questions if they recognize that their result is unreasonable and point that out. Assessed on every exam.	
(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	CHE-107 CHE-270	Every laboratory work station has a dedicated computer on which data is compiled and analyzed using a spreadsheet. In laboratory 3, 'Reaction Energetics', Vernier software and the LoggerPro program are used to measure and graph temperature changes in exothermic and endothermic reactions for further analysis. In experiment 7 'Spectroscopic Analysis of a Standard Curve', students take absorbance measurements for a copper standard, then plot a standard curve on the computer to use for analysis of a copper unknown. Student abilities are assessed on weekly graded laboratory reports, which include a copy of the graphed data. Computer program "Acid-Base Calculator" is provided on network for analysis of protonic acid-base equilibria. Two major assignments are given and evaluated for this program. It is an important supplement to classroom discussion.	Met
(b) design a mathematical model to provide a reasonable fit to a given set of data; and	CHE-107 CHE-270	In experiment 7, 'Spectroscopic Analysis of a Copper Salt', absorbance values are calculated for a copper standard and a working/standard curve is plotted using a Vernier Software program. Error analysis is performed and this working curve is used to determine the copper concentration in an unknown following which the student is able to determine the waters of hydration of the original copper salt. The results/conclusions are graded by comparison to the actual waters of hydration present in the original copper salt. Least squares analysis of lab data (spec iron experiment). Analysis of variance exercise in statistics unit requires students to use functions of Excel. Assessed as graded problems.	Met
(3) develop a plan to ensure a safe environment and practices in chemistry learning activities.	CHE-107 CHE-270	Material is presented in lab manual on lab safety. Safety orientation is conducted on the first day of lab and students are required to sign a 'safety contract' that is kept on file in the chemistry stockroom. Questions about laboratory safety are asked on Exam 1. Material is presented in lab manual on lab safety. Safety orientation is conducted on first day of lab. Reminders are made regularly.	Met with weakness. Students should be able to develop their own plan.
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	CHE-107	Lectures, in-class problems, and textbook homework from Chapter 2 'Chang' –Exam 1 (electrical conductivity, metallic character) and final.	Met

trends in electrical conductivity, atomic radii, ionization energy, electronegativity, electron affinity, and metallic character of a given set of elements;		Lectures, in-class problems, and textbook homework from Chapter 8&9 'Chang' –Exam 2, 3 (filling orbitals, ionization, electronegativity, electron affinity) and final	
(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;	CHE-107	Lectures, in-class problems, and textbook homework from Chapter 2 'Chang' –Exam 1 and final (determination of substance type for purpose of naming compounds, primarily ionic compounds discussed here) Lectures, in-class problems, and textbook homework from Chapter 9 'Chang' –Exam 3, 4, and final (covalent bonds, Lewis structures, bond energies)	Met
(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;	CHE-107	Lectures in-class problems, and textbook homework from Chapters 2, 8, 9, 10, 12 'Chang' – Exam 2,4, final. Characteristics of the individual elements and bonds are discussed in chapters 2, 8, & 9. In Chapter 10, the concept of polarity is introduced. In Chapters 12 & 13, the properties of elements and bonds come together in the extensive unit on intermolecular forces.	Met
(d) predict, using existing models including the Valence Shell electron Pair Repulsion theory, the shape of a given molecule; and	CHE-107 CHE-141	Lectures, in-class problems, and textbook homework from Chapter 10 'Chang' –Exam 3, 4 & final. We have extensive discussions, structural modeling, and group work in class to determine shapes of molecules, bond angles, and dipole moment directions. Chapter 1 (reading, discussion, assignments). Students are required to construct Lewis structures from molecular formulae. Students also are required to use VESPR and the hybridization models to predict bond angles and overall molecular geometry from the Lewis structures. This is assessed in the first graded homework set and on the first exam, and it continues to be an important part of each unit in the organic sequence.	Met
(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;	PHY 170/172	Inquiry into Physics, 4th Ed., V.J. Ostdiek & D.J. Bord: Ch. 11* or Principles of Physics, 4th Ed., R. A. Serway & J.W. Jewett: Ch. 30*	Not met. Evidence and syllabus insufficient to determine whether subject is taught.
(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;	CHE-107	Lectures, in-class problems, and textbook homework from Chapter 3 & 4 'Chang' –Exams 1,2 & final. We do mathematical calculations and discussions in class using experimental data to determine empirical and molecular formulas of compounds. In laboratory 6 'Finding the experimental formula of Zn iodide', students use their own experimental data to support prediction of a formula. In laboratory 7, 'Analysis of a Copper Salt by Spectrophotometry', students experimentally determine the number of waters of hydration in a copper salt. Both laboratories are assessed with written laboratory reports, students may also be tested on exams (4 & 5).	Met
(b) explain and predict qualitatively and quantitatively, using the Periodic Table and the concept of chemical stoichiometry,	CHE-270	Development of understanding of % recovery, quantitative reactions (99.9%), solubility loss, stoichiometry and expected yields (gravimetric	Met

the mass relationships between reactants and products for a given chemical reaction;		factors). Assessed on exams and in interactions in laboratory.	
(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	CHE-107 CHE 371	Lectures, in-class problems, and textbook homework from Chapter 6 'Chang' –Exams 2,3 & final. We discuss state functions and why Hess's law is effective for ΔH determination. Many in-class problems are done on the chalkboard to illustrate Hess's law (students work with groups in class as well). Covered in lecture, in reading of Chapter 19 section 10 (Hess's Law) and section 11 (heats of formation), and in laboratory exercises on calculating heats of reaction. Topics are assessed on Exam 2 and in laboratory reports.	Met
(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;	CHE-107 CHE-270 CHE-258 CHE-141	See Chapter 4, Reactions in Aqueous Solution Course reviews chemical reactivity, free energy changes, spontaneity, strengths of acids and bases and electrolytes. This is often done in the context of descriptive chemistry. Assessed on exams. The first, second, and third sessions of laboratory deal with qualitative analysis of metal cations (includes redox, solubilities and solubility rules, acid/base concepts, and likely types of reaction). These areas are assessed by graded laboratory reports, by the first two lecture examinations, and by the final examination. The activity series is covered in lecture, on the basis of electrochemical potential; radicals involved in reaction mechanisms are covered in coordination chemistry and bioinorganic chemistry (electron-transfer mechanisms), and also in inorganic and bioinorganic chemistry of diatomic oxygen. These are assessed by the third and fourth lecture examinations and by the final examination. Chapter 8. (reading, discussion, assignment) The radical chain reaction mechanisms are discussed, and theoretical model that explains the relative stability of radicals is examined. This is assessed on the third exam. CHE-141 Chapter 2. (reading, discussion, assignment) Properties of acids and bases are discussed. Specifically, this section of CHE-141 addresses: identifying conjugate acid/base pairs; using pKa values to predict the position of equilibria; and predicting relative acidity based upon electronegativity, inductive effects, resonance, atomic size, and polarizability Prediction of solubilities is introduced in the context of acid/base extractions for the separation of compounds based upon acidity/bacisity. This is explicitly assessed on the second exam in CHE-141 and in the second and third graded laboratory reports. It is critical to understanding problems throughout the remainder of the CHE-141 and 251 sequence. Examples of assessment questions include predicting the product when given a set of reagents, and identifying the starting materials given a product and a set of conditions. (Experience) The third laboratory project in CHE-141	Met with weakness. Different chemical reactions are addressed throughout the series of courses, but no evidence of students determining most likely type of reaction is seen.

		involves the separation of a mixture of compounds based upon their reactivity under acid or base conditions. Students must predict where a carboxylic acid, an amine, and a neutral compound will be isolated after acid and base extraction. CHE-141 Chapter 6 introduces students to the basic reaction types (addition, elimination, substitution, rearrangement) in organic chemistry, and both polar reactions and radical reactions are discussed in terms of mechanism. Chapters 7 and 8 focus on reaction mechanism (in the context of alkenes), and students must predict the products given a set of reactants and conditions. This continues for the remainder of the CHE-141 and 251 sequence. Students are explicitly assessed on the third exam and the final exam of CHE-141 and all exams in CHE-251. Examples of assessment questions include predicting the product when given a set of reagents, and identifying the starting materials given a product and a set of conditions.	
(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;	CHE-107 CHE 371	Lectures, in-class problems, and textbook homework from Chapter 6 'Chang' –Exams 2,3 & final. In laboratory 3, 'Temperature Change, Heat of Reaction, Enthalpy Change, and Reaction Energetics', students measure the ΔT for a series of endothermic (citric acid and sodium bicarbonate) and exothermic (HCl + NaOH, and Mg + HCl) reactions. They calculate q and ΔH under a series of different experimental conditions. Results are graded on a post-laboratory report. Measurements and calculations to determine heat released in a chemical reaction is completed in the laboratory experiments "Bomb Calorimetry" and "Calculating the Heats of Combustion and Formation". The material is also covered in lecture and in reading of Ch. 19 in McQuarrie and Simon, and assessed either on Exam2.	Met
(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;	CHE 371	Covered in lecture and in reading of Chapter 16 in McQuarrie and Simon, and assessed on quiz 1 (end of week 1) as well as through two short answer questions on exam 1.	Met
(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;	CHE-270 CHE 371	A two-day unit introduces many thermodynamic ideas prior to calculations of equilibrium concentrations. Free energy diagrams are used, enthalpies, entropies are discussed and framed in context for units that follow, and then are referred to in those units for review. Assessed on exams. Covered in lecture and in reading of Chapter 22 section 1-2 and Ch. 26 section 4-6 in McQuarrie and Simon, and assessed on quiz at end of week 7 as well as through one detailed question on exam 2.	Met

(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;	CHE-270 CHE 371	See above 3c. Covered in lecture and in reading of Ch. 26 sections 1-3 in McQuarrie and Simon, and assessed on quiz at end of week 8 as well as through one detailed question on exam 2.	Met
(e) design, using Gibb's free energy, a method for changing the direction of spontaneity of a given reaction; and	CHE-270 CHE 371	Developed and reviewed in context of "pushing reactions" to produce quantitative yields. Covered in lecture and in reading of Ch. 26 section 4 in McQuarrie and Simon, and assessed on quiz at end of week 9 as well as through one conceptual question on exam 2.	Met
(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;	CHE 371 CHE-258	Covered in lecture and in reading of Ch. 25 section 5 in McQuarrie and Simon, and assessed on quiz at end of week 6 as well as through one conceptual question on exam 2. This is covered extensively via the relation of Gibbs free energy to cell potential, including applications of the Nernst equation; numerous commercial batteries and fuel cells are studied. Electrolytic systems are also covered, including many of industrial importance. These areas are assessed on the fourth lecture examination and on the final examination.	Met
(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;	CHE 371	Laboratory experiment "Solution Kinetics of an SN2 Reaction" week 6-9 and covered in lecture and in reading of Ch. 28 in McQuarrie and Simon, and assessed on quiz at end of week 12 as well as through one short-answer and one detailed question on final exam.	Met
(b) describe, using words, energy diagrams, graphs, and mathematical relationships, the activation energy, enthalpy changes, and reaction rate of a given reaction;	CHE-270 CHE 371	Developed in approach to equilibrium theory, assessed on one exam. Covered in lecture and in reading of Ch. 28 in McQuarrie and Simon. Assessed on Exam 4 and/or on 2-3 questions on final exam. Activation energy and reaction rates are also determined the in the laboratory experiment "Solution Kinetics of an SN2 Reaction" and students must describe them in laboratory reports.	Met
(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;	CHE 371	Laboratory experiment "Solution Kinetics of an SN2 Reaction" and "Kinetics of a Diffusion Controlled Reaction…" week 6-9 and covered in lecture and in reading of Ch. 28 in McQuarrie and Simon. Assessed on quiz at end of week 12 as well as through one short-answer and one detailed question on final exam.	Met
(d) predict, using the rate equation and the presence or absence of intermediates, a possible mechanism for a given reaction;	CHE 371	Covered in lecture and in reading of Ch. 28 in McQuarrie and Simon. Assessed on quiz at end of week 11 as well as through one short-answer and one detailed question on final exam.	Met
(e) describe, using words, diagrams, chemical equations, concentration and rate graphs, and mathematical relationships, the equilibrium of a given reaction;	CHE 371	Laboratory experiment "Solution Kinetics of an SN2 Reaction" and "Kinetics of a Diffusion Controlled Reaction…" week 6-9 and covered in lecture and in reading of Ch. 28 in McQuarrie and Simon. Assessed on quiz at end of week 12 as well as through one short-answer and one detailed question on final exam	Met

(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;	CHE 371	Covered in lecture and in reading of Ch. 27, Ch. 30 in McQuarrie and Simon. Assessed on quiz at end of week 13 as well as through one short-answer and one detailed question on final exam.	Met
(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;	CHE-270 CHE 371	This is a recurring theme in CHE-270. It appears first in a thermodynamics unit (week three) and then in subsequent units on Acid-base equilibria, solubility equilibria, complexation equilibria, and then crosscurrent separations. Skill/comprehension is assessed on every examination, including the final exam. Covered in lecture and in reading of Ch. 26 sections 1-3 in McQuarrie and Simon, and assessed on quiz at end of week 8 as well as through one detailed question on exam 2.	Met
(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	CHE-270 CHE 371 CHE-251	LeChatelier is a regular fake-guest commentator in class. Students learn this concept earlier and can use it to bridge to more sophisticated and mathematical approaches. Covered in lecture week 5 and in reading of Ch. 22 sections 1-3 in McQuarrie and Simon, and assessed on quiz at end of week 5 as well as through one detailed question on exam 1. CHE-251 Chapters 14. (reading, discussion, assignment) The formation of acetals from ketones or aldehydes and alcohols is discussed, and students learn about removal of a specific product (water) or addition of excess starting material to drive a reaction to a thermodynamically unfavorable product. This is assessed on the second exam. Chapter 16. (reading, discussion, assignment) Students learn how to drive the equilibrium of a reaction to either products or starting materials in a thermodynamically neutral reaction by removal of a specific equilibrium species (water) or excess addition an appropriate species. This is assessed on the third exam.	Met
(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	CHE 371	Laboratory experiment “Solution Kinetics of an SN2 Reaction” and “Kinetics of a Diffusion Controlled Reaction…” week 6-9 and covered in lecture and in reading of Ch. 28 in McQuarrie and Simon. Assessed on quiz at end of week 12 as well as through one short-answer and one detailed question on final exam.	Met
(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;	CHE-141	(Experience) The measurement of physical properties is introduced in experiment 1 of the laboratory for CHE-141. It remains a critical part of the laboratory for subsequent experiments and is used either to identify unknown compound or confirm the identity of reaction products. This is assessed in the graded laboratory reports for each experiment.	Met
(b) describe, using words, structural and chemical formulas, and physical and computer models, the functional groups and polarity of the molecule of a given	CHE-141 CHE-251	Chapter 3. (reading, discussion, assignment) The principle functional groups are introduced. Electronegativity and polar-covalent bonds are discussed. Computer generated electrostatic potential	Met with weakness. No use of physical and computer models

organic compound;		maps are used to visualize the effects of polarization. Students identify polar covalent bonds and assign partial charge based upon electronegativities of the bonded atoms. This is assessed in the first exam in CHE-141. (experience) In the second laboratory project of CHE-141, students are given an unknown compound and must find other people in the lab with that compound and identify the compound based upon thin-layer chromatography (TLC), solubility, and melting point experiments. In the end, students build a physical model of their compound and explain the TLC results based upon the functional groups present in the compound. This is assessed in a graded laboratory report. Chapter 3, 7, 8, 9, 12 - 18. (reading, discussion, assignment) Each functional group is discussed in terms of its effect on physical properties and polarity. Students must be able to draw Lewis Structures that depict the functional groups and must demonstrate an understanding of how each group affects the polarity of a given molecule. Class discussion is aided by computer-generated models (Jmol, Spartan) and students build physical models throughout the sequence. This is assessed on the relevant exams (each exam covers new functional groups).	seen.
(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;	CHE-141 CHE-251	Chapter 2. (reading, discussion, assignment) Students learn about straight chain and branched aliphatic hydrocarbons and how to distinguish alkanes from aromatics, alkenes, and alkynes. This is assessed on the first exam in CHE-141 Chapters 7 and 8. (reading, discussion, assignment) Students examine unsaturated hydrocarbons (alkenes and alkynes), both branched and straight chain, in more depth. This is assessed explicitly on the second exam in CHE-141 and the first exam in CHE-251. Chapter 9. (reading, discussion, assignment) Students examine the concept of aromaticity and learn to identify aromatic compounds. This is assessed on the fourth exam in CHE-141.	Met with weakness. No use of physical and computer models seen
(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;	CHE-141 CHE-251	Chapter 8. (reading, discussion, assignment) Students discuss allylic halogenation and learn to predict the regiochemical outcome using molecular orbital theory to explain radical stability. This is assessed on the third exam of CHE-141. Chapter 8. (reading, discussion, assignment) Students discuss allylic and benzylic cations stability in terms of resonance and molecular orbital theory. The influence of these cations on product distribution from the competing elimination and substitution mechanisms is emphasized. This is assessed on the fourth exam of CHE-141. Chapter 9. (reading, discussion, assignment) Students discuss the unique reactivity of aromatic compounds in terms of resonance/aromatic stabilization. Students	Met

		discuss nucleophilic and electrophilic aromatic substitution reactions and learn to predict the outcome of the reactions. Molecular orbital descriptions of aromatics are stressed. Chapter 8 (reading, discussion, assignment) Synthesis of organic molecules is discussed, and pericyclic reactions of conjugated systems is introduced. Frontier molecular orbital theory is used to explain reaction selectivity (photochemical vs thermal) and regioselectivity in cycloaddition reactions. This is assessed on the final exam in CHE-251. (Experience) The second experiment in CHE-251 involves the selectivity of bromine substitution on acetanalide derivatives. Students use AM1 calculations to examine the carbocation intermediates and predict the major product. This is assessed in a graded laboratory assignment.	
(e) explain and predict, using functional groups, structure, and polarity, the reactivity, solubility, melting point, and boiling point of an organic compound;	CHE-141	In Chapter 3, intermolecular forces are introduced and discussed in terms of alkane properties. These principles are discussed for each type of compound as we cover the various functional groups. For example, in CHE-251 Chapter 13, the physical properties of alcohols are discussed. The influence of hydrogen bonding and polarity are used to rationalize solubility and boiling point when compared to other functional groups, and the electronegativity of the oxygen is used to rationalize the functional group's reactivity.	Met
(f) predict, using infrared, nuclear magnetic resonance, and mass spectra, the structure of an organic molecule;	CHE-141 CHE-251	Chapter 10 - 12. (reading, discussion, assignment) Students learn the principles of IR and NMR spectroscopy as well as Mass Spectrometry (MS). They learn the sequence of steps required to solve the structure of unknown organic molecules based upon a combination of MS, IR spectra, and proton and carbon NMR spectra, including DEPT. This is assessed on exam 4 of CHE-141. COSY and HMBC NMR experiments are introduced in CHE-251, and they are expected to solve the structure of unknown compounds using a combination of IR and NMR spectra and MS data. (Experience) Experiment 4 in the CHE-251 lab required students to use proton and carbon NMR spectra, IR spectra, and mass spectrometry to identify unexpected reaction products from the catalytic hydrogenation of cinnamic acid derivatives. Students are assessed by means of both a written report and an oral presentation of their results.	Met
(g) design and carry out a single step synthesis of an organic compound, purify the compound, and characterize the product;	CHE-141 CHE-251	((Experience) Experiment 4 in CHE-141 involved the stereoselective bromination of an alkene. Students purify the product and identify the relative stereochemistry of the product using melting point. Students are assessed on a graded lab report. (Experience) Experiment 3 in CHE-251 involves the synthesis of an alcohol from a carbonyl compound and a grignard. Students are given a variety of carbonyl compounds, and the products are purified by distillation. Pure products are identified by boiling	Met

		point and NMR spectroscopy. Students are assessed on a graded lab report. (Experience) Experiment 6 in CHE-251 involves the synthesis of hydantoin. Students purify and identify the compound using melting point and NMR spectral data. Students are assessed on a graded lab report.	
(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;	CHE-141	Chapter 5. (reading, discussion, assignment) Students are introduced to chirality and the conventions used for designating stereochemistry in both nomenclature and structural drawings. Students build physical models of molecules to aid in the stereochemical designation, and computer generated models are used to enrich discussion. This is assessed on the second exam in CHE-141.	Met
(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;	CHE-255	Stereochemistry and chirality is discussed in lecture, based on material in Chapter 2 & 3 of Lehninger textbook. The application of substrate chirality to enzymes is addressed in lecture during Chapter 6 lecture and discussion. Students are given in-class examples to choose which substrate will undergo catalysis based on an enzyme active site. Students work with the enzyme fumarase during the entire semester of laboratory. During the last experiment, students compare proton NMR spectra of deuterated substrates (malate and fumarate), and the products of the fumarase-catalyzed reaction to experimentally determine the stereospecificity of the enzyme. Students are tested on the material in Exams 1, 2, and the final.	Met
(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;	CHE-255	In class lecture and discussion covers chapter 3 & 4 (proteins), chapter 7 (carbohydrates), chapter 8 (nucleic acids), and chapter 10 (lipids). Students are exposed to the structural features of each class of biomolecules, how each class is synthesized, and degraded. Students are assigned two 'Protein Explorer' exercises, in which they input protein structure coordinates into a modeling program, and manipulate the manner in which the protein structure, ligands, and/or water molecules are illustrated. Students are tested on the material in Exams 1,2,3 & the final.	Met
(k) perform tests and measurements to determine if a given biological substance is a carbohydrate, lipid, protein, or nucleic acid;	CHE-255	Our laboratory curriculum has a central theme, the enzyme fumarase. Students determine protein concentration of a BSA unknown and the products of a His-tagged fumarase purification using the Bradford assay (i.e. read Abs at 280 and compare to a standard curve of BSA). Students carry out the fumarase purification beginning at the yeast cell pellet, and break the cells using a Bead Mill, thus providing some exposure to the breaking of cell membranes.	Met with weakness. Tests to determine carbohydrate, lipid or nucleic acid presence are not done.
(l) explain, using the concepts of electrostatic attraction, repulsion, and stereochemistry in the catalytic process, how enzymes facilitate a given biochemical reaction; and	CHE-255	In class lecture and discussion covering Chapter 6, enzymes, provides many examples of electrostatic attraction, repulsion, and stereochemistry. We focus on the reaction mechanism of chymotrypsin as a representative example. As stated above, the laboratory curriculum is focused on the enzyme, fumarase. We determine stereospecificity of the enzyme using NMR as described in 5i. More mechanistic discussion of enzymes occurs during lectures on glycolosis and the TCA cycle. During this	Met

		period, the mechanisms of greater than ten of the enzymes involved in metabolism (hexokinase, phosphofructokinase,etc to name a few) are specifically discussed in detail. Attention is paid to the attractive forces between the substrate and enzyme (based on structural components and stereochemistry) and why the product is released from the enzyme. Students are tested on the material in Exams 2, 3, 4 and the final.	
(m) design a method to use organic compounds to demonstrate a given general chemical principle.	CHE-141 CHE-251	(Experience) Experiment 4 in CHE-141 involves the bromination of an alkene. The stereochemistry of the product demonstrates that the addition is *trans* stereoselective. Students are assessed on a graded lab report. (Experience) Experiment 6 in CHE-141 involves the isolation of carvone from caraway seeds, cuminaldehyde from cumin seeds, eugenol from cloves, and limonene from orange peels. Students measure the optical rotation of the isolated oil, only two of which are optically active. Students are assessed on a graded lab report. (Experience) Experiment 7 in CHE-141 involves the identification of an unknown compound. Students are given an array of chemical tests and the opportunity to measure physical properties. Students design a testing protocol to find others in the class with the same compound, and they identify the compound based upon the physical properties and chemical reactivities. They then present to the class how the tests led them to identify the compound.	Met
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;	CHE-399 EDU 330 EDU 340	In the chemistry seminar course, students are exposed to research opportunities through weekly presentations by Gustavus faculty, invited faculty from other institutions, industrial chemists, and professional chemists. Unit on Development (Cognitive, Personal, Social, and Emotional) Chapters 2-3 Learner Project (See Class #22) Unit on Learning (Chapters 6-9), Chapter 13 Principles of Instruction Students view 'Teen Species; Boys and Girls' to provide knowledge of preadolescent and adolescent physical, social, emotional, moral, and cognitive development and apply their understanding of these principles in their unit plan and exploratory lesson.	Met
(2) select an option and complete a research experience that includes conducting a literature search on a problem;	CHE-255	Students have a three week opportunity to design their own experiment (as a group), carry out the investigation, then present their results orally to the class. The experiment must be based on the enzyme, fumarase, in order to allow for use of knowledge/skills	Met with weakness. Students have a restricted opportunity to

		that are learned in laboratory earlier in the semester. The experiment proposed and carried out must be 'novel' and must have at least two literature references to support the experimental idea/plan (in addition to background references on the enzyme/working with the enzyme itself).	select a research project.
	CHE 371	Students have a four week opportunity to design their own experiment (as a group), carry out the investigation, then present their results orally to the class. The experiment must be broadly based in physical chemistry so students often bring in their experiences from other courses to design their projects. The experiment must have at least two literature references to support the experimental idea/plan.	
	EDU 351; EDU 368	Students read and apply research on effective classroom practices by reading Marzano's 'Classroom instruction that Works' and implementing these research-based strategies in their microteaching (EDU 368) and lesson planning (EDU 351).	
(3) design and carry out an investigation;	CHE-255	See (2) immediately prior.	Met
	CHE 371	See (2) immediately prior.	
	EDU 351 EDU 355	Students develop a year plan and an entire unit based on curricular goals and the central concepts of the subject area while incorporating the MN Academic Standards and applying instructional strategies and materials that will provide for student achievement.	
(4) project; and identify modes for presenting the research	CHE-255	In the laboratory component of the class, students are exposed to several modes for presentation of research. The primary mode for the majority of the semester is writing, students write two short laboratory reports (only a materials & methods and results section), and one manuscript style laboratory report (purification of recombinant baker's yeast fumarase). Students are exposed to scientific posters through a poster symposium at the end of the fall and spring semesters. The primary mode for presentation of their experimental design and investigation is orally to peers and faculty.	Met
	CHE 371	In the laboratory component of the class, students are exposed to several modes for presentation of research. The primary mode for the majority of the semester is writing, students write several manuscript style laboratory reports and their final independent project is written up as future laboratory manual pages. The primary mode for presentation of their experimental design and investigation is orally to peers and faculty.	
	EDU 351 EDU 355	Students discuss the structure of the school community and environment and the relationship to departmental goals and planning. See calendar for specific date.	
(5) present the research project in the selected mode.	CHE-255	See (4) above. Results of experimental investigation are presented orally to peers and faculty.	Met
	CHE 371	See (4) above. Results of experimental investigation are presented orally to peers and faculty.	

	EDU 330 EDU 351 EDU 389	Chapter 8- Contructivism. Meaningful learning occurs in real-world tasks. Connecting content to real world. Chapter 10- Motivation. Personalization: Links to Students' lives Student unit plans include lessons that must identify the purpose for each lesson; emphasis is placed on connections to everyday life, the workplace and ongoing learning. The students study and implement the strategies in Chapter 14 - Helping All Students Succeed from Teaching Exceptional, Diverse, and At-Risk Students in the General Education Classroom by Vaughn, Bos and Schumm (2006). Students use the following concepts and strategies in designing lesson plans for their Virtual Classrooms: establishing appropriate goals, providing appropriate instruction, providing practice, strategies for helping all students acquire basic skills, strategies for helping all learners, strategies for cueing students, helping students move from concrete to abstract learning, and promoting positive attitudes toward learning	
(6) know how to involve representatives of business, industry, and community organizations as active partners in creating educational opportunities;	EDU 340 EDU 351	Students read and reflect on the opportunities service learning provides students and participate in a service learning activity at the middle school to experience the value of creating partnerships. Students' unit plans must include a community linkage or service learning opportunity that provides partnership connections for students and their community.	Met with weakness. Syllabi do not address standard.
(7) understand the role and purpose of co-curricular and extracurricular activities in the teaching and learning process;	EDU394 Student Teaching	Students experience the entire school process during student teaching,	Met with weakness. Standard not specifically addressed.
(8) understand the impact of reading ability on student achievement in Subject Area, recognize the varying reading comprehension and fluency levels represented by students, and possess the strategies to assist students to read mathematical content materials more effectively; and	EDU 350	In regard to reading ability on student achievement, candidates read and discuss: • "Hiding out in secondary content classrooms" by W.G. Brozo • "Every American a strong reader," U.S. Dept. of Education Issue Paper • chapters in Reiss, *Teaching Content to English Language Learners* • *Teaching Reading in the Content Areas* (McREL publication) In regard to reading comprehension and fluency, candidates read and discuss: • "Creating fluent readers" by T. Rasinski • "Assessing readers and their texts" by N. Unrau • chapters in Reiss, *Teaching Content to English Language Learners* *In regard to strategies for reading mathematical content, candidates learn and practice a variety of content literacy*	Met

		strategies, drawn in part from Teaching Reading in Mathematics, *2nd ed. (a McREL publication). These are distributed as handouts when there are mathematics candidates in the class that semester.* *To build skills in strategies, candidates also read and discuss:* • *"Using textbooks with students who cannot read them" by J. Ciborowski* • *"Vocabulary lessons" by Blachowicz and Fisher* • chapters in Reiss, *Teaching Content to English Language Learners* • Teaching Reading in the Content Areas (McREL publication), especially specific reading strategies at the back of the book.	
(9) apply the standards of effective practice in teaching students through a variety of early and ongoing clinical experiences with middle level and high school students within a range of educational programming models.	EDU 268 EDU 340 EDU 368 EDU 392 ST	Freshman experience designed to have students examine schools, teachers, and students in a wide range of program models. Students participate in a service learning experience at the local middle school and also teach an exploratory lesson in another middle school setting. Students teach for two – two and a half weeks in a local secondary setting; they develop and implement all lessons for one block course in their content area; all lessons must reflect the standards of effective practice. Students will meet all requirements of student teaching with Best Practice and MN Standards applied.	Met

Standards that integrate knowledge of science with knowledge of pedagogy, students, learning environments, and professional development were articulated in subpart 3 E of rule 8710.4750. These pedagogy standards need to be evidenced in addition to the specific content science standards.

Subpart 3E. 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:	**Course ID Number**	**Any and all referenced experiences must be verifiable in the course syllabi submitted. Use specific references to activities* in the syllabi that evidence learning opportunities & assessments that align to the standard. (*readings, activities, topics of discussion, assignments, experiences, etc.)**	**THIS COLUMN IS FOR REVIEWER USE**
(1) curriculum and instruction in science as evidence by the ability to:			*Reviewers will evaluate the evidence cited for each standard.* *RATINGS:* **MET** **MET WITH WEAKNESS** *NOT MET*
(a) select, using local, state, and national science standards,	EDU 351	Students develop a year plan and an entire unit based on curricular goals and the central concepts of the subject area	**Met**

appropriate science learning goals and content;	EDU 355	while incorporating the MN Academic Standards and applying instructional strategies and materials that will provide for student achievement.	
(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;	EDU 351 EDU 355	Students develop a year plan and an entire unit based on curricular goals and the central concepts of the subject area while incorporating the MN Academic Standards and applying instructional strategies and materials that will provide for student achievement.	**Met**
(c) plan assessments to monitor and evaluate learning of science concepts and methods of scientific inquiry; and	EDU 351 EDU 355 EDU 399	The lesson planning and micro teaching processes require students to incorporate assessment strategies. The "Teacher Impact on Student Learning Project" is an extensive assessment project that students complete as part of their student teaching experiences in the science classroom.	Met
(d) justify and defend, using knowledge of student learning, research in science education, and national science education standards, a given instructional model or curriculum;	EDU 351/368	Students read and apply research on effective classroom practices by reading Marzano's 'Classroom instruction that Works' and implementing these research-based strategies in their microteaching (EDU 368) and lesson planning (EDU 351).	Met
(2) safe environments for learning science as evidenced by the ability to:			
(a) use required safety equipment correctly in classroom, field, and laboratory settings;	EDU 355 CHE-107 CHE-255	Chapters 14 & 17 in the text "Teaching Secondary School Science: Strategies for Developing Scientific Literacy specifically addresses how to create and maintain effective and safe science laboratory environments. Students are required to develop a lab safety policy document that includes the handling and management of all lab materials and specimens, and a list of the equipment and basic materials required to do so. Students are introduced to the safety components of the laboratory on the first day of class and laboratory. Laboratory instructors discuss the laboratory safety policies and location of various safety equipment in the laboratory. Students are introduced to the safety components of the laboratory on the first day of class and laboratory. Laboratory instructors discuss the laboratory safety policies and location of various safety equipment in the laboratory (pages III-XV in lab manual). Students are required to fill out and turn in a map (and keep a copy for their reference, pg XV lab manual) describing the location of the safety equipment. Questions about the location of safety equipment may be asked on Exam 1 or the final exam.	Met
(b) describe, using knowledge of	EDU 355	Chapters 14 & 17 in the text "Teaching Secondary School	Met

ethics and state and national safety guidelines and restrictions, how to make and maintain a given collection of scientific specimens and data;		Science: Strategies for Developing Scientific Literacy specifically addresses how to create and maintain effective and safe science laboratory environments. Students are required to develop a lab safety policy document that includes the handling and management of all lab materials and specimens, and a list of the equipment and basic materials required to do so.	
(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;	EDU 355	Chapters 14 & 17 in the text "Teaching Secondary School Science: Strategies for Developing Scientific Literacy specifically addresses how to create and maintain effective and safe science laboratory environments. Students are required to develop a lab safety policy document that includes the handling and management of all lab materials and specimens, and a list of the equipment and basic materials required to do so.	Met. See Chem 255
(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;	EDU 355 CHE-255 CHE-107	Chapters 14 & 17 in the text "Teaching Secondary School Science: Strategies for Developing Scientific Literacy specifically addresses how to create and maintain effective and safe science laboratory environments. Students are required to develop a lab safety policy document that includes the handling and management of all lab materials and specimens, and a list of the equipment and basic materials required to do so. Students are introduced to working with live organisms (i.e. yeast) during experiment 3 of the laboratory. The laboratory instructors discuss how the yeast were acquired, genetically modified, grown, handled, and disposed of following the experiment. Information about work with live cultures is discussed (and is present within the lab manual, page XIII). Questions about work with live cultures may be asked on Exam 2 or the final exam. Each week, students are reminded of the dangers of the chemicals and equipment used in laboratory that week during pre-laboratory lecture. Students are informed about where to dispose of chemical waste on a weekly basis.	Met
(e) implement safe procedures during supervised science learning experiences in the public schools; and	EDU 368 Student Teaching Handbook	During all field experiences, students are required to implement the policies of the schools in which they are placed.	Met
(f) develop a list of materials needed in an elementary science safety kit;	EDU 355	Chapters 14 & 17 in the text "Teaching Secondary School Science: Strategies for Developing Scientific Literacy specifically addresses how to create and maintain effective and safe science laboratory environments. Students are required to develop a lab safety policy document that includes the handling and management of all lab materials and specimens, and a list of the equipment and basic materials required to do so.	Met
(3) how to apply educational principles relevant to the physical, social, emotional, moral, and cognitive development of preadolescents and adolescents;	EDU 330	Unit on Development (Cognitive, Personal, Social, and Emotional) Chapters 2-3 Learner Project (See Class #22) Unit on Learning (Chapters 6-9), Chapter 13 Principles of Instruction Students view 'Teen Species; Boys and Girls' to provide	Met

	EDU 340	knowledge of preadolescent and adolescent physical, social, emotional, moral, and cognitive development and apply their understanding of these principles in their unit plan and exploratory lesson.	
(4) how to apply the research base for and the best practices of middle level and high school education;	EDU 351, EDU 368	Students read and apply research on effective classroom practices by reading Marzano's 'Classroom instruction that Works' and implementing these research-based strategies in their microteaching (EDU 368) and lesson planning (EDU 351).	Met
(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;	EDU 351 EDU 362	Students develop a year plan and an entire unit based on curricular goals and the central concepts of the subject area while incorporating the MN Academic Standards and applying instructional strategies and materials that will provide for student achievement. Alan J. Singer & the Hofstra New Teachers Network, *Social Studies for Secondary Schools* (2nd edition). Readings distributed in class or through Moodle	Met EDU 362 is a social studies course.
(6) the role and alignment of district, school, and department mission and goals in program planning;	EDU 351 EDU 362	Students discuss the structure of the school community and environment and the relationship to departmental goals and planning. See calendar for specific date. Alan J. Singer & the Hofstra New Teachers Network, *Social Studies for Secondary Schools* (2nd edition). Readings distributed in class or through Moodle	Met with weakness. No calendar in syllabus. EDU 362 is a social studies course.
(7) the need for and how to connect students' schooling experiences with everyday life, the workplace, and further educational opportunities;	EDU 330 EDU 351 EDU 389	Chapter 8- Contructivism. Meaningful learning occurs in real-world tasks. Connecting content to real world. Chapter 10- Motivation. Personalization: Links to Students' lives Student unit plans include lessons that must identify the purpose for each lesson; emphasis is placed on connections to everyday life, the workplace and ongoing learning. The students study and implement the strategies in Chapter 14 - Helping All Students Succeed from Teaching Exceptional, Diverse, and At-Risk Students in the General Education Classroom by Vaughn, Bos and Schumm (2006). Students use the following concepts and strategies in designing lesson plans for their Virtual Classrooms: establishing appropriate goals, providing appropriate instruction, providing practice, strategies for helping all students acquire basic skills, strategies for helping all learners, strategies for cueing students, helping students move from concrete to abstract learning, and promoting positive attitudes toward learning	Met
(8) how to involve representatives of business, industry, and community organizations as active partners in creating educational opportunities;	EDU 340 EDU 351	Students read and reflect on the opportunities service learning provides students and participate in a service learning activity at the middle school to experience the value of creating partnerships. Students' unit plans must include a community linkage or service learning opportunity that provides partnership connections for students and their community.	Met
(9) the role and purpose of cocurricular and extracurricular activities in the teaching and learning process;	EDU 394 ST Handbook	Students will meet all requirements of student teaching with Best Practice and MN Standards applied. Through the student teaching experience all aspects of schools and teaching and learning process.	Met with weakness. Standard not specifically

			addressed.
(10) the impact of reading ability on student achievement in science, recognize the varying reading comprehension and fluency levels represented by students, and possess the strategies to assist students to read science content more effectively; and	EDU 350	In regard to reading ability on student achievement, candidates read and discuss: • "Hiding out in secondary content classrooms" by W.G. Brozo • "Every American a strong reader," U.S. Dept. of Education Issue Paper • chapters in Reiss, *Teaching Content to English Language Learners* • *Teaching Reading in the Content Areas* (McREL publication) In regard to reading comprehension and fluency, candidates read and discuss: • "Creating fluent readers" by T. Rasinski • "Assessing readers and their texts" by N. Unrau • chapters in Reiss, *Teaching Content to English Language Learners* In regard to strategies for reading mathematical content, candidates learn and practice a variety of content literacy strategies, drawn in part from *Teaching Reading in Mathematics*, 2nd ed. (a McREL publication). These are distributed as handouts when there are mathematics candidates in the class that semester. To build skills in strategies, candidates also read and discuss: • "Using textbooks with students who cannot read them" by J. Ciborowski • "Vocabulary lessons" by Blachowicz and Fisher • chapters in Reiss, *Teaching Content to English Language Learners* • Teaching Reading in the Content Areas (McREL publication), especially specific reading strategies at the back of the book.	Met
(11) how to apply the standards of effective practice in teaching through a variety of early and ongoing clinical experiences with middle level and high school students within a range of educational programming models.	EDU 268 EDU 340 EDU 368 EDU 399	Freshman experience designed to have students examine schools, teachers, and students in a wide range of program models. Students participate in a service learning experience at the local middle school and also teach an exploratory lesson in another middle school setting. Students teach for two – two and a half weeks in a local secondary setting; they develop and implement all lessons for one block course in their content area; all lessons must reflect the standards of effective practice. The senior seminar requires students to develop a portfolio that documents their competence across all the Standards of Effective Practice.	Met