General Chemistry
2006-2007
Introduction and Syllabus

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Text: **Introductory Chemistry: A Foundation (4th Ed.)**
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Extra Help: **TBA**

Welcome to chemistry class! Chemistry is the branch of science that is concerned with matter and the changes it undergoes. I look forward to an exciting year of learning and hope that I can assist you in attaining the highest grade possible in this class.

What you can expect from me

I will make every effort to

- Come to class every day with a lesson prepared
- Be fair and consistent in how I deal with all students
- Return graded assignments in a timely manner
- Explain the course material as clearly as possible

My goals for this course:

- I want every student to come to class every day
- I want every student to understand the material and, if possible, enjoy class
- I want every student to make an "A" or "B"
- I want every student to feel prepared to take college-level chemistry after completing this course.

What I expect from you

I expect you to make every effort to

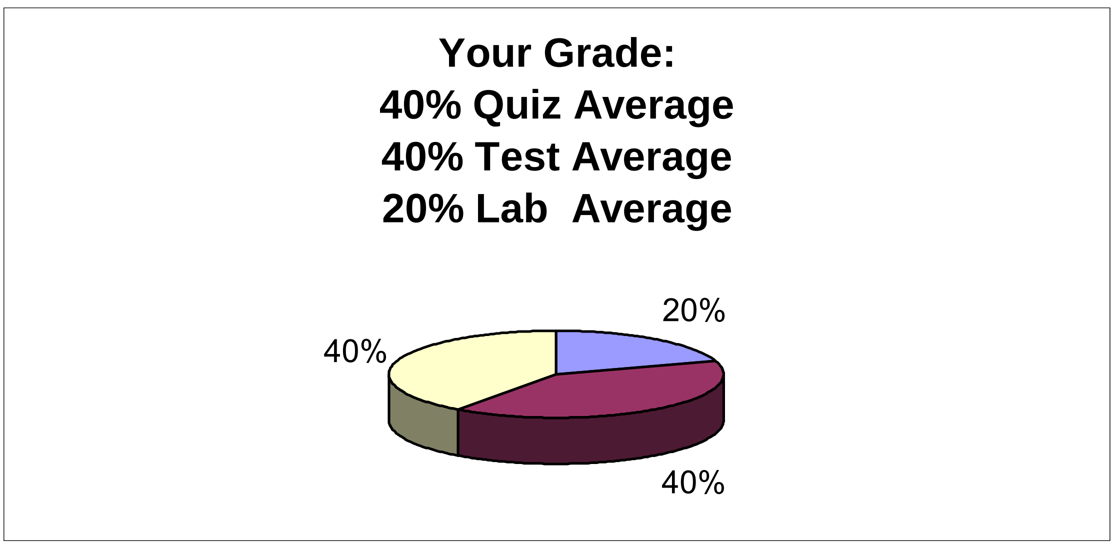
- Come to class every day on time
- Prepare for Chemistry outside of class by doing the assigned homework
- Push yourself to learn as much as possible

What you can expect from this course

Most of you have, at a minimum, already taken (or are taking) biology and geometry. Some people find chemistry to be more difficult than biology because chemistry requires a lot more problem-solving than biology does. However, some people find that chemistry is a lot easier for this same reason. Expect a lot less vocabulary and memorization than in biology, and expect a lot more mathematical problems. If you have taken algebra, you have more than enough math for 95% of this course. The math in chemistry <u>is not hard</u>; it is very low-level arithmetic for the most part. However, even though the math in this class is generally easy, <u>there is a lot of it</u>.

Grading scheme

Your class average in Chemistry will be determined as follows:



On average, there will be one or two quizzes and one lab per week. There will be a test roughly every other week.

Grading Scale:

- A: 90 – 100 %
- B: 80 – 89.9 %
- C: 70 – 79.9 %
- D: 60 – 69.9 %
- F: Below 60

Make-up work and other grading policies

- **Homework** is not usually collected. (The quizzes come right from the HW, so it's usually pretty obvious whether or not you understood the previous night's assigned problems.) You are expected to do the HW on your own, whether or not you are here. You are responsible for any changes in the HW assignments that were announced while you were gone.
- **Labs** that are missed due to an absence of any kind cannot be made up. Unexcused absences will therefore result in a grade of zero. Excused absences will be "omit" grades that neither help nor hurt the student's class average. (Missing labs for any reason will put you at a great disadvantage in preparing for tests.) If you are absent on the due date of a lab report, make sure that you turn it in as soon as you get back! I will not remember that you were not here to turn it in!
- **Quizzes** that are missed cannot be made up. Excused and unexcused absences (and tardies) will result in a grade of zero. The lowest two quizzes will be dropped for all students at the end of the nine weeks. (Only quizzes can be dropped – tests and labs are never dropped.) Thus, a student who has missed two quizzes can still theoretically achieve a quiz average of 100%. Obviously, students who come to class have a big advantage over students who miss class and/or who are frequently tardy to class.
- **Tests:** If you miss a test, you will need to make it up as soon as possible after you return. Obviously, it is your responsibility to set up a time with me to take the make-up test. (I will probably not remember that you missed it.)
- There will be no "extra" projects or papers assigned this semester. We have plenty to do without them, believe me! ☺

Materials that you will need

- **Loose leaf notebook** with pockets and/or folders. This is your notebook; it will never be collected. Just make sure that it can hold plenty of odd-shaped handouts.
- **Pens, pencils, lots of filler paper, and a scientific calculator**. Graphing calculators are fine, but not necessary. You should be able to get a scientific calculator for 10 or 20 dollars. Necessary functions: memory, logarithm ("log"), scientific notation, and exponents. *Bring your calculator every day*.
- Your **textbook**. (Please cover it.)
- Long pants, closed-toe shoes, and a hair band (if you have long hair) for lab days.

Final thoughts and tips:

I am looking forward to a great semester, and I hope you are, too. Please just do me (and you!) this favor: keep up with the work and come to class. This will make life easier for you and for me.

If you find that you're having trouble understanding something, see me sooner rather than later. Most of the time, students taking chemistry know a lot more than they realize; they may think they are totally clueless, but in fact are actually quite close to understanding how to do a certain type of problem that seems "impossible."

Don't concentrate on reading the book if you find it boring. (However, if you happen to be a good text-reader, this is also an excellent way to learn.) Work the problems. If you can solve the HW problems, then you are ready for the test.

Get a study group – it's usually a lot faster and a lot more fun to learn from a fellow student than it is to learn from a teacher. However, if there's anything I can do to help, I'll be glad to give you a hand.

Never cheat. I'll lose respect for you, and so will everyone else. It's not worth it.

Good luck

Chemistry Tests and Quizzes

CHAPTER	TESTS	QUIZZES
1		1. Chemistry and Scientific Notation 2. Measurement
2	Chapters 1 & 2	3. Dimensional Analysis I 4. Dimensional Analysis II
3		5. Properties and Classification of Matter 6. Energy and Energy Changes
4	Chapters 3 & 4	7. Development of the Atomic Model 8. Atomic Calculations 9. Introduction to the Periodic Table
10		10. Quantum Theory & Light 11. Electron Config's. & Aufbau Diagrams 12. Periodic Trends
11	Chapters 10 & 11	13. Types of Bonding 14. Lewis Dot Structures 15. Molecular Geometry & Polarity
5		16. Ionic Nomenclature 17. Ionic and Covalent Nomenclature
8	Chapters 5 & 8	18. Molar Calculations 19. Empirical and Molecular Formulas
6 & 7		20. Types of Chemical Reactions 21. Writing & Balancing Chemical Equations 22. Solubility, Precipitates, & Rxn. Prediction
9	Chapters 6, 7, & 9	23. Stoichiometry I 24. Stoichiometry II
Midterm Exam, Chapters 1 through 11		
12		25. Gas Laws I 26. Gas Laws II 27. Gas Stoichiometry
13	Chapters 12 &13	28. Phase Diagrams 29. Heating & Cooling Curves
14		30. Solutions and Other Mixtures 31. Molarity 32. Dissociation and Colligative Properties
16	Chapters 14 & 16	33. Thermodynamic Calculations 34. Kinetics 35. Chemical Equilibrium and K_{eq} 36. Le Châtelier's Principle
15		37. Identifying and Naming Acids and Bases 38. pH Calculations I 39. pH Calculations II
17	Chapters 15 & 17	40. Redox Reactions 41. Electrochemistry
18		42. Nuclear Processes and Calculations
19/20	Chapters 18, 19, & 20	43. Hydrocarbons and Functional Groups 44. Biological Polymers
Final Exam (Chapters 1 through 20)		

Homework Problems

CHAPTER	HOMEWORK PROBLEMS* (*These problem sets are tentative and subject to change.)
1	10, 11, 12
2	2-22 even, 30, 34, 36, 42, 44, 48-56 even, 60, 62, 70-78 even, 84-94 even, 98, 100
3	2, 4, 8-14 even, 18-22 even, 28, 30, 32, 33, 34-56 even, 60, 62
4	2-28 even, 29-34 all, 36-84 even
10	2-24 even, 28-40 even, 44-78 even
11	4 - 44 even, 52-88 even
5	2, 4, 8-14 even, 18-26 even, 30-36 even, 40-50 even
8	2-10 even, 16-28 even, 34, 36, 40-46 even, 50, 54-62 even, 68, 76-82 even
6	2, 6-44 even
7	2-8 even, 24, 58-66 even
9	2, 4, 6ab, 8, 12, 14, 16, 24, 27, 28-34 even, 42, 46, 56, 62, 66
12	6-36 even, 42-64 even, 68-74 even, 78-88 even, 92, 100
13	2-12 even, 13, 14, 16, 18, 24-32 even, 36, 42, 48, 49
14	7, 10-18 even, 24, 30-40 even, 44, 46, 50, 54, 56, 60, 64-74 even
16	2-28 even, 32-60 even
15	2-22 even, 32-36 even, 40 -50 even, 58, 60
17	2-8 even, 12-20 even, 26, 30-34 even, 49-54 all, 61-64 all
18	8-36 even, 40, 42-47 all, 49, 50, 52, 54, 55, 60, 61, 65
19	2-22 even, 26-32 even, 39, 40, 57, 58
20	2, 4, 13, 17, 19, 20, 21, 24, 26, 28, 46

Lab Curriculum

EXPERIMENT	PRIMARY OBJECTIVES	RELEVANT CHAPTER
1. Observing a Candle	12	1
2. Evidence of Chemical Change	3a, 7b, 12	1
3. Paper Chromatography	6af, 12	3
4. Accuracy and Precision in Measurements	12	2
5. Flame Tests	1ab, 12	4, 11
6. Molecular Models & Molecular Geometry	2abef,12	11
7. Determination of an Empirical Formula	3be,12	9
8. Properties of Hydrogen and Oxygen	4abc	6, 12
9. Properties of Carbon Dioxide	4abc	6, 12
10. Activity Series of Metals	1bcd,12	6
11. Simple Qualitative Analysis	1ab,12	5, 7
12. Water of Crystallization and Formula of a Hydrate	3abcd, 7b,12	8
13. Mass-Mole Relationships in a Chemical Reaction	3abcdef,12	9
14. Limiting & Excess Reagents	3abcde,12	9
15. Boyle's Law	4ach,12	12
16. Molar Volume of a Gas	3abcde, 4acdefhi,12	12
17. Molar Mass of Butane	4acdefhi,12	12
18. Energy and Entropy: Phase Changes	7abcd, 12	13
19. Heat of Fusion of Ice	7abcd,12	13
20. Reacting Ionic Species In Aqueous Solution	6a, 2c,12	16
21. Equilibrium	9abc,12	16
22. Determining pH	5abcdef,12	15
23. Titration of a Strong Acid and a Strong Base	5abcdef,12	15
24. Redox Reactions & Electrochemistry	3g,12	17
25. Radioactivity	11a, 12	18
26. Synthesis of an Ester	10b, 10e, 12	19

Polyatomic Ions Schedule

WEEK #	IONS
1	sulfate, sulfite
2	phosphate, phosphate
3	carbonate, hydrogen carbonate
4	nitrate, nitrite
5	chromate, dichromate
6	cyanide, hydroxide
7	Ammonium, permanganate
8	oxalate, peroxide
9	acetate
10	hypochlorite, chlorite, chlorate, perchlorate

☺ Why “survive” Chemistry? *Enjoy* it, instead! ☺

Guidelines for Success in Chemistry

1. If you’re going to take Chemistry, try to get an “A+.”

2. Please show up on time and show up every day, no matter what.

3. Bring your book, notebook, calculator, and pen/pencil every day.

4. Please finish eating, drinking, and sleeping before you get to class.

5. Don’t be afraid to ask questions and participate – none of this stuff makes any sense to 98% of the class at first. Believe me.

6. Do at least a little studying every night.

7. Do every homework problem (on time if possible).

8. Look at the pictures in the textbook.

9. Treat me and your classmates with respect. Expect respect from me.

10. Keep your graded papers, keep track of your grades and absences, and examine your progress reports and report cards for errors.

Syllabus

Chapter 1 Chemistry: An Introduction
- What is science? What is chemistry?

Chapter 2 Measurements and Calculations
- Scientific notation: how can we represent very small and very big numbers?
- Why are units of measurement and prefixes important?
- How are measurements made?
- What is uncertainty? How are significant figures used?
- How are calculations performed using measurements? How is density determined?

Chapter 3 Matter and Energy
- What is matter?
- What are physical properties and physical changes? What are chemical properties and chemical changes?
- How is matter classified according to composition?
- What are energy, temperature, and heat? How are they related? What is specific heat?

Chapter 4 Chemical Foundations: Elements, Atoms, and Ions
- What are elements? What are atoms?
- What were the initial theories of matter? What is our current view of the composition of matter, the atomic theory? What evidence supports our current model of the atom?
- What are the components of an atom? What is mass number? What is atomic mass?
- What is some of the useful information that the periodic table contains?
- What is an isotope? What is an ion?

Chapter 10 Modern Atomic Theory
- What is light? What is the relationship between light and atoms?
- What evidence suggests that electrons exist in energy levels?
- What is the significance of wave-particle duality?
- What are atomic orbitals? What are the different types of atomic sublevels? What are the rules governing quantum numbers?
- How are an atom’s Aufbau diagram and electron configuration related? How is electron configuration related to an atom’s position on the periodic table?

Chapter 11 Chemical Bonding
- How do atoms connect with another to make compounds?
- How are covalent, ionic, and metallic bondings different from one another?
- How are molecular geometry and molecular polarity determined?

Chapter 5 Nomenclature (Sections: 5.1 - 5.5, 5.7)
- How can we give write names for compounds, given their formulas?
- How can we write formulas from the names of compounds?

Chapter 8 Chemical Composition
- When is it important for a chemist to know the mass of a chemical? When is it important for a chemist to know how many particles (atoms, molecules, etc.) there are in a given amount of a substance?

- How can we determine the mass of a substance, given the number of particles of that substance?
- How can we determine the number of particles of a substance, given the mass of that substance?
- How are empirical and molecular formulas determined from experimental data? What is the relationship between a compound's formula and its percent composition?

Chapters 6 & 7 Chemical Reactions

- How can we represent chemical reactions with chemical equations?
- How and why are chemical equations balanced?
- What are the five types of chemical reactions?
- What are the three "forces that drive" chemical reactions?

Chapter 9 Chemical Quantities

- How can chemical equations be used to determine the mass of the product that will be formed in a chemical reaction?
- What are limiting and excess reagents? How are they used in stoichiometric calculations?
- How is percent yield calculated?

Chapter 12 Gases

- What are gases? Why are some substances gases under standard conditions, while others are liquids or solids?
- What causes gas pressure? How is the pressure of a sample of gas related to its temperature, volume, and number of moles?
- How is gas pressure measured?
- How can we calculate the pressure of a mixture of gases? How molar mass of a gas related to the rms velocity of its particles?
- What is meant by "STP"? Why must calculations involving gases always be done using Kelvin temperatures?

Chapter 13 Liquids and Solids

- What is the relationship between energy and phase changes?
- What forces hold the particles of a substance together in the solid or liquid state?
- How are evaporation, boiling, and vapor pressure related to one another?

Chapter 14 Solutions

- What are solutions? How can we describe their composition qualitatively and quantitatively?
- What are colligative properties? How does the concentration of a solution affect vapor pressure, boiling point, and freezing point?

Chapter 16 Equilibrium

- How do chemical reactions occur? How do temperature, pressure, concentration, and the presence of a catalyst affect reaction rate?
- What is chemical equilibrium? How can it be described using the law of mass action? How is it affected by temperature and pressure?
- How is K_{sp} used to describe solubility?
- How is equilibrium described using Le Châtelier's principle?
- What is a spontaneous reaction? How is reaction spontaneity related to enthalpy, entropy, and Gibbs free energy?
- How can Hess's law be used to calculate the enthalpy change of a chemical reaction?

Chapter 15 Acids and Bases (Ch. 15 and Section 5.6)

- What are acids? What are bases?
- How is pH calculated? How is it related to [H_3O^+] and [OH^-]?
- How does K_a describe the strength of an acid?
- What is the role of water in acid-base chemistry? What is K_w?
- What is acid-base titration? How are neutralization reactions described by stoichiometry?

Chapter 17 Oxidation-Reduction Reactions and Electrochemistry

- What are redox reactions?
- How are redox equations balanced?
- How is redox chemistry related to electrochemistry?

Chapter 18 Radioactivity and Nuclear Chemistry

- What are the three main types of radiation?
- How are nuclear equations balanced?
- What are radioactive decay, fission, and fusion? What role do they play in nuclear energy, atomic weapons, the burning of the sun, and medicine?
- What is half-life? How is carbon dating used in the study of archaeology?

Chapters 19 & 20 Organic Chemistry and Biochemistry

- Why is there an entire branch of chemistry devoted to the element carbon?
- What are the bonding characteristics of alkanes, alkenes, and alkynes?
- What is the significance of organic chemistry in the study of biology? In the production of synthetics and plastics?
- What functional groups are associated with alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids?
- What is a polymer? What are the monomer subunits that combine to make nucleic acids, starches, and proteins?
- What are the primary, secondary, and tertiary structures of a protein and how do they contribute to the function of a protein?

State of California
Science Content Standards: Chemistry

Standards that all students are expected to achieve in the course of their studies are unmarked.
Standards that all students should have the opportunity to learn are marked with an asterisk (*).

Atomic and Molecular Structure

1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:
   a. *Students know* how to relate the position of an element in the periodic table to its atomic number and atomic mass.
   b. *Students know* how to use the periodic table to identify metals, semimetals, nonmetals, and halogens.
   c. *Students know* how to use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electronegativity, and the relative sizes of ions and atoms.
   d. *Students know* how to use the periodic table to determine the number of electrons available for bonding.
   e. *Students know* the nucleus of the atom is much smaller than the atom yet contains most of its mass.
   f. * *Students know* how to use the periodic table to identify the lanthanide, actinide, and transactinide elements and know that the transuranium elements were synthesized and identified in laboratory experiments through the use of nuclear accelerators.
   g. * *Students know* how to relate the position of an element in the periodic table to its quantum electron configuration and to its reactivity with other elements in the table.
   h. * *Students know* the experimental basis for Thomson's discovery of the electron, Rutherford's nuclear atom, Millikan's oil drop experiment, and Einstein's explanation of the photoelectric effect.
   i. * *Students know* the experimental basis for the development of the quantum theory of atomic structure and the historical importance of the Bohr model of the atom.
   j. * *Students know* that spectral lines are the result of transitions of electrons between energy levels and that these lines correspond to photons with a frequency related to the energy spacing between levels by using Planck's relationship ($E = h\nu$).

Chemical Bonds

2. Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:
   a. *Students know* atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.
   b. *Students know* chemical bonds between atoms in molecules such as H_2 , CH_4 , NH_3 , H_2CCH_2 , N_2 , Cl_2 , and many large biological molecules are covalent.
   c. *Students know* salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.
   d. *Students know* the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.
   e. *Students know* how to draw Lewis dot structures.

f. * *Students know* how to predict the shape of simple molecules and their polarity from Lewis dot structures.

g. * *Students know* how electronegativity and ionization energy relate to bond formation.

h. * *Students know* how to identify solids and liquids held together by van der Waals forces or hydrogen bonding and relate these forces to volatility and boiling/ melting point temperatures.

Conservation of Matter and Stoichiometry

3. The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants. As a basis for understanding this concept:

   a. *Students know* how to describe chemical reactions by writing balanced equations.

   b. *Students know* the quantity one mole is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams.

   c. *Students know* one mole equals 6.02×10^{23} particles (atoms or molecules).

   d. *Students know* how to determine the molar mass of a molecule from its chemical formula and a table of atomic masses and how to convert the mass of a molecular substance to moles, number of particles, or volume of gas at standard temperature and pressure.

   e. *Students know* how to calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.

   f. * *Students know* how to calculate percent yield in a chemical reaction.

   g. * *Students know* how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions.

Gases and Their Properties

4. The kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. As a basis for understanding this concept:

   a. *Students know* the random motion of molecules and their collisions with a surface create the observable pressure on that surface.

   b. *Students know* the random motion of molecules explains the diffusion of gases.

   c. *Students know* how to apply the gas laws to relations between the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.

   d. *Students know* the values and meanings of standard temperature and pressure (STP).

   e. *Students know* how to convert between the Celsius and Kelvin temperature scales.

   f. *Students know* there is no temperature lower than 0 Kelvin.

   g. * *Students know* the kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms.

   h. * *Students know* how to solve problems by using the ideal gas law in the form $PV = nRT$.

   i. * *Students know* how to apply Dalton's law of partial pressures to describe the composition of gases and Graham's law to predict diffusion of gases.

Acids and Bases

5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:

   a. *Students know* the observable properties of acids, bases, and salt solutions.

   b. *Students know* acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.

c. *Students know* strong acids and bases fully dissociate and weak acids and bases partially dissociate.

d. *Students know* how to use the pH scale to characterize acid and base solutions.

e. * *Students know* the Arrhenius, Brønsted-Lowry, and Lewis acid-base definitions.

f. * *Students know* how to calculate pH from the hydrogen-ion concentration.

g. * *Students know* buffers stabilize pH in acid-base reactions.

Solutions

6. Solutions are homogeneous mixtures of two or more substances. As a basis for understanding this concept:

   a. *Students know* the definitions of solute and solvent.

   b. *Students know* how to describe the dissolving process at the molecular level by using the concept of random molecular motion.

   c. *Students know* temperature, pressure, and surface area affect the dissolving process.

   d. *Students know* how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.

   e. * *Students know* the relationship between the molality of a solute in a solution and the solution's depressed freezing point or elevated boiling point.

   f. * *Students know* how molecules in a solution are separated or purified by the methods of chromatography and distillation.

Chemical Thermodynamics

7. Energy is exchanged or transformed in all chemical reactions and physical changes of matter. As a basis for understanding this concept:

   a. *Students know* how to describe temperature and heat flow in terms of the motion of molecules (or atoms).

   b. *Students know* chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.

   c. *Students know* energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.

   d. *Students know* how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.

   e. * *Students know* how to apply Hess's law to calculate enthalpy change in a reaction.

   f. * *Students know* how to use the Gibbs free energy equation to determine whether a reaction would be spontaneous.

Reaction Rates

8. Chemical reaction rates depend on factors that influence the frequency of collision of reactant molecules. As a basis for understanding this concept:

   a. *Students know* the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.

   b. *Students know* how reaction rates depend on such factors as concentration, temperature, and pressure.

   c. *Students know* the role a catalyst plays in increasing the reaction rate.

   d. * *Students know* the definition and role of activation energy in a chemical reaction.

Chemical Equilibrium

9. Chemical equilibrium is a dynamic process at the molecular level. As a basis for understanding this concept:
   a. *Students know* how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature, and pressure.
   b. *Students know* equilibrium is established when forward and reverse reaction rates are equal.
   c. * *Students know* how to write and calculate an equilibrium constant expression for a reaction.

Organic Chemistry and Biochemistry

10. The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the biochemical basis of life. As a basis for understanding this concept:
    a. *Students know* large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.
    b. *Students know* the bonding characteristics of carbon that result in the formation of a large variety of structures ranging from simple hydrocarbons to complex polymers and biological molecules.
    c. *Students know* amino acids are the building blocks of proteins.
    d. * *Students know* the system for naming the ten simplest linear hydrocarbons and isomers that contain single bonds, simple hydrocarbons with double and triple bonds, and simple molecules that contain a benzene ring.
    e. * *Students know* how to identify the functional groups that form the basis of alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids.
    f. * *Students know* the R-group structure of amino acids and know how they combine to form the polypeptide backbone structure of proteins.

Nuclear Processes

11. Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes, nuclear fission, and nuclear fusion. As a basis for understanding this concept:
    a. *Students know* protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons.
    b. *Students know* the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. The change in mass (calculated by $E = mc^2$) is small but significant in nuclear reactions.
    c. *Students know* some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.
    d. *Students know* the three most common forms of radioactive decay (alpha, beta, and gamma) and know how the nucleus changes in each type of decay.
    e. *Students know* alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.
    f. * *Students know* how to calculate the amount of a radioactive substance remaining after an integral number of half-lives have passed.
    g. * *Students know* protons and neutrons have substructures and consist of particles called quarks.

Investigation & Experimentation

12. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
    a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
    b. Identify and communicate sources of unavoidable experimental error.
    c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
    d. Formulate explanations by using logic and evidence.
    e. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.
    f. Distinguish between hypothesis and theory as scientific terms.
    g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.
    h. Read and interpret topographic and geologic maps.
    i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
    j. Recognize the issues of statistical variability and the need for controlled tests.
    k. Recognize the cumulative nature of scientific evidence.
    l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
    m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.
    n. Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e.g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).