General Chemistry 001 A B C - Syllabus Addendum for Prospective Teachers Silberberg, M. S. (2006). *Chemistry: The molecular nature of matter and change* Fourth Edition		
Chapter	**Subject Matter Requirements for Prospective Teachers General Science**	**Academic content standards for kindergarten through grade twelve, adopted by the California State Board of Education**
Ch 1-Keys to the study of chemistry	11.1g Distinguish between physical and chemical change and provide examples of each	Science Content Standards for California Public Schools, Grade 8.3b compounds have properties that are different from their constituent elements; 8.3c *Students know* atoms and molecules form solids by building up repeating patterns, such as the crystal structure of NaCl or long-chain polymers
	12.1e Discuss the physical properties of matter including structure, melting point, boiling point, hardness, density, and conductivity	*Science Content Standards for California Public Schools, Grade 8:5d Students know* physical processes include freezing and boiling, in which a material changes form with no chemical reaction
	12.1f Recognize that all chemical substances are characterized by a unique set of physical properties	*Science Content Standards for California Public Schools, Grade 8:3b Students know* that compounds are formed by combining two or more different elements and that compounds have properties that are different from their constituent elements; 8.5d *Students know* physical processes include freezing and boiling, in which a material changes form with no chemical reaction; 8.6a *Students know* that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms; 8.7c *Students know* substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity
	12.1g Define and calculate density, and predict whether an object will sink or float in a fluid	*Science Content Standards for California Public Schools, Grade 8: 8a Students know* density is mass per unit volume; 8b *Students know* how to calculate

		the density of substances (regular and irregular solids and liquids) from measurements of mass and volume; *8c Students know* the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced;*8d Students know* how to predict whether an object will float or sink.
	12.1p Explain the central role of carbon in living system chemistry	*Science Content Standards for California Public Schools, Grade 8:6a Students know* that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms; 6c *Students know* that living organisms have many different kinds of molecules, including small ones, such as water and salt, and very large ones, such as carbohydrates, fats, proteins, and DNA
Ch 2-The components of matter	12.1a Identify, describe, and diagram the basic components within an atom (i.e., proton, neutron, and electron)	*Science Content Standards for California Public Schools, Grade 8: 3a Students know* the structure of the atom and know it is composed of protons, neutrons, and electrons
	12.1b Know that isotopes of any element have different numbers of neutrons but the same number of protons, and that some isotopes are radioactive	*Science Content Standards for California Public Schools, Grade 8:3 b Students know* that compounds are formed by combining two or more different elements and that compounds have properties that are different from their constituent elements
	12.1c Differentiate between atoms, molecules, elements, and compounds	*Science Content Standards for California Public Schools, Grade 8:3b Students know* that compounds are formed by combining two or more different elements and that compounds have properties that are different from their constituent elements; 3c *Students know* atoms and molecules form solids by building up repeating patterns, such as the crystal

		structure of NaCl or long-chain polymers
	12.1f Recognize that all chemical substances are characterized by a unique set of physical properties	*Science Content Standards for California Public Schools, Grade 8:3b Students know* that compounds are formed by combining two or more different elements and that compounds have properties that are different from their constituent elements; 8.5d *Students know* physical processes include freezing and boiling, in which a material changes form with no chemical reaction; 8.6a *Students know* that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms; 8.7c *Students know* substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity
	12.1h Explain that chemical changes in materials result in the formation of a new substance corresponding to the rearrangement of the atoms in molecules	*Science Content Standards for California Public Schools, Grade 8:5a Students know* reactant atoms and molecules interact to form products with different chemical properties *Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11c Students know* some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions
Ch 3-Stoichiometry of formulas and equations	12.1f Recognize that all chemical substances are characterized by a unique set of physical properties	*Science Content Standards for California Public Schools, Grade 8:3b Students know* that compounds are formed by combining two or more different elements and that compounds have properties that are different from their constituent elements; 8.5d *Students know* physical processes include freezing and boiling, in which a material changes form with no chemical reaction; 8.6a *Students know* that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms; 8.7c *Students know* substances can be classified by

		their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity
	12.1h Explain that chemical changes in materials result in the formation of a new substance corresponding to the rearrangement of the atoms in molecules	*Science Content Standards for California Public Schools, Grade 8:5a Students know* reactant atoms and molecules interact to form products with different chemical properties *Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11c Students know* some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions
	12.1i Explain and apply principles of conservation of matter to chemical reactions, including balancing chemical equations	*Science Content Standards for California Public Schools, Grade 8:5b Students know* the idea of atoms explains the conservation of matter: In chemical reactions the number of atoms stays the same no matter how they are arranged, so their total mass stays the same
Ch 5-Gases and the Kinetic-molecular theory	11.1d Describe the methods of heat transfer by conduction, convection and radiation and provide examples for each	Science Content Standards for California Public Schools, Grade 6: 3b *Students know* that when fuel is consumed, most of the energy released becomes heat energy; 6.3c *Students know* heat flows in solids by conduction (which involves no flow of matter) and in fluids by conduction and by convection (which involves flow of matter).; 6.3d *Students know* heat energy is also transferred between objects by radiation (radiation can travel through space); 6.4d *Students know* convection currents distribute heat in the atmosphere and oceans *Grade 9-12 Physics:3c Students know* the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object
	12.1d Compare and contrast	*Science Content Standards for*

	states of matter and describe the role energy plays in the conversion from one state to another	*California Public Schools, Grades 9-12, Chemistry: 7b Students know* chemical processes can either release (exothermic) or absorb (endothermic) thermal energy. *Science Content Standards for California Public Schools, Grade 8:*5c *Students know* chemical reactions usually liberate heat or absorb heat
Ch 6-Thermochemistry: Energy flow and chemical change	11.1a Know the principle of conservation of energy and apply it to energy transfers	Science Content Standards for California Public Schools, Grade 6: 3a *Students know* energy can be carried from one place to another by heat flow or by waves, including water, light and sound waves, or by moving objects *Grade 9-12 Physics:3a students know* heat flow and work are two forms of energy transfer between systems. *Physics:3b Students know* that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy Chemistry: 7a *Students know* how to describe temperature and heat flow in terms of the motion of molecules (or atoms)
	11.1b Discuss how the transfer of energy as heat is related to changes in temperature	Science Content Standards for California Public Schools, Grade 6: 3b Students know that when fuel is consumed, most of the energy released becomes heat energy Grades 9-12 Chemistry:7b Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy
	11.1c Diagram the direction of heat flow in a system	Science Content Standards for California Public Schools, Grade 6: 3b Students know that when fuel is consumed, most of the energy released becomes heat

		energy Grade 9-12 Chemistry:7a Students know how to describe temperature and heat flow in terms of the motion of molecules (or atoms)
	11.1d Describe the methods of heat transfer by conduction, convection and radiation and provide examples for each	Science Content Standards for California Public Schools, Grade 6: 3b *Students know* that when fuel is consumed, most of the energy released becomes heat energy; 6.3c *Students know* heat flows in solids by conduction (which involves no flow of matter) and in fluids by conduction and by convection (which involves flow of matter).; 6.3d *Students know* heat energy is also transferred between objects by radiation (radiation can travel through space); 6.4d *Students know* convection currents distribute heat in the atmosphere and oceans *Grade 9-12 Physics:3c Students know* the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object
	11.1e Explain how chemical energy in fuel is transformed to heat	Science Content Standards for California Public Schools, Grade 6: 3b *Students know* that when fuel is consumed, most of the energy released
	11.1f Design and explain experiments to induce a physical change such as freezing, melting, or boiling	Science Content Standards for California Public Schools, Grade 8.3d *Students know* the states of matter (solid, liquid, gas) depend on molecular motion; *8.3e Students know* that in solids the atoms are closely locked in position and can only vibrate; in liquids the atoms and molecules are more loosely connected and can collide with and move past one another; and in gases the atoms and molecules are free to move independently, colliding frequently. Grade 9-12 Chemistry: 7c Students know energy is released when a material condenses or freezes and is absorbed when a

		material evaporates or melts
	11.1g Distinguish between physical and chemical change and provide examples of each	Science Content Standards for California Public Schools, Grade 8.3b compounds have properties that are different from their constituent elements; 8.3c *Students know* atoms and molecules form solids by building up repeating patterns, such as the crystal structure of NaCl or long-chain polymers
Ch 7-Quantum theory and atomic structure	12.1m Explain chemical reactivity using position on the periodic table	*Science Content Standards for California Public Schools, Grade 8: 7b Students know* each element has a specific number of protons in the nucleus (the atomic number) and each isotope of the element has a different but specific number of neutrons in the nucleus
	12.1n Predict and explain chemical bonding using elements' positions in the periodic table	*Science Content Standards for California Public Schools, Grade 8: 7c Students know* substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity.
Ch 8-Electron configuration and chemical periodicity	12.1k Describe the construction and organization of the periodic table	*Science Content Standards for California Public Schools, Grade 8:7a Students know* how to identify regions corresponding to metals, nonmetals, and inert gases; *8.7b Students know* each element has a specific number of protons in the nucleus (the atomic number) and each isotope of the element has a different but specific number of neutrons in the nucleus; *8.7c Students know* substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity
	12.1l Based on position in the periodic table, predict which elements have characteristics of metals, semi-metals, non-metals, and inert gases	*Science Content Standards for California Public Schools, Grade 8: 7a Students know* how to identify regions corresponding to metals, nonmetals, and inert gases.
	12.1m Explain chemical reactivity using position on the periodic table	*Science Content Standards for California Public Schools, Grade 8: 7b Students know* each

		element has a specific number of protons in the nucleus (the atomic number) and each isotope of the element has a different but specific number of neutrons in the nucleus
	12.1n Predict and explain chemical bonding using elements' positions in the periodic table	*Science Content Standards for California Public Schools, Grade 8: 7c Students know* substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity.
Ch 9-Models of chemical bonding	12.1e Discuss the physical properties of matter including structure, melting point, boiling point, hardness, density, and conductivity	*Science Content Standards for California Public Schools, Grade 8:5d Students know* physical processes include freezing and boiling, in which a material changes form with no chemical reaction
	12.1m Explain chemical reactivity using position on the periodic table	*Science Content Standards for California Public Schools, Grade 8: 7b Students know* each element has a specific number of protons in the nucleus (the atomic number) and each isotope of the element has a different but specific number of neutrons in the nucleus
	12.1n Predict and explain chemical bonding using elements' positions in the periodic table	*Science Content Standards for California Public Schools, Grade 8: 7c Students know* substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity.
Ch 10-The shapes of molecules	12.1e Discuss the physical properties of matter including structure, melting point, boiling point, hardness, density, and conductivity	*Science Content Standards for California Public Schools, Grade 8:5d Students know* physical processes include freezing and boiling, in which a material changes form with no chemical reaction
Ch 12-Intermolecular forces: Liquids, solids and phase changes	12.1d Compare and contrast states of matter and describe the role energy plays in the conversion from one state to another	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 7b Students know* chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.

		*Science Content Standards for California Public Schools, Grade 8:*5c *Students know* chemical reactions usually liberate heat or absorb heat
	12.1e Discuss the physical properties of matter including structure, melting point, boiling point, hardness, density, and conductivity	*Science Content Standards for California Public Schools, Grade 8:5d Students know* physical processes include freezing and boiling, in which a material changes form with no chemical reaction
	12.1g Define and calculate density, and predict whether an object will sink or float in a fluid	*Science Content Standards for California Public Schools, Grade 8: 8a Students know* density is mass per unit volume; 8b *Students know* how to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume; *8c Students know* the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced;*8d Students know* how to predict whether an object will float or sink.
	12.1h Explain that chemical changes in materials result in the formation of a new substance corresponding to the rearrangement of the atoms in molecules	*Science Content Standards for California Public Schools, Grade 8:5a Students know* reactant atoms and molecules interact to form products with different chemical properties *Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11c Students know* some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions
Ch18-Acid-Base equilibria	12.1j Distinguish among acidic, basic, and neutral solutions by their observable properties	*Science Content Standards for California Public Schools, Grade 8:5e Students know* how to determine whether a solution is acidic, basic, or neutral
Ch 25-Biomolecules: Carbohydrates	12.1o Recognize that inorganic and organic compounds (e.g., water, salt, carbohydrates, lipids,	*Science Content Standards for California Public Schools, Grade 8:6a Students know* that carbon, because of its ability to combine in many ways with itself and other

	proteins, nucleic acids) are essential to processes within living systems	elements, has a central role in the chemistry of living organisms
Ch 26-Biomolecules: Amino Acids, peptides and proteins	12.1o Recognize that inorganic and organic compounds (e.g., water, salt, carbohydrates, lipids, proteins, nucleic acids) are essential to processes within living systems	*Science Content Standards for California Public Schools, Grade 8:6a Students know* that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms
Ch 27-Biomolecules: Lipids	12.1o Recognize that inorganic and organic compounds (e.g., water, salt, carbohydrates, lipids, proteins, nucleic acids) are essential to processes within living systems	*Science Content Standards for California Public Schools, Grade 8:6a Students know* that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms
Ch 28-Biomolecules: Heterocycles and nucleic a	12.1o Recognize that inorganic and organic compounds (e.g., water, salt, carbohydrates, lipids, proteins, nucleic acids) are essential to processes within living systems	*Science Content Standards for California Public Schools, Grade 8:6a Students know* that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms
Ch 29-The organic chemistry of metabolic pathways	12.1o Recognize that inorganic and organic compounds (e.g., water, salt, carbohydrates, lipids, proteins, nucleic acids) are essential to processes within living systems	*Science Content Standards for California Public Schools, Grade 8:6a Students know* that carbon, because of its ability to combine in many ways with itself and other elements, has a central role in the chemistry of living organisms
Chapter	**Chemistry Subject Matter Requirements**	**Academic content standards for kindergarten through grade twelve, adopted by the California State Board of Education**
1 - Keys to the study of chemistry	3.1d Convert between Kelvin and Celsius temperature scales	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 4e Students know* how to convert between the Celsius and Kelvin temperature scales.
	3.1e Recognize the significance of absolute zero	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 4f Students know* there is no temperature lower than 0 Kelvin; 4g *Students know* the kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of

		its molecules or atoms
2 - The components of matter	1.1a Differentiate periodic groups and families of elements and their properties	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1c* *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.
	1.2a Analyze the evolution of the atomic model (including, but not limited to, the historical importance of the Bohr model and the development of the quantum structure of the atom)	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1h* *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. 1i *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
	1.2c Illustrate the position and describe the properties of quarks, protons, neutrons, and electrons within atoms	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry:1g* *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
	4.1e Describe various methods for separation of solutions (e.g., chromatography, distillation)	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 6f* *Students know* how molecules in a solution are separated or purified by the methods of chromatography and distillation
3 - Stoichiometry of formulas and equations	2.1a Calculate molar mass, mass, number of particles, and volume, at standard temperature and pressure (STP) for elements and compounds	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 3b* *Students know* the quantity one mole is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams.; *2c Students know* one mole equals 6.02×10^{23} particles (atoms or molecules).; *2d 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; 4d. *Students know* the values and meanings of standard temperature and pressure (STP).
	2.1b Calculate the masses of reactants and products, and percent yield using balanced chemical equations, including problems with a limiting reagent	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 3a Students know* how to describe chemical reactions by writing balanced equations.; 3e *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; 3f Students *know* how to calculate percent yield in a chemical reaction
4 - The major classes of chemical reactions	2.1c Distinguish reaction types, including single replacement, double replacement, synthesis, decomposition, and combustion	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 3a Students know* how to describe chemical reactions by writing balanced equations; 3g *Students know* how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions
	2.1d Utilize the rules of oxidation states to balance oxidation-reduction reactions	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 3g Students know* how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions
5 - Gases and the kinetic-molecular theory	2.1a Calculate molar mass, mass, number of particles, and volume, at standard temperature and pressure (STP) for elements and compounds	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 3b Students know* the quantity one mole is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams; *2c Students know* one mole equals 6.02×10^{23} particles (atoms or molecules).; *2d 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; 4d. *Students know* the values and meanings of standard temperature and pressure (STP).
	3.1a Solve problems using the ideal gas law and use the ideal gas law to predict pressure-volume, pressure-	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 4a Students know* the random motion of molecules and their collisions with a

	temperature, and volume-temperature relationships	surface create the observable pressure on that surface; *4b Students know* the random motion of molecules explains the diffusion of gases; *4c 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; *4h Students know* how to solve problems by using the ideal gas law in the form PV = nRT
	3.1b Relate pressure, volume, and temperature to the kinetic theory of atoms and molecules in gases	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry:* 4d *Students know* the values and meanings of standard temperature and pressure (STP).
	3.1c Know and use STP to solve gas law problems	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 4d Students know* the values and meanings of standard temperature and pressure (STP).
	3.1e Recognize the significance of absolute zero	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 4f Students know* there is no temperature lower than 0 Kelvin; 4g *Students know* the kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms
	3.1f Solve problems using Dalton's law of partial pressures and Graham's Laws of diffusion	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 4i 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
6-Thermochemistry: Energy	5.1a Perform calculations	*Science Content Standards for*

flow and chemical change	using specific heat, heats of fusion, heats of vaporization, and heat of reaction (enthalpy)	*California Public Schools, Grades 9-12, Chemistry: 7b* *Students know* chemical processes can either release (exothermic) or absorb (endothermic) thermal energy 5e *Students know* how to apply Hess's law to calculate enthalpy change in a reaction
7 - Quantum theory and atomic structure	1.1b Relate valence electrons and the electron shell structure (s, p, d, f orbitals) to an element's position in the periodic table	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1d* *Students know* how to use the periodic table to determine the number of electrons available for bonding.; 1g *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
	1.2a Analyze the evolution of the atomic model (including, but not limited to, the historical importance of the Bohr model and the development of the quantum structure of the atom)	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1h* *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. 1i *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
	1.2b Relate atomic spectroscopy and the photoelectric effect to the quantum structure of the atom	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry:1j* *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 = hv).
8 - Electron configuration and chemical periodicity Lab-The Alkaline Earths and Halogens	1.1a Differentiate periodic groups and families of elements and their properties	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1c* *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.
	1.1b Relate valence electrons and the electron shell structure (s, p, d, f orbitals) to an element's position in the periodic table	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1d Students know* how to use the periodic table to determine the number of electrons available for bonding.; 1g *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
	1.1c Predict periodic trends including electronegativity, ionization energy, and the relative sizes of ions and atoms	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1f 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.; *1C 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.
9 - Models of chemical bonding	1.3a Compare types of molecular bonds including ionic, covalent and hydrogen bonds	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry:2a Students know* atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.; *2b Students know* chemical bonds between atoms in molecules such as H_2 , CH_4 , NH_3 , H_2 CCH_2 , N_2 , Cl_2 , and many large biological molecules are covalent; *2c Students know* salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.; *2d 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.
	1.3b Draw Lewis dot structures for compounds and ions	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry:2e Students know* how to draw Lewis dot structures
10 - Shapes of molecules	1.3c Predict molecular geometries using Lewis dot structures and hybridized atomic orbitals, e.g., valence shell electron pair repulsion model (VSEPR)	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 2e Students know* how to draw Lewis dot structures *2f Students know* how to predict the shape of simple molecules and their polarity from Lewis dot structures *2g Students know* how electronegativity and ionization energy relate to bond formation
11 - Theories of covalent bonding	1.3a Compare types of molecular bonds including ionic, covalent and hydrogen bonds	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry:2a Students know* atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.; *2b 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; *2c Students know* salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.; *2d 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.
12 - Intermolecular forces: Liquids, solids, and phase changes	1.3a Compare types of molecular bonds including ionic, covalent and hydrogen bonds	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry:2a Students know* atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.; *2b Students know* chemical

		bonds between atoms in molecules such as H_2 , CH_4 , NH_3 , H_2 CCH_2 , N_2 , Cl_2 , and many large biological molecules are covalent.; *2c Students know* salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction. *2d 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.
	1.3d Relate intermolecular electrostatic forces, including Van der Waals, polar and induced polar, and ionic, to their expected states of matter and their characteristic physical properties.	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry:2h 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
	5.1a Perform calculations using specific heat, heats of fusion, heats of vaporization, and heat of reaction (enthalpy)	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 7b Students know* chemical processes can either release (exothermic) or absorb (endothermic) thermal energy; 5e *Students know* how to apply Hess's law to calculate enthalpy change in a reaction
	5.1b Interpret phase diagrams	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 7b Students know* chemical processes can either release (exothermic) or absorb (endothermic) thermal energy
13 - The properties of mixtures: Solutions and colloids	4.1a Recognize and identify solutes and solvents	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 6a Students know* the definitions of solute and solvent

	4.1b Calculate concentration in terms of molarity, parts per million, and percent composition	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 6d* *Students know* how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition
	4.1c Describe the dissolving process at the molecular level	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 6b* *Students know* how to describe the dissolving process at the molecular level by using the concept of random molecular motion
	4.1d Explain how factors such as temperature, pressure, and surface area affect the dissolving process	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 6c* *Students know* temperature, pressure, and surface area affect the dissolving process
16 - Kinetics: Rates and mechanisms of chemical reactions	2.2a Predict the effect of temperature, pressure, and concentration on chemical equilibrium (LeChatelier's principle) and the reaction rate	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 8a* *Students know* the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time*; 8b Students know* how reaction rates depend on such factors as concentration, temperature, and pressure; 9a *Students know* how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature, and pressure
	2.2b Interpret a diagram showing activation energy along the reaction pathway	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 8d* *Students know* the definition and role of activation energy in a chemical reaction
	2.2c Identify and predict the role of catalysts on the reaction rate	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 8c* *Students know* the role a catalyst plays in increasing the reaction rate
	7.1c Perform calculations involving half-life	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11f* *Students know* how to calculate the amount of a radioactive substance

		remaining after an integral number of half-lives have passed
17 - Equilibrium: The extent of chemical reactions	2.2a Predict the effect of temperature, pressure, and concentration on chemical equilibrium (LeChatelier's principle) and the reaction rate	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 8a Students know* the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time; *8b Students know* how reaction rates depend on such factors as concentration, temperature, and pressure; 9a *Students know* how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature, and pressure
	2.2d Write and calculate an equilibrium constant expression for a given reaction	Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 9c *Students know* how to write and calculate an equilibrium constant expression for a reaction
	2.2e Know that equilibrium is established when the reaction rates of the forward and reverse reactions are equal	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 9b Students know* equilibrium is established when forward and reverse reaction rates are equal; *9c Students know* how to write and calculate an equilibrium constant expression for a reaction
18 -Acid-base equilibria	4.2a Distinguish between strong and weak acids and bases based on degree of dissociation and their chemical properties	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 5a Students know* the observable properties of acids, bases, and salt solutions.; *5b Students know* acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.; *5c Students know* strong acids and bases fully dissociate and weak acids and bases partially dissociate
	4.2b Calculate pH and hydrogen ion concentration in solutions including buffer solutions	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 5b Students know* acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances; 5d *Students know* how to use the pH scale to

		characterize acid and base solutions; 5f Students *know* how to calculate pH from the hydrogen-ion concentration; 5g *Students know* buffers stabilize pH in acid-base reactions
	4.2c Use Arrhenius, Brønsted-Lowry, and Lewis acid-base definitions appropriately to characterize acids and bases and in acid-base reactions	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 5e Students know* the Arrhenius, Brønsted-Lowry, and Lewis acid-base definitions
24-Nuclear reactions and their applications	7.1a Understand how mass-energy relationships in nuclear reactions and radioactive decay requires the relationship $E=mc^2$	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11b Students know* the energy release per gram of material is much larger in nuclear fusion or fission
	7.1b Compare and contrast alpha, beta, and gamma decay, and the relative kinds of damage to matter caused by α-, β-, and γ-rays	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11d 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; 11e *Students know* alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations *Science Content Standards for California Public Schools, Grades 9-12, Investigation and Experimentation: 1m* 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
	7.1c Perform calculations involving half-life	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11f Students know* how to calculate the amount of a radioactive substance remaining after an integral number of half-lives have passed
	7.1d Contrast the benefits and hazards of the use of radiation and radioactivity	*Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 11e Students know* alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different

		penetrations *Science Content Standards for California Public Schools, Grades 9-12, Investigation and Experimentation: 1m* 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