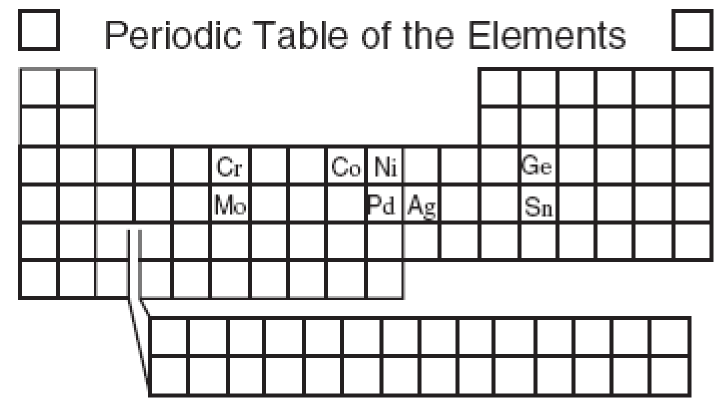
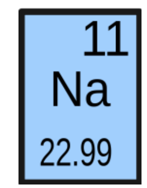
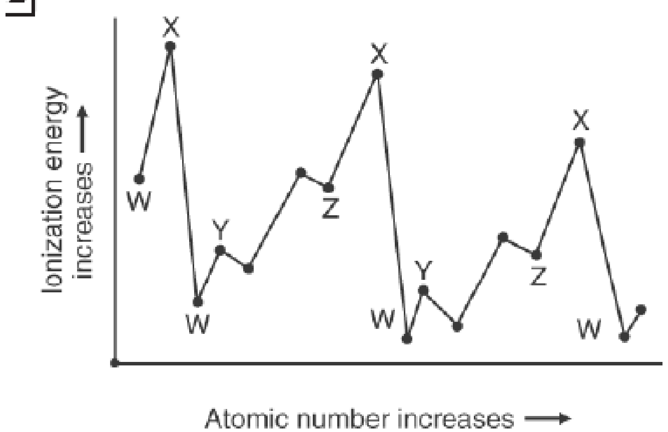
Subject Area Assessment Guides, Sem. 1
Chemistry
Matter: Properties and Changes, Atomic Structure, Nuclear Chemistry, Electrons in Atoms, Periodic Table, The Elements, Ionic and Covalent Compounds, Bonding, Stoichiometry

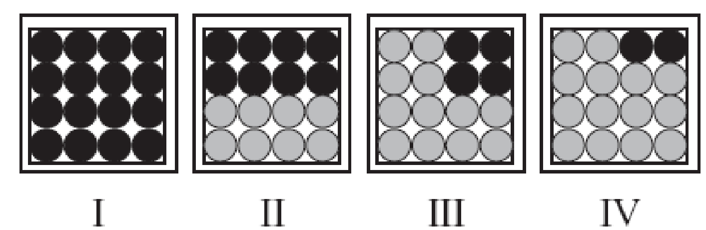
California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
1a. Students know how to relate the position of an element in the periodic table to its atomic number and atomic mass.	An atom consists of a nucleus made of protons and neutrons that is orbited by electrons. The number of protons, not electrons or neutrons, determines the unique properties of an element. This number of protons is called the element's atomic number. Elements are arranged on the periodic table in order of increasing atomic number. Historically, elements were ordered by atomic mass, but now scientists know that this order would lead to misplaced elements (e.g., tellurium and iodine) because differences in the number of neutrons for isotopes of the same element affect the atomic mass but do not change the identity of the element.	ATOM INTERNAL STRUCTURE OF THE ATOM SUB-ATOMIC PARTICLES [n^o, e^-, and p^+] ATOMIC THEORY RUTHERFORD, BOHR MODEL ORBITALS ATOMIC NUMBER MASS NUMBER/ATOMIC MASS ISOTOPES	 **Which of the following ordered pairs of elements shows an increase in atomic number but a decrease in average atomic mass?** **A** Ag to Pd **B** Co to Ni **C** Ge to Sn **D** Cr to Mo *From: CST Released Test Items* *DOK Level: 2 [Analyze, Application]* **In which list are the elements arranged in order of increasing atomic mass?** (1) Cl, K, Ar (3) Te, I, Xe (2) Fe, Co, Ni (4) Ne, F, Na *From: NY Regents Chemistry 2003* *DOK Level: 2 [Analyze, Application]*

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
1. b. Students know how to use the periodic table to identify metals, semimetals, nonmetals, and halogens.	Most periodic tables have a heavy stepped line running from boron to astatine. Elements to the immediate right and left of this line, excluding the metal aluminum, are semimetals and have properties that are intermediate between metals and nonmetals. Elements further to the left are metals. Those further to the right are nonmetals. Halogens, which are a well-known family of nonmetals, are found in Group 17 (formerly referred to as Group VIIA). A group, also sometimes called a "family," is found in a vertical column in the periodic table.	PERIODIC TAVLE SEMI-METALS METALS NON-METALS HALOGENS FAMILY, GROUP PERIOD	**Which list of elements contains two metalloids?** (1) Si, Ge, Po, Pb (3) Si, P, S, Cl (2) As, Bi, Br, Kr (4) Po, Sb, I, Xe *From: NY Regents Chemistry 2003* *DOK Level: 1 [Recall, Reproduction]* **The high electrical conductivity of metals is primarily due to-** (1) high ionization energies (2) filled energy levels (3) mobile electrons (4) high electronegativities *From: NY Regents Chemistry 2003* *DOK Level: 1 [Recall, Reproduction]* **How many protons, neutrons, and electrons are in a neutral atom of sodium?**  **F** 11 p_, 12 n_, 11e_ **G** 11 p_, 11 n_, 12e_ **H** 12 p_, 11 n_, 12e_ **J** 12 p_, 11 n_, 11e_ *From: Virginia Chemistry SOL, EOC Assessments* *DOK Level: 2 [Analysis, Application]*

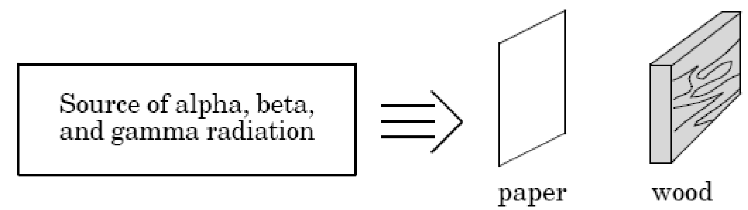
California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
1c. Students know how to use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electronegativity, and the relative sizes of ions and atoms.	A few other groups are given family names. These include the alkali metals (Group 1), such as sodium and potassium, which are soft and white and extremely reactive chemically. Alkaline earth metals (Group 2), such as magnesium and calcium, are found in the second column of the periodic table. The transition metals (Groups 3 through 12) are represented by some of the most common metals, such as iron, copper, gold, mercury, silver, and zinc. All these elements have electrons in their outer *d* orbitals. *Electronegativity* is a measure of the ability of an atom of an element to attract electrons toward itself in a chemical bond. The values of electronegativity calculated for various elements range from one or less for the alkali metals to three and one-half for oxygen to about four for fluorine. *Ionization energy* is the energy it takes to remove an electron from an atom. An element often has multiple ionization energies, which correspond to the energy needed to remove first, second, third, and so forth electrons from the atom. Generally in the periodic table, ionization energy and electronegativity increase from left to right because of increasing numbers of protons and decrease from top to bottom owing to an increasing distance between electrons and the nucleus. Atomic and ionic sizes generally decrease from left to right and increase from top to bottom for the same reasons. Exceptions to these general trends in properties occur because of filled and half-filled subshells of electrons.	ALKALI METALS ALKALINE-EARTH METALS TRANSITION METALS s, p, d, f ORBITALS ELECTRON PROBABILITY DENSITIES ELECTRON AFFINITY ELECTRONEGATIVITY IONIZATION ENERGY PT TRENDS ATOMIC/IONIC RADIUS SUBSHELL SHELL	**From which of these atoms in the ground state can a valence electron be removed using the least amount of energy?** (1) nitrogen (3) oxygen (2) carbon (4) chlorine *From: New York Regents 2003 Chemistry* *DOK Level: 2 [Analysis, Application]* **The chart below shows the relationship between the first ionization energy and the increase in atomic number. The letter on the chart for the alkali family of elements is** 2  **A** W. **B** X. **C** Y. **D** Z. *From: CST Released Test Items* *DOK Level: 3 [Strategic Thinking]*

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
1d. Students know how to use the periodic table to determine the number of electrons available for bonding.	Only electrons in the outermost energy levels of the atom are available for bonding; this outermost bundle of energy levels is often referred to as the valence shell or valence shell of orbitals. All the elements in a group have the same number of electrons in their outermost energy level. Therefore, alkali metals (Group 1) have one electron available for bonding, alkaline earth metals (Group 2) have two, and elements in Group 13 (once called Group III) have three. Unfilled energy levels are also available for bonding. For example, Group 16, the chalcogens, has room for two more electrons; and Group 17, the halogens, has room for one more electron to fill its outermost energy level. To find the number of electrons available for bonding or the number of unfilled electron positions for a given element, students can examine the combining ratios of the element's compounds. For instance, one atom of an element from Group 2 will most often combine with two atoms of an element from Group 17 (e.g., MgCl2) because Group 2 elements have two electrons available for bonding, and Group 17 elements have only one electron position open in the outermost energy level. (Note that some periodic tables indicate an element's electron configuration or preferred oxidation states. This information is useful in determining how many electrons are involved in bonding.)	VALENCE SHELL VALENCE ELECTRON CHALCOGENS BONDING COMBINING RATIOS ELECTRON CONFIGURATION EXCITED STATE vs. GROUND STATE	**Which of the following atoms has six valence electrons?** **A** magnesium (Mg) **B** silicon (Si) **C** sulfur (S) **D** argon (Ar) *From: CST Released Test Items* *DOK Level: 1 [Recall & Reproduction]*

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
1e. Students know the nucleus of the atom is much smaller than the atom yet contains most of its mass.	The volume of the hydrogen nucleus is about one trillion times less than the volume of the hydrogen atom, yet the nucleus contains almost all the mass in the form of one proton. The diameter of an atom of any one of the elements is about 10,000 to 100,000 times greater than the diameter of the nucleus. The mass of the atom is densely packed in the nucleus. The electrons occupy a large region of space centered around a tiny nucleus, and so it is this region that defines the volume of the atom. If the nucleus (proton) of a hydrogen atom were as large as the width of a human thumb, the electron would be on the average about one kilometer away in a great expanse of empty space. The electron is almost 2,000 times lighter than the proton; therefore, the large region of space occupied by the electron contains less than 0.1 percent of the mass of the atom.	NUCLEUS [Atom is mostly empty space] RUTHERFORD'S GOLD FOIL EXPERIMENT SIZE, MASS, CHARGE, and LOCATION OF SUB-ATOMIC PARTICLES SHELLS, ENERGY LEVELS	**Which statement *best* describes the density of an atom's nucleus?** **A** The nucleus occupies most of the atom's volume but contains little of its mass. **B** The nucleus occupies very little of the atom's volume and contains little of its mass. **C** The nucleus occupies most of the atom's volume and contains most of its mass. **D** The nucleus occupies very little of the atom's volume but contains most of its mass.
11a. *Students know* protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons.	The nucleus is held together by the strong nuclear force. The strong nuclear force acts between protons, between neutrons, and between protons and neutrons but has a limited range comparable to the size of an atomic nucleus. The nuclear force is able to overcome the mutual electrostatic repulsion of the protons only when the protons and neutrons are near each other as they are in the nucleus of an atom.	-Strong nuclear force -Repulsion -proton-proton/proton-neutron/neutron-neutron interactions -Nucleon	**Why are enormous amounts of energy required to separate a nucleus into its component protons and neutrons even though the protons in the nucleus repel each other?** **A** The force of the protons repelling each other is small compared to the attraction of the neutrons to each other. B The electrostatic forces acting between other atoms lowers the force of repulsion of the protons. C The interactions between neutrons and electrons neutralize the repulsive forces between the protons. D The forces holding the nucleus together are much stronger than the repulsion between the protons.

			From: CST Released Test Questions ***DOK Level: 1 [Recall and Reproduction]***
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
11b. 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.	Two major types of nuclear reactions are fusion and fission. In fusion reactions two nuclei come together and merge to form a heavier nucleus. In fission a heavy nucleus splits apart to form two (or more) lighter nuclei. The binding energy of a nucleus depends on the number of neutrons and protons it contains. A general term for a proton or a neutron is a nucleon. In both fusion and fission reactions, the total number of nucleons does not change, but large amounts of energy are released as nucleons combine into different arrangements. This energy is one million times more than energies involved in chemical reactions.	-Nuclear vs. chemical changes -Nuclear fusion vs. fission -Heavy nucleus -Binding energy -$E = mc^2$	**Which best contrasts nuclear fission and nuclear fusion?** A fission: splitting of small nuclei & fusion: joining of large nuclei B fission: splitting of large nuclei & fusion: joining of small nuclei C fission: joining of small nuclei & fusion: joining of large nuclei D fission: needs extremely low temperatures & fusion: needs slightly higher temperatures than fission ***From: North Carolina Testing Program, Physical Science*** ***DOK Level: [1] Recall and Reproduction***
11c. *Students know* some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.	Sometimes atoms with the same number of protons in the nucleus have different numbers of neutrons. These atoms are called isotopes of an element. Both naturally occurring and human-made isotopes of elements can be either stable or unstable. Less stable isotopes of one element, called parent isotopes, will undergo radioactive decay, transforming to more stable isotopes of another element, called daughter products, which can also be either stable or radioactive. For a radioactive isotope to be found in nature, it must either have a long half-life, such as potassium-40, uranium-238, uranium-235, or thorium-232, or be the daughter product, such as radon-222, of a parent with a long half-life, such as uranium-238.	-Isotopes -Radioactivity -Stability of the nucleus -Radioactive decay -Transmutation -Parent isotope -Daughter isotopes -Synthetic isotopes -Half-life	The diagram below shows a radioactive isotope going through several half-lives as it decays.  In sample I, the original isotope has a mass of 40 g. How many grams of the original isotope remain in sample IV? A. 3 7.5 g B. 2 0 g C. 1 0 g D. 5 g ***From: New England Common Assessments Chemistry, 2008*** ***DOK Level: [2] Apply and Analyze***

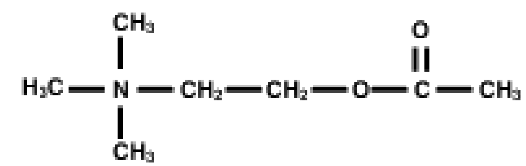
			The nucleus of a radium-226 atom is unstable, which causes the nucleus to spontaneously- (1) absorb electrons (3) decay (2) absorb protons (4) oxidize ***From: NY Regents, Chemistry [2008]*** ***DOK Level: [1] Recall and Reproduction***
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
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.	Radioactive isotopes transform to more stable isotopes, emitting particles from the nucleus. These particles are helium-4 nuclei (alpha radiation), electrons or positrons (beta radiation), or high-energy electromagnetic rays (gamma radiation). Isotopes of elements that undergo alpha decay produce other isotopes with two less protons and two less neutrons than the original isotope. Uranium-238, for instance, emits an alpha particle and becomes thorium-234. Isotopes of elements that undergo beta decay produce elements with the same number of nucleons but with one more proton or one less proton. For example, thorium-234 beta decays to protactinium-234, which then beta decays to uranium Alpha and beta decay are ionizing radiations with the potential to damage surrounding materials. After alpha and beta decay, the resulting nuclei often emit high-energy photons called *gamma rays*. This process does not change the number of nucleons in the nucleus of the isotope but brings about a lower energy state in the nucleus.	-Types of radioactive decay -Beta vs. Alpha particles -Gamma rays -Writing/Completing Equations for nuclear reactions	**Given the balanced equation representing a nuclear reaction:** $^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{142}_{56}\mathrm{Ba} + ^{91}_{36}\mathrm{Kr} + 3\mathrm{X} + \text{energy}$ **Which particle is represented by X?** (1) $^{0}_{-1}\mathrm{e}$ (3) $^{4}_{2}\mathrm{He}$ (2) $^{1}_{1}\mathrm{H}$ (4) $^{1}_{0}\mathrm{n}$ ***From: NY Regents, Chemistry [2008]*** ***DOK Level: [2] Apply and Analyze*** **The loss of an alpha particle has what effect on the atomic number and mass number of an atom?** A Atomic number and mass number both decrease. B Atomic number increases; mass number decreases. C Atomic number decreases; mass number increases. D Atomic number and mass number both increase. ***From: North Carolina Testing Program, Physical Science*** ***DOK Level: [1] Recall and Reproduction***

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
11e. *Students know* alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.	Alpha, beta, and gamma rays are ionizing radiations, meaning that those rays produce tracks of ions of atoms and molecules when they interact with materials. For all three types of rays, the energies of particles emitted in radioactive decay are typically for each particle on the order of 1MeV, equal to 1.6×10^{-13} joule, which is enough energy to ionize as many as half a million atoms. Alpha particles have the shortest ranges, and matter that is only a few millimeters thick will stop them. They will not penetrate a thick sheet of paper but will deposit all their energy along a relatively short path, resulting in a high degree of ionization along that path. Beta particles have longer ranges, typically penetrating matter up to several centimeters thick. Those particles are electrons or positrons (the antimatter electron), have one unit of either negative or positive electric charge, and are approximately 1/2000 of the mass of a proton. These high-energy electrons have longer ranges than alpha particles and deposit their energy along longer paths, spreading the ionization over a greater distance in the material. Gamma rays can penetrate matter up to several meters thick. Gamma rays are high-energy photons that have no electric charge and no rest mass (the structural energy of the particle). They will travel unimpeded through materials until they	-Ionizing Radiation -Range -Penetration through different materials -Biological/Health risks -Geiger counter	**A serious risk factor associated with the operation of a nuclear power plant is the production of -** (1) acid rain (2) helium gas (3) greenhouse gases, such as CO2 (4) radioisotopes with long half-lives ***From: NY Regents, Chemistry [2008]*** ***DOK Level: [1] Recall and Reproduction*** **Consider this diagram:**  **Which of the three types of radiation will penetrate the paper and wood?** A alpha, beta, gamma B alpha and beta only C gamma only D beta only ***From: North Carolina EOC Assessments, Chemistry Goal 4*** ***DOK Level: [2] Apply and Analyze***

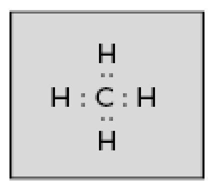
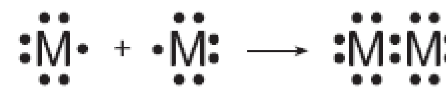
	strike an electron or the nucleus of an atom. The gamma ray's energy will then be either completely or partially absorbed and neighboring atoms will be ionized. Therefore, these three types of radiation interact with matter by losing energy and ionizing surrounding atoms. Alpha radiation is dangerous if ingested or inhaled. For example, radon-222, a noble gas element, is a naturally occurring hazard in some regions. Living organisms or sensitive materials can be protected from ionizing radiation by shielding them and increasing their distance from radiation sources. Because many people deeply fear and misunderstand radioactivity, chemistry teachers should address and explore the ability of each form of radiation to penetrate matter and cause damage. Students may be familiar with radon detection devices, similar to smoke detectors, found in many homes. Discussion of biological and health effects of ionizing radiation can inform students about the risks and benefits of nuclear reactions. Videos can be used in the classroom to show demonstrations of the penetrating ability of alpha, beta, and gamma radiation through paper, aluminum, and lead or through other dense substances of varying thicknesses. Geiger counter measurements can be used to record radiation data. The order of penetrating ability, from greatest to least, is gamma > beta > alpha, and this order is the basis for assessing proper shielding of radiation sources for safety. There are a number of naturally occurring sources of ionizing radiation. One is potassium-40, which can be detected easily in potash fertilizer by using		

	a Geiger counter. The other is background cosmic and alpha radiation from radon. This radiation can be seen in cloud chambers improvised in the classroom.		
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
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.	In the <u>localized electron model</u>, a covalent bond appears as a shared pair of electrons contained in a region of <u>overlap</u> between two <u>atomic orbitals</u>. Atoms (usually nonmetals) of similar electronegativities can form covalent bonds to become molecules. In a covalent bond, therefore, <u>bonding electron pairs</u> are localized in the region between the bonded atoms. In metals valence electrons are not localized to individual atoms but are free to move to temporarily occupy vacant orbitals on adjacent metal atoms. For this reason metals conduct electricity well. When an electron from an atom with low electronegativity (e.g., a metal) is removed by another atom with high electronegativity (e.g., a nonmetal), the two atoms become oppositely charged ions that attract each other, resulting in an ionic bond. Chemical bonds between atoms can be almost entirely covalent, almost entirely ionic, or in between these two extremes. The triple bond in nitrogen molecules (N2) is nearly 100 percent covalent. A salt such as sodium chloride (NaCl) has bonds that are nearly completely ionic. However, the electrons in gaseous hydrogen chloride are shared somewhat unevenly between the two atoms. This kind of bond is called polar covalent. (Note that elements in groups 1, 2, 16,	ORBITAL OVERLAP COVALENT BOND MOBILE ELECTRONS IN METALS ELECTROSTATIC ATTRACTION POLARITY OF A COVALENT BOND OCTET RULE UNEQUAL SHARING OF ELECTRONS	**When elements from group 1 (1A) combine with elements from group 17 (7A), they produce compounds. Which of the following the correct combining ratio is between group 1 (1A) elements and group 17 (7A) elements?** A. 1:1 B. 1:2 C. 2:1 D. 3:2 *From: Massachusetts MCAS Chemistry Test 2005* *DOK Level: [2] Analysis, Application* **The bonds in BaO are best described as-** (1) covalent, because valence electrons are shared (2) covalent, because valence electrons are transferred (3) ionic, because valence electrons are shared (4) ionic, because valence electrons are transferred *From: NY Regents Chemistry 2009* *DOK Level: [2] Analysis, Application* The strength of an atom's attraction for the electrons in a chemical bond is the atom's- (1) electronegativity (3) heat of reaction (2) ionization energy (4) heat of formation *From: NY Regents Chemistry 2003* *DOK Level: [1] Recall and Reproduction* **The chemical bond between which two atoms is most polar?**

	and 17 in the periodic table usually gain or lose electrons through the formation of either ionic or covalent bonds, resulting in eight outer shell electrons. This behavior is sometimes described as "the octet rule.")		(1) C–N (3) S–Cl (2) H–H (4) Si–O *From: NY Regents Chemistry 2009* *DOK Level: [2] Analysis, Application* **When cations and anions join, they form what kind of chemical bond?** A ionic B hydrogen C metallic D covalent From: CST Released Test Questions *DOK Level: [1] Recall & Reproduction*

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
2b. Students know chemical bonds between atoms in molecules such as H_2, CH_4, NH_3, H_2CCH_2, N_2, C_{l2}, and many large biological molecules are covalent.	Organic and biological molecules consist primarily of carbon, oxygen, hydrogen, and nitrogen. These elements share valence electrons to form bonds so that the outer electron energy levels of each atom are filled and have electron configurations like those of the nearest noble gas element. (Noble gases, or inert gases, are in the last column on the right of the periodic table.) For example, nitrogen has one lone pair and three unpaired electrons and therefore can form covalent bonds with three hydrogen atoms to make four electron pairs around the nitrogen. Carbon has four unpaired electrons and combines with hydrogen, nitrogen, and oxygen to form covalent bonds sharing electron pairs. The great variety of combinations of carbon, nitrogen, oxygen, and hydrogen make it possible, through covalent bond formation, to have many compounds from just these few elements. Teachers can use ball and stick or	ORGANIC MOLECULES VALENCE ELECTRONS ENERGY LEVELS ELECTRON CONFIGURATION NOBLE GASES INERT UNPAIRE ELECTRONS LONE PAIRS OF e^- BALL AND STICK MODELS	Which of the following atoms has six valence electrons? A magnesium (Mg) B silicon (Si) C sulfur (S) D argon (Ar) *From: CST Released Test Questions* *DOK Level: [1] Recall & Reproduction* **The diagram below shows the structure of a brain chemical called acetylcholine:**  **Based on the nature of the elements making up acetylcholine, the bonds present in the compound are most likely…** a. nuclear b. hydrogen c. metallic d. covalent *DOK Level: [2] Analyze, Application*

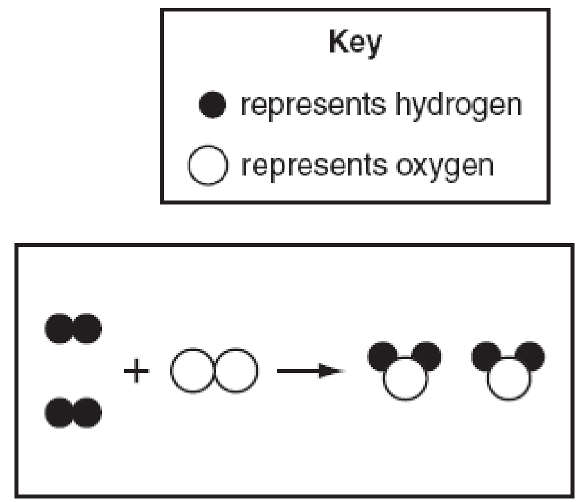
	gumdrop and toothpick models to explore possible bonding combinations.		
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
2c. Students know salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.	The energy that holds ionic compounds together, called lattice energy is caused by the electrostatic attraction of cations, which are positive ions, with anions, which are negative ions. To minimize their energy state, the ions form repeating patterns that reduce the distance between positive and negative ions and maximize the distance between ions of like charges.	CATIONS ANIONS CRYSTAL LATTICE IONIC COMPOUNDS LATTICE ENERGY SALT, NaCl	Which of the following elements can form an anion that contains 54 electrons, 74 neutrons, and 53 protons? (262) **Bh** 107 Bohrium 183.85 **W** 74 Tungsten a-b 126.905 **I** 53 Iodine c-d 131.29 **Xe** 54 Xenon *From: Massachusetts MCAS Chemistry Test 2005* *DOK Level: [2] Analysis, Application*
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.	In any substance at any temperature, the forces holding the material together are opposed by the internal energy of particle motion, which tends to break the substance apart. In a solid, internal agitation is insufficient to overcome intermolecular or inter-atomic forces. When enough energy is added to the solid, the kinetic energy of the atoms and molecules increases	PARTICLE MOTION LIQUIDS SOLIDS INTERMOLECULAR FORCES OF ATTRACTION [IMF]	**Which change in state would involve a decrease in the intermolecular force of attraction holding the water particles together?** (1) H2O(s) → H2O(□) (2) H2O(g) → H2O(s) (3) H2O(g) → H2O(l) (4) H2O(l) → H2O(s) *DOK Level: [2] Analysis, Application*

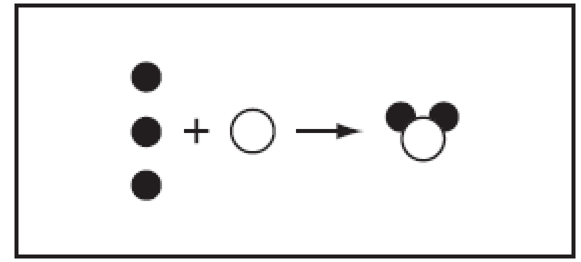
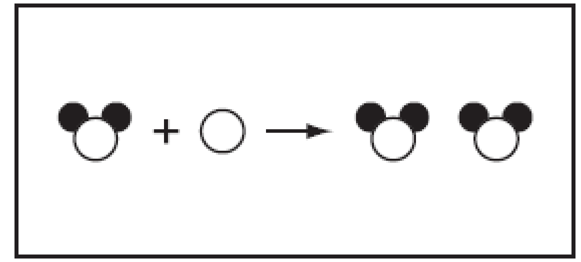
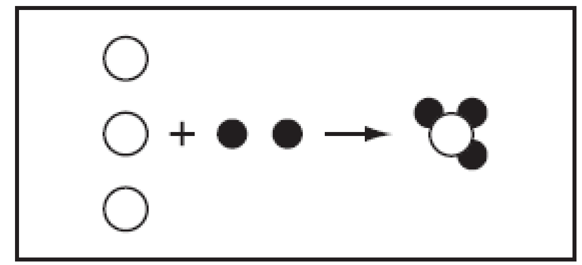
	sufficiently to overcome the attractive forces between the particles, and they break free of their fixed lattice positions. This change, called melting, forms a liquid, which is disordered and non-rigid. The particles in the liquid are free to move about randomly although they remain in contact with each other.	KINETIC ENERGY MELTING	
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
2e. Students know how to draw Lewis dot structures.	A Lewis dot structure shows how valence electrons and covalent bonds are arranged between atoms in a molecule. Teachers should follow the rules for drawing Lewis dot diagrams provided in chemistry textbook. Students should be able to use the periodic table to determine the number of valence electrons for each element in Groups 1 through 3 and 13 through 18. Carbon, for example, would have four valence electrons. Lewis dot diagrams represent each electron as a dot or an x placed around the symbol for carbon, which is C. A covalent bond is shown as a pair of dots, or x's, representing a pair of electrons. For example, a Lewis dot diagram for methane, which is CH4, would appear as shown in Figure 3.  **Fig. 3. Lewis Dot Diagram** Lewis dot diagrams provide a method for	LEWIS ELECTRON DOT STRUCTURE	The illustration below shows two atoms of a fictitious element (M) forming a diatomic molecule.  What type of bonding occurs between these two atoms? A. covalent B. ionic C. nuclear D. polar *From: Massachusetts MCAS Chemistry Test 2005* *DOK Level: [2] Analysis, Application*

	predicting correct combining ratios between atoms and for determining aspects of chemical bonds, such as whether they are covalent or consist of single, double, or triple bonds.		
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
3a. Students know how to describe chemical reactions by writing balanced equations.	Reactions are described by balanced equations because all the atoms of the reactants must be accounted for in the reaction products. An equation with all correct chemical formulas can be balanced by a number of methods, the simplest being by inspection. Given an unbalanced equation, students can do an inventory to determine how many of each atom are on each side of the equation. If the result is not equal for all atoms, coefficients (not subscripts) are changed until balance is achieved. Sometimes, reactions refer to substances with written names rather than to chemical symbols. Students should learn the rules of chemical nomenclature. This knowledge can be acquired in stages as new categories of functional groups are introduced.	CHEMICAL REACTIONS CHEMICAL EQUATIONS REACTANTS PRODUCTS NOMENCLATURE [RULES] CHEMICAL FORMULAS BALANCED EQUATIONS CHEMICAL SYMBOLS COEFFICIENTS SUBSCRIPTS	**Potassium carbonate (K_2CO_3) is an important component of fertilizer. The partially balanced equation for the reaction of 6 moles of potassium hydroxide (KOH) and 3 moles of carbon dioxide (CO_2) to produce potassium carbonate and water is given below.** $6KOH + 3CO_2 \rightarrow \_\_ K_2CO_3 + 3H_2O$ **When this equation is balanced, what is the coefficient for potassium carbonate?** A. 2 B. 3 C. 6 D. 9 *From: Massachusetts MCAS Chemistry Test 2005* *DOK Level: [2] Analysis, Application* **Aluminum reacts vigorously and 20 exothermically with copper(II) chloride. Which of the following is the balanced equation for this reaction?** A. Al + CuCl2 → AlCl3 + Cu B. Al + 3CuCl2 → 2AlCl3 + Cu C. 2Al + 3CuCl2 → 2AlCl3 + 3Cu D. 3Al + 2CuCl2 → 3AlCl3 + 2Cu *From: Massachusetts MCAS Chemistry Test 2005* *DOK Level: [2] Analysis, Application*

			In the formula X_2O_5, the symbol X could represent an element in Group- (1) 1 (2) 2 (3) 15 (4) 18 *From: NY Regents Chemistry 2009* *DOK Level: [3] Strategic Thinking*
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
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.	The mole concept is often difficult for students to understand at first, but they can be taught that the concept is convenient in chemistry just as a dozen is a convenient concept, or measurement unit, in the grocery store. The mole is a number. Specifically, a mole is defined as the number of atoms in 12 grams of carbon-12. When atomic masses were assigned to elements, the mass of 12 grams of carbon-12 was selected as a standard reference to which the masses of all other elements are compared. The number of atoms in 12 grams of carbon-12 is defined as one mole, or conversely, if one mole of 12C atoms were weighed, it would weigh exactly 12 grams. (Note that carbon, as found in nature, is a mixture of isotopes, including atoms of carbon-12, carbon-13, and trace amounts of carbon-14.) The definition of the mole refers to pure carbon-12. The atomic mass of an element is the weighted average of the mass of one mole of its atoms based on the abundance of all its naturally occurring isotopes. The atomic mass of carbon is 12.011 grams. If naturally occurring carbon is combined with oxygen to form carbon dioxide,	MOLE ISOTOPES ATOMIC MASS CARBON-12 MASS-MOLE RELATIONSHIP	**How many moles of carbon-12 are contained in exactly 6 grams of carbon-12?** A 0.5 mole B .20 moles C 3.01×10^{23} moles D 6.02×10^{23} moles From: CST Released Test Questions *DOK Level: [1] Recall & Reproduction*

	the mass of one mole of naturally occurring oxygen can be determined from the combining mass ratios of the two elements. For example, the weight, or atomic mass, of one mole of oxygen containing mostly oxygen-16 and a small amount of oxygen-18 is 15.999 grams.		
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
3c. *Students know* one mole equals 6.02×10^{23} particles (atoms or molecules).	A mole is a very large number. Standard 3.b describes the mole as the number of atoms in 12 grams of 12C. The number of atoms in a mole has been found experimentally to be about 6.02×10^{23}. This number, called Avogadro's number, is known to a high degree of accuracy.	6022 x 10^{23} AVOGADRO'S NUMBER	**How many molecules of water are in sample containing 6.00 moles of the compound?** A. 3.61 x 10^{23} molecules B. 3.61 x 10^{24} molecules C. 1.00 x 10^{23} molecules D. 1.00 x 10^{22} molecules *DOK Level: [2] Analyze, Apply*
3d. 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.	The molar mass of a compound, which is also called either the molecular mass or molecular weight, is the sum of the atomic masses of the constituent atoms of each element in the molecule. Molar mass is expressed in units of grams per mole. The periodic table is a useful reference for finding the atomic masses of each element. For example, one mole of carbon dioxide molecules contains one mole of carbon atoms weighing 12.011 grams and two moles of oxygen atoms weighing 2 × 15.999 grams for a total molecular mass of 44.009 grams per mole of carbon dioxide molecules. The mass of a sample of a compound can be converted to moles by dividing its mass by the molar mass of the compound. This process is similar to the unit conversion discussed in the introduction to Standard Set 3. The number of	MOLAR MASS CONSTITUENT ELEMENTS CONVERSIONS [MOLE-MASS-PARTICLES]	**How many moles are in 59.6 grams of BaSO4?** A 0.256 mole B 3.91 moles C 13.9 moles D 59.6 moles *From: North Carolina End-of-Course Assessments Chemistry* *DOK Level: [2] Analyze, Apply* **How many molecules are contained in 55.0 g of H_2SO_4?** A 0.561 molecule B 3.93 molecules C 3.38 x 10^{23} molecules D 2.37 x 10^{24} molecules *From: North Carolina End-of-Course Assessments Chemistry* *DOK Level: [2] Analyze, Apply* **How many moles of chlorine are in 100 g chlorine (Cl)?** __Element__ __Molar Mass (g/mol)__ Hydrogen 1.01 Carbon 12.01

	particles in the sample is determined by multiplying the number of moles by Avogadro's number. The volume of an ideal or a nearly ideal gas at a fixed temperature and pressure is proportional to the number of moles. Students should be able to calculate the number of moles of a gas from its volume by using the relationship that at standard temperature and pressure (0°C and 1 atmosphere), one mole of gas occupies a volume of 22.4 liters.*		Chlorine 35.45 a. 64.6 b. 2.82 c. 100 d. 0.355 *From : www.chemistrymc.com/standardized_test*
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
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.	Atoms are neither created nor destroyed in a chemical reaction. When the chemical reaction is written as a balanced expression, it is possible to calculate the mass of any one of the products or of any one of the reactants if the mass of just one reactant or product is known. Students can be taught how to use balanced chemical equations to predict the mass of any product or reactant. Teachers should emphasize that the coefficients in the balanced chemical equation are mole quantities, not masses. Here is an example: How many grams of water will be obtained by combining 5.0 grams of hydrogen gas with an excess of oxygen gas, according to the following balanced equation? $$2H_2 + O_2 \rightarrow 2H_2O$$ This calculation is often set up algebraically, for example, as and can be easily completed by direct	CHEMICAL REACTIONS REACTANTS PRODUCTS LAW OF CONSERVATION OF MASS BALANCED EQUATION MOLES COEFFICIENTS MOLE-MASS RELATIONSHIP DIMENSIONAL ANALYSIS	**Which model demonstrates the Law of Conservation of Matter?** A. 

	calculation and unit cancellation (dimensional analysis). Students should learn to recognize that the coefficients in the balanced equations refer to moles rather than to mass.		B.  C.  D.  *From: New England Common Assessments 2008* *DOK Level: [2] Apply, Analyze* ***$Zn + 2HCl \rightarrow ZnCl_2 + H_2$*** **If 0.600 gram of zinc is used, what is the amount of zinc chloride that is produced in the above reaction?** F 0.125 gram G 1.25 grams H 12.5 grams J .018 gram ***From: Virginia SOL Chemistry, 2001*** ***DOK Level: [2] Apply and Analyze***

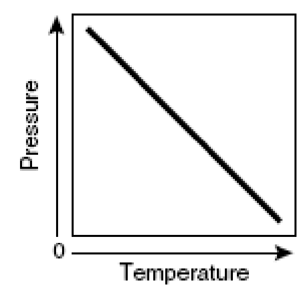
Subject Area Assessment Guides, Sem. 2
Chemistry
States of Matter, Gases, Solutions, Thermochemistry, Energy and Chemical Change, Reaction Rates and Chemical Equilibrium, Acids and Bases, Organic Chemistry, Electrochemistry

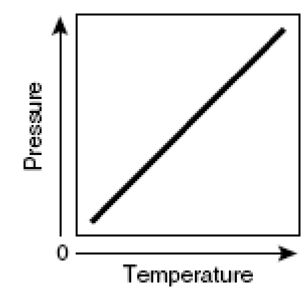
California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
4a. *Students know* the random motion of molecules and their collisions with a surface create the observable pressure on that surface.	Fluids consist of molecules that freely move past each other in random directions. Intermolecular forces hold the atoms or molecules in liquids close to each other. Gases consist of tiny particles, either atoms or molecules, spaced far apart from each other and reasonably free to move at high speeds, near the speed of sound. In the study of chemistry, gases and liquids are considered fluids. Pressure is defined as force per unit area. The force in fluids comes from collisions of atoms or molecules with the walls of the container. Air pressure is created by the weight of the gas in the atmosphere striking surfaces. Gravity pulls air molecules toward Earth, the surface that they strike. Water pressure can be understood in the same fashion, but the pressures are much greater because of the greater density of water. Pressure in water increases with depth, and pressure in air decreases with altitude. However, pressure is felt equally in all directions in fluids because of the random motion of the molecules.	FLUID INTERMOLECULAR FORCES GAS SPEED OF SOUND PRESSURE [f/a] COLLISIONS	
4b. *Students know* the random motion of molecules explains the diffusion of gases.	Another result of the kinetic molecular theory is that gases diffuse into each other to form homogeneous mixtures. An excellent demonstration of diffusion is the white ammonium chloride ring formed by simultaneous diffusion of ammonia vapor and hydrogen chloride gas toward the middle of a glass tube. The white ring forms nearer the region where hydrogen chloride was introduced, illustrating both diffusion and the principle that heavier gases have a slower rate of diffusion.	KINETIC MOLECULAR THEORY OF MATTER DIFFUSION	**Methane (CH4) gas diffuses through air because the molecules are-** A moving randomly. B dissolving quickly. C traveling slowly. D expanding steadily. ***From: CST Released Test Questions 2008*** ***DOK Level: [1] Recall & Reproduction***

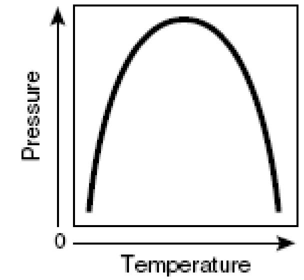
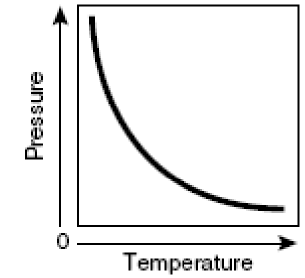
<table>
<tr><th>California Content Standards</th><th>What the Science Frameworks states…</th><th>Key Ideas + Vocabulary*</th><th>Sample Test Item</th></tr>
<tr>
<td>4c. Students know how to apply the gas laws to relations between the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.</td>
<td>A fixed number of moles n of gas can have different values for pressure P, volume V, and temperature T. Relationships among these properties are defined for an ideal gas and can be used to predict the effects of changing one or more of these properties and solving for unknown quantities. Students should know and be able to use the three gas law relationships summarized in Table 1, "Gas Law Relationships."

Table 1
Gas Law Relationships
<table>
<tr><th>Expression of gas laws</th><th>Fixed values</th><th>Variable relationships</th><th>Form for calculations</th></tr>
<tr><td>PV = constant</td><td>n, T</td><td>Inverse</td><td>$P_1V_1 = P_2V_2$</td></tr>
<tr><td>V/T = constant</td><td>n, P</td><td>Direct</td><td>$V_1/T_1 = V_2/T_2$</td></tr>
<tr><td>P/T = constant</td><td>n, V</td><td>Direct</td><td>$P_1/T_1 = P_2/T_2$</td></tr>
</table>

The first expression of the gas law shown in Table 1 is sometimes taught as Boyle's law and the second as Charles's law, according to the historical order of their discovery. They are both simpler cases of the more general ideal gas law introduced in Standard 4.h in this section. For a fixed number of moles of gas, a combined gas law has the form PV/T = constant, or P1V1/T1= P2V2/T2. This law is useful in calculations where P, V, and T are changing. By placing a balloon over the mouth of an Erlenmeyer flask, the teacher can demonstrate that volume divided by temperature equals a constant. When the flask is heated, the balloon inflates; when the flask is cooled, the balloon deflates.</td>
<td>GAS LAWS
IDEAL GAS LAW
[PV=nRT]
BOYLE'S LAW
CHARLE'S LAW
GAY-LUSSAC'S LAW
COMBINED GAS LAW</td>
<td>$R = 8.31 \frac{\text{kPa} \cdot \text{dm}^3}{\text{moles} \cdot \text{K}}$

A gas cylinder is filled with 4.00 moles of oxygen gas at 300.0 K. The piston is compressed to yield a pressure of 400.0 kPa. What is the volume inside the cylinder?
A 3.19 dm^3 B 6.25 dm^3
C 24.9 dm^3 D 31.5 dm^3
From: Virginia SOL [Chemistry] 2001
DOK LEVEL: [2] Apply, Analyze
At a constant volume, the pressure of a gas will increase as the temperature increases. Which of the following graphs shows that relationship?
F 

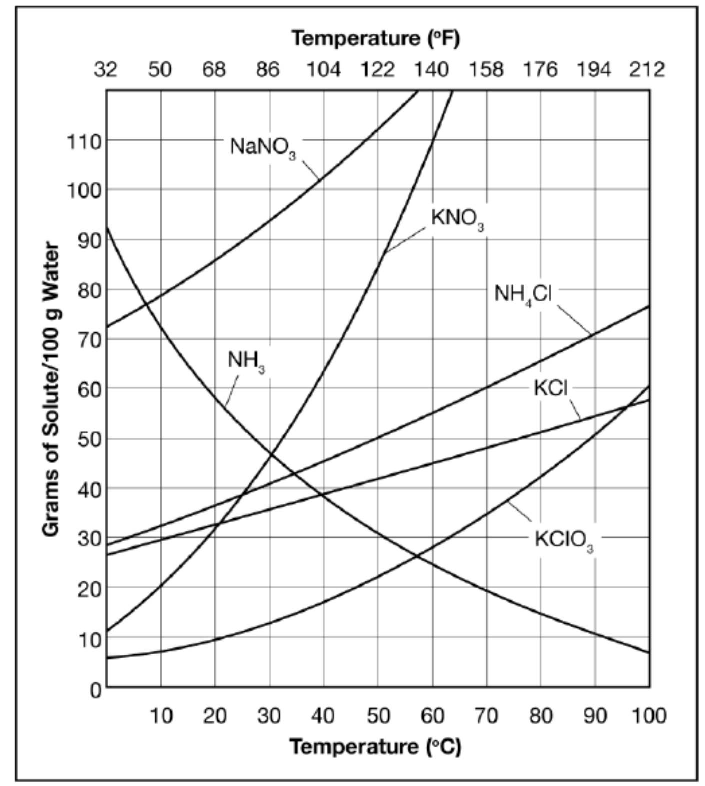
G 
</td>
</tr>
</table>

			H  J  ***From: Virginia SOL Chemistry 2001*** ***DOK Level: [2] Apply, Analyze***

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
4d. *Students know* the values and meanings of standard temperature and pressure (STP).	Standard temperature is 0°C, and standard pressure (STP) is 1 atmosphere (760 mm Hg). These standards are an agreed-on set of conditions for gases against which to consider other temperatures and pressures. When volumes of gases are being compared, the temperature and pressure must be specified. For a fixed mass of gas at a specified temperature and pressure, the volume is also fixed.	STP [1 atm and 0°C] At STP, 1 mole of gas = 22.4L [volume]	**A sample of oxygen gas is sealed in container X. A sample of hydrogen gas is sealed in container Z. Both samples have the same volume, temperature, and pressure. Which statement is true?** (1) Container X contains more gas molecules than container Z. (2) Container X contains fewer gas molecules than container Z. (3) Containers X and Z both contain the same number of gas molecules. (4) Containers X and Z both contain the same mass of gas. *From: NY Regents Chemistry, 2005* *DOK Level: [1] Recall and Reproduction*

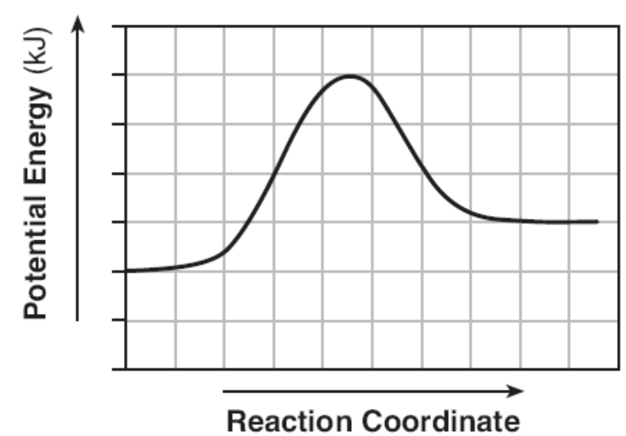
California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
4e. Students know how to convert between the Celsius and Kelvin temperature scales.	Some chemical calculations require an absolute temperature scale, called the Kelvin scale (K), for which the coldest possible temperature is equal to zero. There are no negative temperatures on the Kelvin scale. In theory if a sample of any material is cooled as much as possible, the lowest temperature that can be reached is 0 K, experimentally determined as equivalent to −273.15°C. The Kelvin scale starts with absolute zero (0 K) because of this theoretical lowest temperature limit. A Kelvin temperature is always 273.15 degrees greater than an equivalent Celsius temperature, but a Kelvin temperature is specified without the degree symbol. The magnitude of one unit of change in the K scale is equal to the magnitude of one unit of change on the °C scale.	Celsius Scale Kelvin Scale	**What is the equivalent of 423 kelvin in degrees Celsius?** A −223 ºC B −23 ºC C 150 ºC D 696 ºC ***From: CST Released Test Questions 2008*** ***DOK Level: [1] Recall & Reproduction***
4f. *Students know* there is no temperature lower than 0 Kelvin.	The kinetic molecular theory is the basis for understanding heat and temperature. The greater the atomic and molecular motion, the greater the observed temperature of a substance. If all atomic and molecular motion stopped, the temperature of the material would reach an absolute minimum. This minimum is absolute zero, or −273.15°C. The third law of thermodynamics states that this temperature can never be reached. Experimental efforts to create very low temperatures have resulted in lowering the temperature of objects to within a fraction of a degree of absolute zero.	Absolute Zero -273.15ºC	**Theoretically, when an ideal gas in a closed container cools, the pressure will drop steadily until the pressure inside is essentially that of a vacuum. At what temperature should this occur?** A 0ºC B −460 ºC C −273 K D 0 K ***From: CST Released Test Questions 2008*** ***DOK Level: [1] Recall & Reproduction***

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
6a. Students know the definitions of solute and solvent.	Simple solutions are homogeneous mixtures of two substances. A solute is the dissolved substance in a solution, and a solvent is, by quantity, the major component in the solution.	HOMOGENEOUS VS. HETEROGENEOUS SOLUTIONS SOLUTE SOLVENT	**An aqueous solution of sodium chloride is best classified as a-** (1) homogeneous compound (2) homogeneous mixture (3) heterogeneous compound (4) heterogeneous mixture ***From: NY Regents Chemistry, 2005*** ***DOK Level: [1] Recall and Reproduction*** **Soda water is a solution of carbon dioxide in water. This solution is composed of a —** F gaseous solute in a gaseous solvent G liquid solute in a liquid solvent H gaseous solute in a liquid solvent J liquid solute in a gaseous solvent ***From: Virginia SOL Chemistry, 2001*** ***DOK Level: [1] Recall and Reproduction***
6b. Students know how to describe the dissolving process at the molecular level by using the concept of random molecular motion.	The kinetic molecular theory as applied to gases can be extended to explain how the solute and solvent particles are in constant random motion. The kinetic energy of this motion causes diffusion of the solute into the solvent, resulting in a homogeneous solution. When a solid is in contact with a liquid, at least some small degree of dissolution always occurs. The equilibrium concentration of solute in solvent will depend on the surface interactions between the molecules of solute and solvent. Equilibrium is reached when all competing processes are in balance. Those processes include the tendency for dissolved molecules to spread randomly in	DISSOLUTION PROCESS DIFFUSION KINETIC ENERGY EQUILIBRIUM SURFACE INTERACTIONS	**If the attractive forces among solid particles are less than the attractive forces between the solid and a liquid, the solid will-** **A** probably form a new precipitate as its crystal lattice is broken and re-formed. **B** be unaffected because attractive forces within the crystal lattice are too strong for the dissolution to occur. **C** begin the process of melting to form a liquid. **D** dissolve as particles are pulled away from the crystal lattice by the liquid molecules. ***From: CST Released Test Questions***

	the solvent and the competing strength of the bonds and other forces among solute molecules, among solvent molecules, and between solute and solvent molecules. When salts dissolve in water, positive and negative ions are separated and surrounded by polar water molecules.		***DOK Level: [1] Recall and Reproduction***
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
6c. Students know temperature, pressure, and surface area affect the dissolving process.	In a liquid solvent, solubility of gases and solids is a function of temperature. Students should have experience with reactions in which precipitates are formed or gases are released from solution, and they should be taught that the concentration of a substance that appears as solid or gas must exceed the solubility of the solvent. Increasing the temperature usually increases the solubility of solid solutes but always decreases the solubility of gaseous solutes. An example of a solid ionic solute compound that decreases in solubility as the temperature increases is Na_2SO_4. An example of one that increases in solubility as the temperature increases is $NaNO_3$. The solubility of a gas in a liquid is directly proportional to the pressure of that gas above the solution. It is important to distinguish solubility equilibrium from rates of dissolution. Concepts of equilibrium describe only how much solute will dissolve at equilibrium, not how quickly this process will occur.	SOLUBILITY CURVES FACTORS INFLUENCING SOLUBILITY TEMPERATURE Na_2SO_4. [solubility decreases with temperature] SOLUBILITY EQULIBRIUM vs. RATES OF DISSOLUTION	Use the solubility curves in the graph below to answer the following question…  Solubility Curves

			Which conclusion is supported by the information provided in the graph? A At 50ºC, KNO3 is approximately twice as soluble as KCl. B At 50ºC, NH4Cl is approximately twice as soluble as NH3. C At 20ºC, the maximum amount of KClO3 that can dissolve in 100 grams of water is 20 grams. D At 20ºC, the maximum amount of NaNO3 that can dissolve in 100 grams of water is 45 grams. *From: Pennsylvania Science Tests, Grade 11 [2006]* *DOK Level: [2] Apply, Analyze*
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
6d. Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.	All concentration units listed previously are a measure of the amount of solute compared with the amount of solution. Grams per liter represent the mass of solute divided by the volume of solution. Molarity describes moles of solute divided by liters of solution. Students can calculate the number of moles of dissolved solute and divide by the volume in liters of the total solution, yielding units of moles per liter. Parts per million, which is a ratio of one part of solute to one million parts of solvent, is usually applied to very dilute solutions. Percent composition is the ratio of one part of solvent to one hundred parts of solvent and is expressed as a percent. To calculate parts per million and percent composition, students determine the mass of solvent and solute and then divide the mass of the solute by the total mass of the solution. This number is then multiplied by 10^6 and expressed as parts per million (ppm) or by 100 and expressed as a percent.	CONCENTRATIONS OF SOLUTIONS MOLARITY PPM [parts per million] PERCENT COMPOSITION	**What is the total number of moles of NaCl(s) needed to make 3.0 liters of a 2.0 M NaCl solution?** (1) 1.0 mol (3) 6.0 mol (2) 0.70 mol (4) 8.0 mol *From: NY Regents, Chemistry 2005* *DOK Level: [2] Apply and Analyze* **A student wants to prepare a 1.0-liter solution of a specific molarity. The student determines that the mass of the solute needs to be 30. grams. What is the proper procedure to follow?** (1) Add 30. g of solute to 1.0 L of solvent. (2) Add 30. g of solute to 970. mL of solvent to make 1.0 L of solution. (3) Add 1000. g of solvent to 30. g of solute. (4) Add enough solvent to 30. g of solute to make 1.0 L of solution. *From: NY Regents, Chemistry 2005* *DOK Level: [2] Apply and Analyze*

			What is the molarity of a solution prepared by dissolving 27.2 g of sodium chloride in enough water to prepare 500.0 mL of solution? F 0.186 M G 0.465 M H 0.930 M J 1.860 M *From: Virginia SOL Chemistry, 2001* *DOK Level: [2] Apply and Analyze*

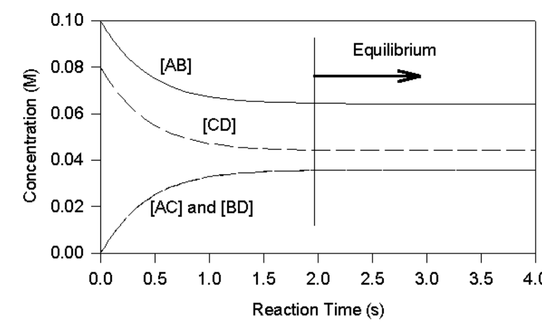
California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
7a. *Students know* how to describe temperature and heat flow in terms of the motion of molecules (or atoms).	*Temperature* is a measure of the average kinetic energy of molecular motion in a sample. *Heat* is energy transferred from a sample at higher temperature to one at lower temperature. Often, heat is described as flowing from the system to the surroundings or from the surroundings to the system. The system is defined by its boundaries, and the surroundings are outside the boundaries, with "the universe" frequently considered as the surroundings.	-Temperature vs. Heat -Heat flow -System and boundaries -Units: Calorie/Joule	**The random molecular motion of a substance is greatest when the substance is-** A condensed. B a liquid. C frozen. D a gas. ***From: CST Released Test Questions, 2008*** ***DOK Level: 1 [Recall and Reproduction]***
7b. Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.	Endothermic processes absorb heat, and their equations can be written with heat as a reactant. Exothermic processes release heat, and their equations can be written with heat as a product. The net heat released to or absorbed from the surroundings comes from the making and breaking of chemical bonds during a reaction. Students understand and relate heat to the internal motion of the atoms and molecules. They also understand that breaking a bond always requires energy and that making a bond almost always releases energy. The amount of energy per bond depends on the strength of the bond. The potential energy of the reaction system may be plotted for the different reaction stages: reactants, transition states, and products. This plot will show	-Endothermic vs. Exothermic -Chemical bonds -Potential energy -Energy Diagrams	The potential energy diagram for a chemical reaction is shown below. 

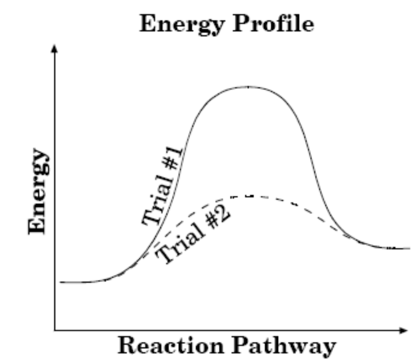
	reactants at lower potential energy than products for an endothermic reaction and reactants at higher potential energy than products for an exothermic reaction. A higher energy transition state usually exists between the reactant and product energy states that affect the reaction rate covered in Standard Set 8, "Reaction Rates," in this section.		Each interval on the axis labeled "Potential Energy (kJ)" represents 40 kilojoules. How much energy was released or absorbed? (1) −120 kJ (3) +40 kJ (2) −40 kJ (4) +160 kJ ***From: NY Regents, Chemistry [2008]*** ***DOK Level: [2] Analyze, Apply*** **The reaction of CaO and water is exothermic. A student mixes the two chemicals in a test tube and touches the side of the test tube. Which statement describes the student's observation?** A The test tube becomes hot as heat is released. B The test tube becomes hot as heat is absorbed. C The test tube becomes cold as heat is released. D The test tube becomes cold as heat is absorbed. *From: North Carolina Testing Program, Physical Science* *DOK Level: [2] Analyze, Apply*
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
7c. Students know energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.	Physical changes are accompanied by changes in internal energy. Changes of physical state either absorb or release heat. Evaporation and melting require energy to overcome the bonds of attractions in the corresponding liquid or solid state. Condensation and freezing release heat to the surroundings as internal energy is reduced and bonds of attraction are formed.	-Physical Changes -Melting -Condensation -Vaporization -Internal energy -Heat Curve	**The boiling point of liquid nitrogen is 77 Kelvin. It is observed that ice forms at the opening of a container of liquid nitrogen. The best explanation for this observation is-** A water at zero degrees Celsius is colder than liquid nitrogen and freezes. B the nitrogen boils and then cools to form a solid at the opening of the container.

			C water trapped in the liquid nitrogen escapes and freezes. D the water vapor in the air over the opening of the liquid nitrogen freezes out. ***From: CST Released Test Questions, 2008*** ***DOK Level: 2- Analysis, Application***
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
7d. Students know how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.	Qualitative knowledge that students gained by mastering the previous standards will help them to solve problems related to the heating or cooling of a substance over a given temperature range. Specific heat is the energy needed to change the temperature of one gram of substance by one degree Celsius. The unit of specific heat is joule/gram-degree. During phase changes, energy is added or removed without a corresponding temperature change. This phenomenon is called latent (or hidden) heat. There is a latent heat of fusion and a latent heat of vaporization. The unit of latent heat is joule/gram or kilojoule/mole. Students should be able to diagram the temperature changes that occur when ice at a temperature below zero is heated to superheated steam, which has temperatures above 100°C.	-Mole -Specific heat -Joule/gram-degree -Latent heat -Heat of fusion -Heat of vaporization -$Q = mc\Delta T$	Study the table below: **Cube Information** Beaker 1, Cube X, aluminum, Mass 10 g, Density 2.7 g/cm^3, Specific Heat 0.90 joules/g • °C Beaker 2, Cube Y, iron, Mass 10 g, Density 7.9 g/cm^3, Specific Heat 0.45 joules/g • °C Two cubes were heated in an oven until each cube reached 250 degrees Celsius (482ºF). The cubes were immediately placed in beakers that contained 50 mL of room-temperature water; cube X was placed in beaker 1 and cube Y was placed in beaker 2. The maximum temperature of the water in each beaker was recorded. Which statement correctly describes the temperature of the water in the beakers? A The temperature of the water in each beaker will increase at the same rate. B The temperature of the water in each beaker will increase the same amount. C The temperature of the water in beaker 1 will increase more than the temperature of the water in beaker 2. *

Cube Information

Beaker	Cube	Material	Mass (g)	Density (g/cm^3)	Specific Heat (joules/g • °C)
1	X	aluminum	10	2.7	0.90
2	Y	iron	10	7.9	0.45

			D The temperature of the water in beaker 2 will increase more than the temperature of the water in beaker 1. ***From: Pennsylvania School of Assessment, Chemistry*** ***DOK Level: [2] Apply and Analyze***
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
8a. Students know the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.	Students may have an intuitive idea that reaction rate is a measure of how fast reactions proceed, but a quantitative measure for reaction rate also is needed. For example, explosive reactions are very fast, as are many biological reactions in the cell; and other reactions, such as iron rusting, are very slow. Reaction rate is defined as the rate of decrease in concentration of reactants or as the rate of increase in concentration of products, and these reciprocal changes form a balanced equation that reflects the conservation of matter. Students can see from the balanced equation that as the reaction proceeds, the concentration of reactants must decrease, and the concentration of products must increase in proportion to their mole ratios.	-Reaction Rate	**The graph below describes the changes in the concentrations of a pair of compounds reacting to form a pair of products:**  **The reactants in the reaction under consideration must be…** a. AB and CD b. AB and AC c. AC and BD d. BD and CD ***From: Unknown Source*** ***DOK Level: [2] Analyze, Apply***

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
8b. Students know how reaction rates depend on such factors as concentration, temperature, and pressure.	Concentration, temperature, and pressure should be emphasized because they are major factors affecting the collision of reactant molecules and, thus, affecting reaction rates. Increasing the concentration of reactants increases the number of collisions per unit time. Increasing temperature (which increases the average kinetic energy of molecules) also increases the number of collisions per unit time. Though the collision rate modestly increases, the greater kinetic energy dramatically increases the chances of each collision leading to a reaction (e.g., the Arrhenius effect). Increasing pressure increases the reaction rate only when one or more of the reactants or products are gases. With gaseous reactants, increasing pressure is the same as increasing concentration and results in an elevated reaction rate.	-CONCENTRATION -TEMPERATURE -PRESSURE -COLLISION THEORY -KINETIC ENERGY -EFFECTIVE COLLISIONS	$C_6H_6 + Br_2 \xrightarrow{\text{catalyst}} C_6H_5Br + HBr$ **Which of the following changes will cause an increase in the rate of the above reaction?** A increasing the concentration of Br_2 B decreasing the concentration of C_6H_6 C increasing the concentration of HBr D decreasing the temperature ***From: CST Released Test Questions 2008*** ***DOK Level: [2] Analyze, Apply***
8c. Students know the role a catalyst plays in increasing the reaction rate.	A catalyst increases the rate of a chemical reaction without taking part in the net reaction. A catalyst lowers the energy barrier between reactants and products by promoting a more favorable pathway for the reaction. Surfaces often play important roles as catalysts for many reactions. One reactant might be temporarily held on the surface of a catalyst. There the bonds of the reactant may be weakened, allowing another substance to react with it more quickly. Living systems speed up life-dependent reactions with biological catalysts called enzymes. Catalysts are used in automobile exhaust systems to reduce the emission of smog-producing unburned hydrocarbons.	-CATALYST -ENZYMES -LOWERING OF ACTIVATION ENERGY -LOCK AND KEY MODEL OF ENZYMATIC ACTION	**This graph represents the change in energy for two laboratory trials of the same reaction:** 

			Which factor could explain the energy difference between the trials? A. Heat was added to trial #2. B. A catalyst was added to trial #2. C. Trial #1 was stirred. D. Trial #1 was cooled. ***From: North Carolina EOC Assessments, Chemistry Goal 4*** ***DOK Level: [2] Analysis, Application***
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
9a. Students know how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature, and pressure.	Le Chatelier's principle can be introduced by emphasizing the balanced nature of an equilibrium system. If an equilibrium system is stressed or disturbed, the system will respond (change or shift) to partially relieve or undo the stress. A new equilibrium will eventually be established with a new set of conditions. When the stress is applied, the reaction is no longer at equilibrium and will shift to regain equilibrium. For instance, if the concentration of a reactant in a system in dynamic equilibrium is decreased, products will be consumed to produce more of that reactant. Students need to remember that heat is a reactant in endothermic reactions and a product in exothermic reactions. Therefore, increasing temperature will shift an endothermic reaction, for example, to the right to regain equilibrium. Students should note that any endothermic chemical reaction is exothermic in the reverse direction. Pressure is proportional to concentration for gases; therefore, for chemical reactions that have a gaseous product or reactant, pressure affects the system as a whole. Increased pressure shifts the equilibrium toward	-Le Chatelier's Principle -Equilibrium -Reversible Equations -Stress -Shift -Dynamic Equilibrium -Forward vs. Reverse Reactions	**When silver nitrate solution is added to salt water, a reaction occurs and a milky white precipitate forms. Which statement correctly describes how the rate of this reaction can be influenced?** A. An increase in the temperature of the salt water will increase the frequency and energy of collisions. B A decrease in the temperature of the silver nitrate will increase the frequency and energy of collisions. C An increase in the volume of salt water will increase the frequency and energy of collisions. D A decrease in the volume of silver nitrate will increase the frequency and energy of collisions. ***From: Pennsylvania School of Assessments, Chemistry 2007*** ***DOK Level: [2] Apply and Analyze***

	the smaller number of moles of gas, alleviating the pressure stress. If both sides of the equilibrium have an equal number of moles of gas, increasing pressure does not affect the equilibrium. Adding an inert gas, such as argon, to a reaction will not change the partial pressures of the reactant or product gases and therefore will have no effect on the equilibrium.		
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
9b. Students know equilibrium is established when forward and reverse reaction rates are equal.	Forward and reverse reactions at equilibrium are going on at the same time and at the same rate, causing overall concentrations of each reactant and product to remain constant over time.	-Forward vs. Reverse Reactions	**In a sealed bottle that is half full of water, equilibrium will be attained when water molecules-** A cease to evaporate. B begin to condense. C are equal in number for both the liquid and the gas phase. D evaporate and condense at equal rates. ***From: CST Released Test Questions 2008*** ***DOK Level: [1] Recall and Reproduction***
5a. a. Students know the observable properties of acids, bases, and salt solutions.	Comparing and contrasting the properties of acids and bases provide a context for understanding their behavior. Some observable properties of acids are that they taste sour; change the color of litmus paper from blue to red; indicate acidic values on universal indicator paper; react with certain metals to produce hydrogen gas; and react with metal hydroxides, or bases, to produce water and a salt. Some observable properties of bases are that basic substances taste bitter or feel slippery; change the color of litmus paper from red to blue; indicate basic values on universal indicator paper; and react with many compounds containing hydrogen ions, or acids, to produce water and a salt. These properties can be effectively demonstrated by using	ACIDS vs. BASES LITMUS PAPER INDICATORS HYDROGEN IONS	**How are HNO3(aq) and CH3COOH(aq) similar?** (1) They are Arrhenius acids and they turn blue litmus red. (2) They are Arrhenius acids and they turn red litmus blue. (3) They are Arrhenius bases and they turn blue litmus red. (4) They are Arrhenius bases and they turn red litmus blue. ***From: NY Regents Chemistry, 2005*** ***DOK Level: [2] Apply, Analyze***

	extracted pigment from red cabbage as an indicator to analyze solutions of household ammonia and white vinegar at various concentrations. When the indicator is added, basic solutions turn green, and acidic solutions turn red. Students can also use universal indicator solutions to test common household substances. ***Students need to follow established safety procedures while conducting experiments.***		
California Content Standards	**What the Science Frameworks states…**	**Key Ideas + Vocabulary***	**Sample Test Item**
5b. Students know acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.	According to the Brønsted-Lowry acid–base definition, acids donate hydrogen ions, and bases accept hydrogen ions. Acids that are formed from the nonmetals found in the first and second rows of the periodic table easily dissociate to produce hydrogen ions because these nonmetals have a large electronegativity compared with that of hydrogen. Once students know that acids and bases have different effects on the same indicator, they are ready to deepen their understanding of acid– base behavior at the molecular level. Examples and studies of chemical reactions should be used to demonstrate these definitions of acids and bases.	BRONSTED-LOWRY DEFINITION OF ACIDS AND BASES HYDROGEN DONOR HYDROGEN ACCEPTOR ELECTRONEGATIVITY	**One acid-base theory states that an acid is-** (1) an electron donor (3) an H+ donor (2) a neutron donor (4) an OH– donor *From: NY Regents Chemistry, 2005* *DOK Level: [1] Recall and Reproduction* **A hydrogen ion, H+, in aqueous solution may also be written as-** (1) H_2O (3) H_3O+ (2) H_2O_2 (4) OH– *From: NY Regents Chemistry, 2005* *DOK Level: [1] Recall and Reproduction*

<table>
<tr><th>California Content Standards</th><th>What the Science Frameworks states…</th><th>Key Ideas + Vocabulary*</th><th>Sample Test Item</th></tr>
<tr>
<td>5c. Students know strong acids and bases fully dissociate and weak acids and bases partially dissociate.</td>
<td>Acids dissociate by donating hydrogen ions, and bases ionize by dissociating to form hydroxide ions (from a hydroxide salt) or by accepting hydrogen ions. Some acids and bases either dissociate or ionize almost completely, and others do so only partially. Nearly complete dissociation is strong; partial dissociation is weak. The strength of an acid or a base can vary, depending on such conditions as temperature and concentration.</td>
<td>DISSOCIATION
WEAK vs. STRONG
PARTIAL DISSOCIATION
TEMPERATURE
CONCENTRATION</td>
<td>Potassium hydroxide (KOH) is a strong base because it -
A easily releases hydroxide ions.
B does not dissolve in water.
C reacts to form salt crystals in water.
D does not conduct an electric current.

From: CST Released Test Questions 2008
DOK Level: [1] Recall & Reproduction</td>
</tr>
<tr>
<td>5d. Students know how to use the pH scale to characterize acid and base solutions.</td>
<td>The pH scale measures the concentrations of hydrogen ions in solution and the acidic or basic nature of the solution. The scale is not linear but logarithmic, meaning that at pH 2, for example, the concentration of hydrogen ions is ten times greater than it is at pH 3. The pH scale ranges from below 0 (very acidic) to above 14 (very basic). Students should learn that pH values less than 7 are considered acidic and those greater than 7 are considered basic.</td>
<td>pH SCALE
NEUTRALITY
LOGARITHMIC SCALE
$[H^+]$ ION CONCENTRATION</td>
<td>Study the table below:
<table>
<tr><th>pH</th><th>1-6</th><th>7</th><th>8-14</th></tr>
<tr><td>Solution added</td><td>Acid</td><td>Neutral</td><td>Base</td></tr>
<tr><td>Litmus paper changes from</td><td>Blue to red</td><td>Does not change</td><td>Red to blue</td></tr>
</table>
Which of the following aqueous solutions will cause litmus paper to turn red?
F NaOH G NaCl
H HCl J H2O
From: Virginia SOL Chemistry, 2001
DOK Level: [2] Apply and Analyze</td>
</tr>
</table>

California Content Standards	What the Science Frameworks states…	Key Ideas + Vocabulary*	Sample Test Item
10a. *Students know* large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.	Students can readily visualize large molecules called polymers as consisting of repetitive and systematic combinations of smaller, simpler groups of atoms, including carbon. All polymeric molecules, including biological molecules, such as proteins, nucleic acids, and starch, are made up of various unique combinations of a relatively small number of chemically simple subunits. For example, starch is a polymer made from a large number of simple sugar molecules joined together.	-Polymers -Carbon -Monomers -Proteins -Carbohydrates -Lipids/Fats -Nucleic Acids	**The reaction that joins thousands of small, identical molecules to form one very long molecule is called-** (1) esterification (3) polymerization (2) fermentation (4) substitution ***From: NY Regents, Chemistry [2008]*** ***DOK Level: [1] Recall and Reproduction***
10b. 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.	Building on what they learned in grade eight about the unique bonding characteristics of carbon, students explore in greater depth the incredible diversity of carbon-based molecules. They are reminded that, given carbon's four bonding electrons and four vacancies available to form bonds, carbon is able to form stable covalent bonds—single or multiple—with other carbon atoms and with atoms of other elements. Students learn how the presence of single, double, and triple bonds determines the geometry of carbon-based molecules. The variety of these molecules is enormous: over 16 million carbon-containing compounds are known. The compounds range from simple hydrocarbon molecules (e.g., methane and ethane) to complex organic polymers and biological molecules (e.g., proteins) and include many manufactured polymers used in daily life (e.g., polyester, nylon, and polyethylene).	-Bonding Capacities of Carbon -Stable covalent bonds -Diversity of Carbon-based Compounds -Hydrocarbons -Synthetic polymers	**Hydrocarbons are compounds that contain-** (1) carbon, only (2) carbon and hydrogen, only (3) carbon, hydrogen, and oxygen, only (4) carbon, hydrogen, oxygen, and nitrogen, only ***From: NY Regents, Chemistry [2008]*** ***DOK Level: [1] Recall and Reproduction***
10c. *Students know* amino acids are the building blocks of proteins.	*Proteins* are large single-stranded polymers often made up of thousands of relatively small subunits called *amino acids*. The bond attaching two amino acids, known as the *peptide bond,* is identical for any pair of amino acids. The chemical composition of the amino acid itself varies. Variation in composition and ordering of amino acids gives protein	-Proteins -Amino acids -Peptide bonds -Protein structure	**Proteins are large macromolecules composed of thousands of subunits. The structure of the protein depends on the sequence of -** A lipids. B monosaccharides. C amino acids. D nucleosides.

	molecules their unique properties and shapes. These properties and shapes define the protein's functions, many of which are essential to the life of an organism. The blueprint for building the protein molecules is deoxyribonucleic acid (DNA). Biotechnology is advancing rapidly as more is learned about DNA, amino acid sequences, and the shapes and functions of proteins.		***From: CST Released Test Questions*** ***DOK Level: [1] Recall and Reproduction***