EL DORADO UNION HIGH SCHOOL DISTRICT
EDUCATIONAL SERVICES

Course of Study Information Page

COURSE TITLE **Advanced Chemistry**	
DISTRICT COURSE NUMBER **0320**	4-DIGIT STATE COURSE CODE (COMPLETED BY SILT) **2607**
Rationale:	Advanced chemistry is a traditional theoretical, mathematics based chemistry course that studies the natural elements and the changes they undergo. The target group is students planning to pursue a career in a science or math related field.
Course Description that will be in the Course Directory:	The course will focus on the properties, composition and structure of elements and compounds and the changes they undergo. The course will consist of classroom and laboratory components that will cover all relevant Next Generation Science Standards (NGSS).
How Does this Course align with or meet State and District content standards?	The course covers the relevant Next Generation Science Standards for California public schools (refer to following document for specific standards covered).
NCLB Core Subjects:	*Select up to two that apply:* ☐Arts ☐Civics and Government ☐Not Core Subject ☐Economics ☐History ☐English ☐Mathematics ☐Foreign Language ☐Reading / Language Arts ☐Geography X Science
CDE CALPADS Course Descriptors: (See Page 2 for Definitions)	CTE TECH PREP COURSE INDICATORS ☐ Tech Prep (32) (Higher Ed) ☐ Tech Prep & ROP(33) (Higher Ed) ☐ ROP (30) ☐ N/A CTE COURSE CONTENT CODE ☐ CTE Introductory (01) ☐ CTE Concentrator (02) ☐ CTE Completer (03) ☐ Voc Subject ☐ N/A INSTRUCTIONAL LEVEL CODE ☐ Remedial (35) ☐ Honors UC-Certified (39) ☐ Honors Non UC-Certified (34) ☐ College (40) ☐ N/A
Length of Course:	X Year ☐Semester
Grade Level(s):	☐9 X 10 X 11 X 12
Credit:	X Number of credits: **10** X Meets graduation requirements (subject: **Science**) ☐Request for UC "a–g" requirements CSU/UC requirement **d** X College Prep
Prerequisites:	Grade of "C" or better in Biology, or teacher approval. Grade of "C" or better in Algebra 1 and concurrent enrollment or completion of Algebra 2.
Department(s):	Science
District Sites:	May be offered at any site
Board of Trustees COS Adoption Date:	June 13, 2006
Textbooks / Instructional Materials:	Chemistry: Matter and Change, Glencoe/McGraw Hill, 2017 ISBN:978-0-07-677461-6
Funding Source:	General Fund
Board of Trustees Textbook Adoption Date:	May 9, 2017

F6143A 10/31/11; Rev. 11/5/15

Definitions

CALPADS	California Longitudinal Pupil Achievement Data System
CTE Technical Prep	A course within a CTE technical career pathway or program that has been articulated with a postsecondary education or through an apprenticeship program of at least 2 years following secondary instruction.
Instructional Level Code	Represents a nonstandard instructional level at which the content of a specific course is either above or below a ‘standard’ course instructional level. These levels may be identified by the actual level of instruction or identified by equating the course content and level of instruction with a state or nationally recognized advanced course of study, such as IB or AP.
Instructional Level Honors, UC Certified	Includes all AP courses.
Instructional Level Honors, non UC Certified	Requires Board approval.
Instructional Level College	Includes ACE courses. Equivalent to college course and content, but not an AP course. Not related to section, but to course.

EL DORADO UNION HIGH SCHOOL DISTRICT

EDUCATIONAL SERVICES

Course Title: Advanced Chemistry

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Department:	**Science**		
Course Title:	**Advanced Chemistry**	Course Number:	**0320**
Unit Title:	Unit 1: Atomic and Molecular Structure		

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

Identify and locate protons, neutrons, and electrons in representations of atoms.

- Provide evidence that protons determine the unique properties of an element, and that neutrons and electrons do not.
- Explain how electrons can be gained and lost, which changes some properties, but can generally be easily reversed.
- Explain how atoms with different numbers of neutrons but the same number of protons (isotopes) exhibit identical properties, except for mass.
- Describe how the periodic table is organized in order of increasing atomic number
- Identify places where the historical method of arranging elements by mass would place elements in the wrong group (i.e., tellurium and iodine).
- Recall that virtually all of an atom's mass is contained in the densely packed nucleus.
- Recall that the diameter of any given atom is about 10,000 to 100,000 times greater than the diameter of the nucleus.
- Describe or construct analogies to show the true scale proportions of the size of the nucleus to the atom.
- Describe or construct analogies to show the true scale proportions of the mass of the nucleus to the electrons of an atom.
- Recall that in hydrogen, less than 0.1% of the mass occupies a trillion times more space than the rest of the mass.
- *Explain that quantum mechanical calculations predict electron energy states.*
- Identify the 7 principal quantum numbers that correspond to the periods (horizontal rows) of the periodic table.
- Recall the angular momentum quantum numbers associated with s, p, d, and f orbitals.
- *Identify the shapes of the different types of atomic orbitals. (LBUSD)*
- Apply the rules for the sequence of orbital filling to determine electron configurations.
- *Explain how electron energy states justify the organization of the periodic table.*
- *Define valence electrons in terms of having the highest principal quantum number and representing the "surface" of an atom involved in chemical reactions.*

- *Explain that electron configurations are associated with regular patterns of chemical reactivity.*
- *Explain that elements that are one electron in excess (alkali metals) or short (halogens) of a full octet are the most reactive.*
- Recall that all the elements in a group have the same number of valence electrons.
- Identify representative groups (also known as families) by number and name (for example: Group 17, also known as halogens, “formerly called” Group VII).
- Recall that only the valence shell electrons are available for bonding.
- *Show valence electron configurations for individual atoms using electron dot diagrams. (LBUSD)*
- Explain how unfilled energy levels (valence shell orbitals) are also available for bonding (for instance, the Group 16 chalcogens have room for two more electrons shared from another atom or atoms).
- Determine the number of electrons or unfilled energy levels available for bonding in atoms from combining ratios of compounds (i.e., $MgCl_2$ and NH_3).
- Identify the elements immediately to the left and right of the stepped line from boron to astatine (except for aluminum) as semimetals.
- Describe semimetals as elements having properties intermediate between metals and nonmetals.
- Identify where metals and nonmetals are located on the periodic table.
- Distinguish properties of metals from nonmetals.
- Identify the location of halogens on the periodic table.
- Describe characteristic properties of halogens.
- Identify and distinguish the properties of alkali metals (Group 1), alkaline earth metals (Group 2), and transition metals (Groups 3-12).
- Explain how the properties of alkali, alkaline earth, and transition metals are related to their electron configurations.
- Define **electronegativity** as the ability of an atom of an element to pull electrons toward itself in a chemical bond.
- Identify small electronegativity values (such as the alkali metals have) as indicating a weak pull for electrons in a bond.
- Identify large electronegativity values (such as the small chalcogens and halogens) as indicating a strong pull for electrons in a bond.
- Define **ionization energy** as the amount of energy needed to remove an electron from an atom.
- Explain why elements may have multiple ionization energies, and why they increase from 1^{st} to 2^{nd} to 3^{rd}, etc.
- Identify the trends for ionization energy and electronegativity in the periodic table.
- Explain how horizontal trends are controlled by the number of protons.
- Explain how vertical trends are controlled by the distance between the electrons and the nucleus.
- Explain how atomic and ionic sizes generally decrease left to right and increase top to bottom for the same reasons.
- Identify exceptions to the trends and explain how these are caused by filled or half-filled subshells.
- Identify the location of the lanthanide series (rare earths) and actinide series elements.
- Recall that all lanthanide and actinide elements are radioactive.
- Explain that these elements are separated from the normal pattern of the periodic table for practical display size.
- Recall that most of these elements appear to have three electrons available for bonding, forming compounds with halogens having the general formula MX_3.
- Identify the transactinide elements, beginning with rutherfordium, element 104.
- Recall that all transuranium elements (elements beyond ^{92}U) were first synthesized and identified in experiments using accelerators.
- Explain how accelerators, using electromagnets to accelerate and collide positive atomic nuclei, have produced and identified the transuranium elements.
- Explain how today some transuranium elements (such as plutonium) are produced commercially in nuclear reactors.
- Describe and/or diagram J. J. Thomson’s 1887 cathode ray experiment.
- Explain how the experiment demonstrated that cathode rays are composed of identical, negatively charged particles, which Thomson named electrons.
- Describe and/or diagram Ernest R. Rutherford’s 1913 experiment with alpha particles (helium nuclei) and gold foil.
- Explain how the results of this experiment lead to new understanding about how atomic mass is condensed in a dense, charged nucleus.

- Describe and/or diagram Robert A. Millikan's oil drop experiment.
- Explain how Millikan's experiment confirmed Thomson's conclusions about electrons and determined their charge.
- Explain how Albert Einstein explained the photoelectric effect by proposing that light consists of discrete bundles, called photons, capable of ejecting electrons from atoms if the light frequency is correct.
- Explain that the kinetic energy of an ejected electron equals the energy of a single photon minus the energy needed to free the electron from the metal.
- Explain that if the frequency of light is too low to free an electron, merely increasing the intensity of light (producing more photons) will not cause electrons to eject.
- Explain that Niels Bohr combined Rutherford's nuclear atom with Einstein's photons (along with other ideas) to develop a quantum model of the atom that successfully explains experimental observations not understood before.
- Explain that Bohr's quantum model explained the colors (wavelengths) of light emitted when excited electrons fall back to their ground state.
- Explain that, because in classical physics accelerating charges must emit energy, scientists could not explain why electrons did not gradually slow down until atoms collapsed.
- Explain that Bohr's quantum model proposed that electrons only gain or lose energy by transitioning from one discrete energy level to another.
- Explain that Louis de Broglie's quantum model proposed that particles have wave properties, for instance, that electrons "resonate" at particular energy levels just as sound waves resonate in a musical instrument.
- Recall that Erwin Shrödinger and others developed quantum mechanics, a theory that describes and predicts atomic and nuclear phenomena, including the shapes of atomic (s, p, d, and f) and molecular bond (σ and π) orbitals.
- *Explain that electrons lose energy when "falling" from higher energy levels to a lower ones by emitting photons of light, which produce an emission (or bright line) spectrum.*
- *Explain that the energy of each photon of light given off is exactly the same as the difference between two energy levels.*
- *Explain that atomic energy levels can also be determined by observing what energy of photons are absorbed to make electrons jump from a lower (ground state) energy level to a higher one, which produce absorption spectra.*
- *Demonstrate how to calculate the energy absorbed or emitted by electron jumps from the observed frequency (or color) of light using Planck's relationship:*

  $$E = h(c/\lambda)$$

  Where E is the amount of energy, h is Planck's constant ($6.626x10^{-34}$ Js), c is the speed of light, and is the wavelength of the light observed.

  Or since c/λ = v, (where v is the frequency of light observed)the equation can be shortened to:

  $$E = hv$$
- *Explain that the quantum mechanical model describes a probabilistic nature for electron distribution that can be envisioned as random hits on a dartboard or the density of bees in the proximity of a beehive.*

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Instructional strategies that will be used to engage students.

Students will participate in labs, activities and direct instruction that will show student understanding of atoms and molecular structure.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Metal vs. Non-metal Properties Lab

Flame Test Lab

Small Scale Lab: Electron Configurations of Atoms & Ions (relating partially filled d-orbitals with ion color)

Historical Atomic timeline

Scale Atoms:

PH Chem, Quick LAB, p 175, “Periodic Trends in Atomic Radii”

PH Chem, Quick LAB, p 108,
“Using Inference: The Black Box”
Group I & II Activity

PH Chem, Quick LAB, p 175, “Periodic Trends in Atomic Radii”

As homework, have students bring in, diagram, or describe accurate proportional representations of size and mass of the nucleus to the electrons in an atom.

PH Chem, Small-Scale Lab 10, p 73, “Electron Config’s of Atoms and Ions”]

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments. Interventions may include but are not limited to the following:

Supplemental Resources:

Los Alamos Nat’l Lab Periodic Table

Chemical Elements.com

WebElements.com

TEACHER demonstrates under carefully controlled conditions the reactivity of elemental Li, Na, Mg, and Ca in water with phenolphthalein. (If the teacher has not done this demonstration before, they should not attempt it without the supervision of a teacher experienced with the demo.)

Students explain observations based atomic size and electron configuration.

Atomic Orbitals

Modeling with Magnets

Students use strong and weak magnets to represent atoms with different electronegativities. A steel ball represents a valence electron. Represent ionization energy by having a magnet holding several steel balls. Note that it is easier to remove the first ball than to remove the last one. Students explain what causes the increasing ionization energy in atoms.

Chemistry Guide – U.K.

Quantum Electron Darts Using darts, or objects that leave a mark on a large paper, demonstrate the spread of “hits” when thrown from a short distance versus throwing from greater distances (representing higher quantum energy levels).Students explain how this relates to electron locations around atoms.

Spectroscopy Observe spectral lines for sodium flame and various gas tubes using a diffraction grating spectroscope. Calculate the wavelengths emitted using the Bragg equation.

5. What will we do if students already know it?

Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

Department:	**Science**		
Course Title:	**Advanced Chemistry**	Course Number:	**0320**
Unit Title:	Unit 2: Chemical Bonds		

Content Area Standards (Please identify the source): List content standards students will master in this unit.

Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

Explain that non-metal atoms with similar electronegativities (equivalent pulls for the shared electrons) form covalent bonds to become molecules.

- Describe a covalent bond as having a shared pair of electrons localized in a region of overlap between two atomic orbitals.
- Explain that the valence electrons of metal atoms are not localized to individual atoms, but are easily pushed from one atom to another, allowing metals to conduct electricity well.
- Explain that when an electron from a low electronegativity atom (like a metal) is removed by an atom with high electronegativity, it creates oppositely charged ions that attract each other, forming an ionic bond.
- Identify various chemical bonds as covalent, ionic, or polar covalent.
- Explain how “the octet rule” applies to the formation of ionic and covalent bonds.
- Determine the number of valence electrons for elements from their position on the periodic table.
- Draw Lewis dot diagrams for atoms and simple molecules.
- Explain how electron pairs in the Lewis dot diagram are shared between two atoms.
- Use Lewis dot diagrams to predict the combining ratios between atoms.
- Use Lewis dot diagrams to determine if bonds will be ionic or covalent.
- Use Lewis dot diagrams to determine where single, double, and triple bonds occur.
- Determine the number of shared and unshared electron regions around atoms in a molecule from a correct Lewis dot diagram.
- Describe how atomic orbitals hybridize to form molecular orbitals that will overlap between atoms to form bonds. (LBUSD)
- Explain that valence electron pairs form negatively charged regions that repel each other, making covalently bonded atoms around a central atom position themselves as far apart as possible (a.k.a., **V**alence **S**hell

Electron **P**air **R**epulsion).

- Determine the correct three-dimensional geometry of molecules.
- Explain how unshared electron pairs and multiple bonds affect the geometry of molecules by occupying a "fatter" region of space than single covalent bonds. (LBUSD)
- Identify and molecular bond orbitals and how they form from atomic or hybrid orbitals. (LBUSD)
- Explain how symmetrical distribution of charge around a central atom leads to a nonpolar molecule in which charge is distributed evenly.
- Recall that organic and biological molecules are primarily made of carbon, oxygen, hydrogen, and nitrogen.
- Identify unpaired electrons in these atoms as available sites for covalent bonding.
- Apply the octet rule to determine bonding patterns between carbon and hydrogen, nitrogen, and oxygen.
- Explain how the great variety of bonding possibilities among carbon, nitrogen, oxygen, and hydrogen make a great diversity of organic and biological molecules possible.
- Explain that ionic compounds do not exist as neutral pairs, but as either separate ions (when dissolved) or as an ordered lattice of ions held together by "static cling" (in solid form).
- Explain that ions form repeating patterns that minimize their energy state by reducing the distance between (+) and (-) charges and maximizing the distance between like charges.
- Define **lattice energy** as the **electrostatic attraction** between **cations** (+) and **anions** (-) that holds ionic compounds together.
- Explain that in any substance, at any temperature, the attractive forces holding the material together are opposed by the internal energy of particle motion.
- Explain that solids exist when the attractive forces between atoms or molecules are stronger than the internal agitation of particle motion.
- Explain that melting occurs when enough energy is added so that the internal kinetic energy of atoms or molecules overcomes the attractive forces.
- Describe melting as releasing particles from a rigid lattice to a disordered, non-rigid state where particles move randomly although they remain in contact with each other and still experience some attraction to each other.

- *Explain that as bonds form, atoms with large electronegativity values attract electrons away from lower electronegativity atoms so that the shared electrons are not shared equally.*
- *Explain that if the electronegativity difference between two atoms is great enough (usually with a metal and a nonmetal), there will be essentially no electron sharing and the bond will be ionic.*
- *Explain that when electronegativity differences are small (usually with two nonmetals), a covalent bond forms with more equal sharing of the electrons.*
- *Define **ionization energy** (more precisely than with standard 1c) as the energy needed to remove an electron from an isolated gaseous atom, leaving a positively charged ion.*
- *Explain that the forces that pull electrons in a bond (electronegativity) are usually directly related to the amount of energy needed to remove an electron (ionization energy).*
- *Explain that solids may be held together by ionic bonds (like salts), covalent bonds (like minerals), or by weaker forces of attraction between molecules called **van der Waals** attractions (like sugar).*
- *Explain that van der Waals forces (a.k.a., London Dispersion forces) exist between all molecules, polar and nonpolar.*
  - *Describe the strongest van der Waals forces, called **hydrogen bonding**, as the attraction between oppositely charged ends of two polar molecules.*
  - *Explain that liquid water is an important example of hydrogen bonding, which is caused by its bent shape.*
  - *Explain how when a polar molecule gets next to a nonpolar molecule, it can pull or push the electrons of nonpolar molecule, making it temporarily polar, so that the two molecules attract each other slightly. (LBUSD)*
  - *Describe how the weakest van der Waals attraction occurs between two nonpolar molecules when one molecule's electrons and are found temporarily closer to one nucleus, making it slightly polar. This can induce a neighboring molecule to become slightly polar and they experience a very weak, very short attraction.*
- *Define volatility as the ability of a substance to evaporate at ordinary temperatures and pressures.*
- *Explain why solids held together by van der Waals forces have low to moderate melting points.*
- *Explain and cite examples of how the volatility and boiling temperature of liquids is affected by van der Waals forces.*
- *Explain that substances with large molecules have more electrons and experience greater van der Waals forces, increasing melting and boiling temperatures and decreasing volatility.*

Instructional Strategies:

Students will participate in labs, activities and direct instruction that will show student understanding of chemical bonds.

Department:	**Science**		
Course Title:	**Advanced Chemistry**	Course Number:	**0320**
Unit Title:	Unit 3: Conservation of Matter		

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

- Describe a chemical formula in terms of atoms and elements.
- Recall and apply basic rules of chemical nomenclature. (Rules for naming complex ions, acids, and organic and biological compounds will be added later as they are needed.)
- Distinguish between reactants and products in a chemical reaction.
- Write unbalanced equations to describe chemical reactions using correct formulas.
- Explain the law of conservation of mass.
- Explain how the law of conservation of mass applies to balancing equations.
- Balance equations, determining correct coefficients for each reactant and product.
- Explain that one mole is a unit that measures a fixed number of atoms.
- Explain that the purpose of the mole is to multiply (or "magnify") from the atomic scale to an amount we can easily measure.
- Recall that carbon-12 (^{12}C) was chosen as the standard for defining a mole: one mole of ^{12}C atoms weighs exactly 12 grams.
- Explain and give examples to show that the atomic mass of an element is the weighted average of one mole of that element based on the natural abundance of all its isotopes.
- Explain that because atoms are so small, it takes an enormous number of them to have enough to measure and work with easily.
- Recall that Avogadro's number (NA) is $6.02X10^{23}$, meaning that there are 602,000,000,000,000,000,000,000 ^{12}C atoms in 12 grams of pure ^{12}C.
- Recall that Avogadro determined the number experimentally, and that today the number is known to a high degree of accuracy.
- Define the molar mass of a compound as the sum of the atomic masses of the elements represented, with each multiplied by the number of atoms represented.
- Recall that molar mass may also be called molecular mass or molecular weight.
- Explain that the units of molar mass are atomic mass units (**amu** – which is equivalent to the total number of proton and neutron masses) at the atomic level OR grams per mole (**g/mol** - which is the practical unit for larger, easily measurable amounts).
- Apply molar mass as a conversion factor between grams and moles
- Apply Avogadro's number, $6.02x10^{23}$, as a conversion factor between moles and particles.
- Explain that one mole of any gas will occupy the same volume at a given temperature and pressure, regardless of the gas composition.
- Define Standard Temperature and Pressure (STP) as 0^oC and 1 atm.
- Apply the molar volume of a gas at STP (22.4 L/mol) as a conversion factor between liters of gas and moles of the gas.
- Explain that since a balanced equation shows how many atoms interact in a chemical reaction, mole conversion will let you determine the masses (in grams) involved.
- Set up and perform calculations to determine the amount of any product or reactant given the amount of one.
- Identify the given quantity and convert it to moles.
- Use the coefficients from the balanced equation to write a mole ratio that converts from one substance in the reaction to another.
- Choose an appropriate conversion factor to determine the amount of substance requested.
- Demonstrate unit cancellation (dimensional analysis), even before plugging in numerical values.
- Identify the calculated amount of a chemical product as the theoretical yield of a reaction.
- Identify the amount of product measured after a chemical reaction as the actual yield of a reaction.
- Recall that percentages are always calculated as (part/whole) x 100.
- Calculate percent yield
- Define **oxidation** as an increase in the oxidation number of an atom caused by a loss of electrons.
- Define **reduction** as a decrease in the oxidation number of an atom caused by a gain of electrons.
- Explain that oxidation numbers are assigned as if all of the electrons in a bond were located on the more electronegative element (as if all bonds were completely ionic).
- Assign oxidation numbers to atoms found in free elements and in compounds.
- Explain that oxidation numbers are assigned as if all of the electrons in a bond were located on the more electronegative element (as if all bonds were completely ionic).
- Balance redox reactions by solving for reduction and oxidation half-reactions, and then recombining when the number of electrons gained and lost are balanced.

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of chemical reactions and stoichiometry.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Observing a Chemical Rxn Lab
Stoichiometry Lab [see p. 46]
Solubility/Qual. Analysis Lab

Balanced Equation Posters Small groups create posters to illustrate balanced equations using a different color for each element. Students will demonstrate understanding of conservation of mass.

Empirical Formula of a Hydrate Lab [see p. 46]
PH Chem, Inquiry Activity, p 286, "Counting by Measuring Mass"

Mole Math Maps
Student groups design and present a visual to represent the use on moles in conversions to and from particles, grams, and liters.

PH Chem, Lab 19, p 121, "Quantitative Analysis"

PH Chem, Lab 19, p 121, "Quantitative Analysis" (*% Yield can be added and contrasted to % Error calculation at the end of this lab.*)
Reduction - Oxidation Lab [see p. 46]

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments.

Supplemental Resources:

Mole Lab

Avogadro Research Students research how Amadeo Avogadro determined NA experimentally.

PH Chemistry, Lab 13, p 85,
"Empirical Formula Determination"

"Molptures" Students calculate and measure out (to the nearest cg) 1 mole of aluminum for "Mole Sculptures".

Stoichiometry

PH Chemistry Lab46, p 275, "Oxidation-Reduction Reactions"

PH Chemistry, Small-Scale Lab 35, p 249, "Oxidation-Reduction Reactions"

PH Chemistry, Lab 47, p 279,"Corrosion"

5. What will we do if students already know it?
Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

EDUCATIONAL SERVICES

Department:	**Science**		
Course Title:	**Advanced Chemistry**	Course Number:	**0320**
Unit Title:	Unit 4: Gases and Their Properties		

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

- Describe both gases and liquids as fluids in which the molecules move freely past each other in random directions.
  - Explain that the atoms and/or molecules of liquids are held close to each other by intermolecular forces.
  - Explain that the atoms and/or molecules of gases are spaced far apart and reasonably free to move at high speeds, near the speed of sound.
- Define **pressure** as force exerted per unit area.
- Explain that the force of the pressure in fluids comes from the sum of all the particles (atoms and /or molecules) colliding against a surface.
  - Describe how air pressure is created by gravity pulling air molecules toward the Earth's surface where they strike objects. This is sometimes referred to as the weight of air.
  - Explain that air pressure decreases with altitude.
  - Describe how gravity creates water pressure in the same way as air, but that the pressures are much greater because water is much denser.
  - Explain that water pressure increases with depth.
- Explain that pressure is felt equally in all directions because of the random motion of the particles.
- Explain and demonstrate how the random motion of molecules causes gases to diffuse into each other to form homogeneous mixtures.
- Explain that particles with large masses will have smaller velocities and particles with small masses will have larger velocities at the same temperature. (This relates to standard 7a.)
- Predict which gases will diffuse faster when given sample molecules of gaseous substances.

*Define **diffusion** as the process of mixing atoms or molecules by random motion.*

- *Define **effusion** as the process by which gas molecules pass from one container to another at low pressure through a small opening.*
- *Estimate the rates of diffusion of gases by calculating effusion rates with the Graham's law equation.*

$$\frac{u_B}{u_A} = \sqrt{\frac{M_A}{M_B}}$$

- *Explain how the combination of observations, Graham's law calculations, and the kinetic molecular theory demonstrate the inverse relationship between the mass of gas particles and their speed.*
- *Explain why the properties of ideal gases depend only on the number of particles present, and not on the chemical identity of the gases.*
- *Calculate partial pressures of component gases using Dalton's law of partial pressures.*

$$P_{TOT} = P_A + P_B + P_C \ldots$$

$$P_A = X_A \cdot P_{TOT}$$

Identify the symbols and units used for pressure, volume, and temperature when working with ideal gases.

- Predict and calculate the changes that will occur *(to a fixed number of moles, n, of an ideal gas)* when one or more of the physical variables above is altered.
- Recall that scientists have agreed upon 0^oC as the standard temperature and 1 atmosphere (760 mm Hg) as the standard pressure for comparing gases.
- Explain that when volumes are being compared, the temperature and pressure must be specified.
- Explain that the greater the atomic and molecular motion, the greater the observed temperature of a substance.
- Explain that the theoretical lowest temperature, or absolute zero, occurs when all molecular motion stops.
- Explain that it is impossible to have a negative absolute temperature, because molecules cannot move slower than a dead stop.
- Recall that absolute zero has been experimentally determined to be -273.15^oC by lowering the temperature of objects to within a fraction of a degree of that value.
- Explain that the Kelvin scale (K) is an absolute temperature scale, because it starts at absolute zero (0 K).
- Explain that the units of change on the Kelvin scale are the same size as degrees on the Celsius scale.
- Convert between Kelvin and Celsius scales by appropriately adding or subtracting 273.15 (or rounded off to 273)

- Explain that the average kinetic energy of particles in an ideal gas is directly proportional to its Kelvin temperature.
- Explain that the effects of average kinetic energy can be observed as changes in pressure and volume that accompany temperature changes.
- Explain that, by definition, at 0 K all motion in an ideal monatomic gas ceases, meaning that the average kinetic energy equals zero. (Note that since a particle cannot have a negative kinetic energy – move slower than stop – the average kinetic energy cannot be zero unless all particles have zero kinetic energy. So it is not your typical mathematical average at this extreme value!)
- Identify the ideal gas law, **PV=nRT**, as a way to determine the relationships among pressure, volume, and temperature for a fixed mass of gas.
- Identify **R** as the universal gas constant (a mathematical correction to take into account the units of measurement), which is 0.0821 liter-atmospheres per mole-Kelvin. These can also be abbreviated as (L·atm)/(mol·K) or L atm mol^{-1} K^{-1}.
- Solve practical and theoretical problems using the ideal gas law

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of gas properties and laws.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Gas Laws Lab [see p. 46]

NH_4Cl Ring

Students observe the white ring formed when $NH_{3\,(g)}$ and $HCl_{(g)}$ are simultaneously placed at opposite ends of a glass tube and diffuse toward one another. They then use Daltons Law to confirm the ratio of molar masses and explain the diffusion and effusion behavior of various gases.

Gas Laws Lab [see p. 46]

Temperature Skit

Have a group of students imitate gas particles by bouncing around. Ask them to demonstrate what happens when the temperature increases, then decreases. Have them demonstrate colder and colder temperatures (include phase changes) until they stop. Ask them how to get colder.

Hydrolysis: Separate H_2O into H_2 and O_2 gas using a Hoffman apparatus (or the set up described in Exp 12 on p 39). Students explain whether it is the size of the molecules or the number of molecules that determines how much is produced and use this reasoning to identify each gas. Test using a glowing wood splint to verify. (OR, may be used for standard 8a)

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments.
Bell Jar Demos Demonstrate pressure effects on marshmallows, shaving cream, balloons, etc.

See “Drop Observations” described for standard 2h*.

Pressure in Fluids

Fluid Pressure Measurement

Diffusion of Gases

Partial Pressures

PH Chem, Lab 23, p 147, “P-V Relationships for Gases”
PH Chem, Lab 24, p 155, “T-V Relationships for Gases”
PH Chem, Virtual Chem Lab 11, “P-V Relationships for Gases”
PH Chem, Virtual Chem Lab 12, “T-V Relationships for Gases”

Elastic Gas Containers Students observe balloon behavior in a bell jar (changing pressure) and under different temperature conditions.

Virtual Lab

PH Chem, Quick LAB, p 428, “CO2 from Antacid Tablets”
PH Chem, Virtual Chem Lab 13, “Deviation from the Ideal Gas Law”
PH Chem, Virtual Chem Lab 14, “Ideal vs Real Gases”

5. What will we do if students already know it?
Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

EDUCATIONAL SERVICES

Department:	**Science**		
Course Title:	**Advanced Chemistry**	Course Number:	**0320**

Unit Title: Unit 5: Acids and Bases

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

- **Unit Outline**: Observe and recall the properties of acids: sour taste, litmus reaction, universal indicator paper range, reaction with certain metals (mossy zinc, for instance) to produce H_2 gas.
- Observe and recall the properties of bases: bitter taste, slippery feeling, litmus reaction, universal indicator range, lack of reaction with metals.
- Demonstrate and explain how acids and bases react to neutralize each to produce water and salt (and occasionally, CO_2).
- Define Brønsted-Lowry acids as substances that donate hydrogen ions, H^+ (a.k.a., protons).
- Define Brønsted-Lowry bases as substances that accept hydrogen ions.
- Explain that acids formed from nonmetals (halogens), in the first two rows easily dissociate to produce hydrogen ions because of their strong electronegativity compared to hydrogen.
- *Explain that the oxygens and nitrogen of nitrate create enough of an electronegativity to easily dissociate and produce hydrogen ions, like the F of HF and Cl of HCl. (LBUSD)*
- Identify and explain various reactions involving Brønsted-Lowry acids and bases.
- Explain that some acids and bases dissociate or ionize almost completely, and others do so only partially.
- Explain that near complete dissociation makes a strong acid or base, because it produces lots of the active ions.
- Explain that partial dissociation is a property of weak acids or bases.
- Explain why the strength of an acid or base (amount of dissociation) can be affected by temperature and concentration.
- Identify the pH scale as a measure of the hydrogen ion concentration that defines the acidic or basic nature of a solution.
- Explain that the pH scale is a logarithmic scale meaning, for example, that a pH 2 solution has ten times more hydrogen ions than a pH 3 solution.
- Identify pH 0 as very acidic, 14 as very basic.
- Identify pH 7 as neutral, any pH greater than 7 as acidic, and any pH less than 7 as basic.
- Identify $[H^+]$ as indicating the molar concentration of H^+ ions in a solution.
- Calculate the pH of a solution as $-\log_{10}[H^+]$.
- Calculate $[H^+]$ from a given pH value.
- Define and cite examples of Arrhenius bases as containing hydroxide, such as KOH.
- Explain why NH_3 fits the definition of a Brønsted-Lowry base, but not an Arrhenius base.
- Define Lewis acids as electron pair acceptors and Lewis bases as electron pair donors.
- Explain how the Lewis definition applies to various acids and bases.
- Explain that the benefit of the Lewis definition is that is extends the concept of acid-base reactions to nonaqueous systems.
- Explain how BF_3 works as an acid, even though it would not be considered an acid by the
- Brønsted-Lowry definition.
- Explain that a buffer is a solution that stabilizes $[H^+]$ (or pH) by releasing H^+ ions if the pH rises or consuming H^+ is the pH decreases.
- Recall that an extremely important and complicated example of a buffered system is the is the equilibria between CO_2, H_2CO_3, HCO_3^-, CO_3^{2-}, and solid $CaCO_3$ keeps the world's oceans at a nearly constant pH of about 8.
- Calculate and interpret pOH values.
- Recall that the sum of pH and pOH is always 14.0 for a given solution at 25^oC

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of the properties of acids and bases.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Properties of Acids/Bases Lab

Acid/Base Titration Lab

PH Chem, Inquiry Activity, p 586, "Effect of Foods on Baking Soda"
PH Chem, Demo, TE p 588, "Reactive Acids"

PH Chem, Lab 41, p 251, “Reactions of Acids”
PH Chem, Lab 42, p 255, “Neutralization Reactions”
PH Chem, Lab 45, p 271, “Buffers”
PH Chem, Small-Scale Lab 33, p 235, “Buffers”

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments.

Interventions may include but are not limited to the following:

Acid Observations
Select students to volunteer. Give each a small cup of orange juice, grapefruit juice, and lemon juice. Have them taste each. Pour a teaspoon of baking soda into each cup. Record observations. Have students explain the results.

Playing with Vinegar and Ammonia
Students observe the reactions of various household substances with red cabbage juice. They should also set up a test to explore various concentrations of vinegar and ammonia

PH Chem, Lab 40, p 247, “Estimation of pH” using pH meter

The pH Factor

PH Chem, Lab 43, p 259, “Acid-Base Titrations”

Virtual Titration

Virtual Titration

The Lewis Acid-Base Concept

Buffer Animation (Chemtoons)

5. What will we do if students already know it?

Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

EDUCATIONAL SERVICES

Department: **Science**

Course Title: **Advanced Chemistry** Course Number: **0320**

Unit Title: Unit 6: Solutions

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

- Define homogeneous as describing substances that have the same makeup throughout, down to the molecular level.
- Define simple solutions as homogeneous mixtures of two substances.
- Define and identify **solutes** as the dissolved substances in solutions.
- Define and identify **solvents** as the larger components in the solutions by quantity.
- Explain that solutions are similar to gases in that the solute and solvent particles are in constant random motion.
- Explain that the kinetic energy of this constant motion causes diffusion of the solute into the solvent, resulting in a homogeneous solution.
- Explain that when a solid solute is placed in a liquid, at least some small part of the surface will dissolve.
- Explain that the amount of solute that dissolves depends on the interactions of the molecules of solute and solvent.
  - Explain that an equilibrium is reached when the process of solute particles breaking off into the solvent occurs as quickly as the process of solute particles running into the solute surface and becoming reattached.
  - Explain the competing processes that create this equilibrium: (1) the tendency of molecules to spread out randomly, (2) the competing strength of bonds and (3) attractions among solute molecules, among solvent molecules, and between solute and solvent molecules.
  - Describe how these processes apply to salt dissolving in water with positive and negative ions separated and surrounded by polar water molecules.
  - *Explain why a nonpolar solvent (like oil) will not dissolve salt. (LBUSD)*
- Define solubility as the maximum amount of a solute that can be dissolved in a particular solvent at a given temperature.
- Explain that chemical reactions that produce bubbles or precipitates have exceeded the solubility of the solvent.
- Recall that increasing the temperature of a solvent usually increases the solubility of solid solutes, but always decreases the solubility of gaseous solutes.
- Explain that the solubility of a gas is directly proportional to the pressure of that gas above the solution, because high pressure will lead to more particles diving into the solution.
- Recognize all concentration units as a measure of the amount of solute compared to the amount of solution:
  - **grams per liter** ≡ mass of solute divided by the volume of solution.
  - **molarity** ≡ moles of solute divided by liters of solution.
  - **parts per million** ≡ ratio of parts of solute to million parts of solution (solute and solvent together) and multiplied by 10^6. This is used with very dilute solutions. May also be calculated as (mg solute/kg solution) or (µg solute/g solution). Since the solute unit is one million times smaller, its numerical value will be a million times bigger.
  - **percent composition** ≡ mass of solute divided by mass of solution (solute and solvent together) and multiplied by 100.
- Define molality as moles of solute divided by kilograms of solvent (not liters of solution) **m** =
- Explain why molality is not affected by temperature, while molarity is.
- Calculate and explain how the concentration of solute can depress the freezing point of a solution.
- Explain why sodium chloride (salt) is sprinkled on icy roads.
- Explain that separating substances from solutions depends on differing attraction forces between molecules.
- **CHROMATOGRAPHY**
- Describe various ways to set up chromatography separation.
- Identify the moving solvent and the moving substrate.
- Explain separation results in terms of solute particle attractions for the substrate compared to attractions for the solvent.
- **DISTILLATION**
- Explain that distillation separates substances based on differences in the forces holding molecules in the liquid state.
- Predict which components in a mixture will leave the liquid state first and explain why.
- Explain how the catalytic reaction called “cracking” that occurs in oil refineries separates crude oil into kerosene, gasoline, & heavier oils.

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of making solutions and quantify concentrations

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Solubility/Qual. Analysis Lab

Super Saturation
Pour enough salt into a (~250 mL) beaker of water to leave a small amount of un-dissolved solid at the bottom. Explain (1) what causes the dissolving, (2) what prevents the rest of the solid from dissolving, and (3) how to dissolve more. Test the hypotheses for #3.

A Depressing Activity
Measure the temperature of a freezer in or near the classroom. Have students calculate the minimum amount of salt needed to prevent freezing at that temperature. Test the hypothesis.

Distillation & Chromatography Lab

PH Chem, Lab 27, p 173, "The Solvent Properties of Water"
PH Chem, Lab 30, p 189, "Factors Affecting Solution Formation"
PH Chem, Lab 31, p 195, "Supersaturation"
PH Chem, Small-Scale LAB, p 497, "Making a Solution"
PH Chem, Lab 26, p 167, "Distillation"

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments.

Virtual Chembook: Solutions

"Colorization"
Observe the spread of food coloring in beakers of cold, ambient, and hot water. Explain what this indicates about molecular motions.

Dissolving Ionic Compounds

Sodas and Gas Solubility
Fill two large test tubes with a cold, brown soda of your choice. Place one-hole stoppers in the top of both. Covering the holes with your fingers, quickly invert both into 1L beakers, one chilled with ice, the other warm. Students explain what their observations tell them about how the solubility of the CO_2 gas is affected by temperature and give practical applications.

Paper Chromatography
Use paper chromatography to separate ink/dye/coloring mixtures. Explain the process in terms of attractions to moving phase versus the stationary substrate.
PH Chem, Lab 32, p 199, "Intro. to Chromatography"

Paper Chromatography

Liquid Chromatography

5. What will we do if students already know it?

Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

EDUCATIONAL SERVICES

Department:	**Science**		
Course Title:	**Advanced Chemistry**	Course Number:	**0320**
Unit Title:	Unit 7: Chemical Thermodynamics		

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

- Define **temperature** as the average kinetic energy of molecular motion in a sample.
  - Explain that some molecules move slower than the average and some move faster.
  - Explain that particles with larger mass will have less speed than small particles to have the same kinetic energy (same temperature).
- Define **heat** as the energy transferred from a sample at higher temperature to one at lower temperature.
- Identify, for given examples, the <u>system</u> and the <u>surroundings</u> between which heat flows.
- Explain that **endothermic processes** absorb heat, and their equations can be written with heat as a reactant.
- Explain that **exothermic processes** release heat, and their equations can be written with heat as a product.
- Explain that breaking bonds always requires energy and that forming bonds always releases energy.
- Explain that the amount of energy per bond depends on the strength of the bond.
- Explain how the energy released or absorbed affects the internal motion of atoms and molecules in the system.
- Draw and interpret potential energy graphs showing the different reaction stages: reactants, transition states, and products.
  - Indicate that reactants are at a lower potential energy than products for endothermic reactions.
  - Indicate that reactants are at a higher potential energy than products for exothermic reactions.
  - Explain that a higher energy transition state usually exists between the reactant and product energy states. (This will be addressed further in 8d*.)
- Explain that changes in physical state either absorb or release heat.
- Explain that evaporation and melting require energy to be put in to overcome bonds of attraction in the liquid or solid state.
- Give examples from personal observations to validate this.
- Explain that condensation and freezing release heat to the surroundings as internal energy is reduced and bonds of attraction are formed.
- Define **specific heat** as the energy needed to change the temperature of one gram of substance by one degree Celsius. *(Unit = joule/gram-degree)*
- Explain that **latent** (or hidden) **heat** is the energy added or removed during phase changes that causes no temperature change. *(Unit = joule/gram or kilojoule/mole)*
  - Describe the latent heat of vaporization (ΔH_{vap}) as the energy needed to vaporize one mole of a liquid at its boiling point.
  - Describe the latent heat of fusion (ΔH_{fus}) as the energy needed to melt one mole of a liquid at its melting point.
  - Explain that these also represent the amount of energy released during the processes of condensing and freezing.
- Diagram and explain the temperature changes that occur when sub-zero ice is steadily heated to superheated steam (above 100^oC), indicating where latent heat is being added.
- Explain that the **standard enthalpy of formation**, $\mathbf{H_f}$, for a substance is the heat absorbed or released when forming one mole of that substance from elements (all substances begin and end at standard temperature, 25^oC (not 0^oC like gas law STP), under standard pressure, 1 atm).
- Recall that H_f is positive if heat is absorbed and negative if heat is released.
- Explain that Hess' law states that the net enthalpy change (heat absorbed) for a chemical reaction is the sum of the individual enthalpy changes needed to form or break apart each substance involved.

- Express Hess' law for the equation where ΔH_r^o is the standard enthalpy for the entire reaction.

$$aA + bB \rightarrow cC + dD \text{ as}$$
$$\Delta H_r^o = [cH_f^o(C) + dH_f^o(D)] - [aH_f^o(A) + bH_f^o(B)]$$

- Explain that the reactants are subtracted because they are pictured as being torn apart into elements, instead of being formed from elements like the products.
- Calculate the heat absorbed or released when a given quantity of a reactant is consumed in a chemical

reaction.

- Explain that since endothermic reactions can occur spontaneously (under standard conditions of temperature and pressure), releasing heat to end up at a lower energy state cannot be the only force driving chemical reactions.
- Define entropy as the tendency toward disorder.
- Explain that the creation of disorder (entropy) and the heat of the reaction (enthalpy) together determine if chemical reactions will be spontaneous.
- Recall the Gibbs free-energy equation and the appropriate units for each variable:
  - $\Delta G = \Delta H - T\Delta S$
- Calculate Gibbs free-energy for chemical reactions.
- Explain why a negative Gibbs free-energy predicts spontaneous formation of products (a spontaneous reaction), while a positive value favors formation of reactants (a nonspontaneous reaction).

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of the nature of energy exchanges and transformations in chemical and physical processes.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Endo-/Exothermic Rxns Lab

Specific Heat/Calorimetry Lab

PH Chem, Lab 35, p 217, "Heats of Reaction"

Stormy Weather Story
Students use energy transfer at the molecular level to explain why winter rain storms raise the local temperature (condensation effect), but a person getting hit by the rain is will find themselves cooling off (relative temperatures and evaporation effect).

Getting the Chemical Cold Shoulder

Research an endothermic reaction and use reference books to find values to calculate ΔG for the reaction. Describe the increase in entropy that allows the reaction to occur spontaneously.

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments.

Supplemental Resources:
PH Chem, Inquiry Activity, p 504, "Observing Heat Flow"

Heat is Not Temperature
Have students touch something metal and something plastic, wood, or rubber at the same time. Since both objects will be at room temperature when first touched, have students explain the sensation of the metal "feeling colder" in terms of heat flow.

Heat & Temperature
http://zonalandeducation.com/ mstm/physics/mechanics/energy/heatAndTemperature/heatAnd Temperature.htm

Hot & Cold Pack Chemistry
Observe examples of spontaneous exothermic and endothermic reactions.

Endo- and Exothermic Rxns

PH Chem, Lab 34, p 211, “The Specific Heat of a Metal”

Melting the Ice
Observe the temperature as water with a great deal of ice in it is heated. Continue recording the temperature until it reaches room temperature. Explain how latent heat can explain the observations.

Heating Curve

Hess’s Law

PH Chem, Teacher Demo, TE p 572, “Observing a Spontaneous Reaction”

Gibbs Free Energy

5. What will we do if students already know it?
Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

EDUCATIONAL SERVICES

Department: **Science**

Course Title: **Advanced Chemistry** Course Number: **0320**

Unit Title: Unit 8: Reaction Rates:

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

- Define **reaction rate** as the rate of decrease in the concentration of reactants.
- Explain that because of conservation of matter, the reaction rate may also be defined as the rate of increase in the concentration or products.
- Explain that from the balanced equation for a reaction, the reactants must decrease and the products must increase in proportion to their mole ratios.
- Explain that anything that affects the collision of reactant molecules will affect the rate of a chemical reaction.
- Explain that increasing the concentration of reactants will increase the number of collisions per unit time, because the distance between collisions is shorter.
- Explain that increasing the temperature (kinetic energy of molecules) will increase the number of collisions per unit time and dramatically increase the likelihood that the collisions will cause the chemical reaction (Arrhenius effect).
- Explain that increasing the pressure on gaseous reactants is the same as increasing the concentration and results in an elevated reaction rate.
- Explain that increasing pressure only affects reaction rates if one or more of the reactants or products are gases.

Explain that even spontaneous reactions must usually pass through a transition state (or activated transition complex) that has a higher energy than either the reactants or products.

- *Define the energy needed to form this transition state as the **activation energy**, or **activation barrier**.*
- *Explain that the activation energy is related to such factors as the strength of the bonds in the reactants.*
- *Explain why a higher activation energy will lead to a slower reaction (by connecting to the idea of average kinetic energy and the number of particles with sufficient energy to form the activated transition complex).*

- Define a **catalyst** as a substance that increases the rate of a chemical reaction without taking part in (or being consumed by) the reaction.
- Explain that a catalyst lowers the energy barrier between reactants and products by providing a more favorable pathway for the reaction.
- Explain that catalysts commonly function by providing a surface that temporarily holds onto one of the reactants and may weaken its bonds so that another substance can react with it more easily.
- Cite examples of biological (**enzymes**) and non-biological (i.e., catalytic converters) catalysts.

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of reaction rates and the frequency of the collision of molecules in reactions.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Reaction Rates Lab [see p. 47]

PH Chem, Small-Scale Lab 28, p 197, “Factors Affecting the Rate of a Chem Rxn”

PH Chem, Lab 36, p 225, “Factors Affecting Reactions Rates”

Reaction Rates in Reality

- In groups of three, students research real applications of using concentration, pressure, and temperature to control reaction rates.

<u>Assessments</u>: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

<u>Interventions</u>: Describe methods used to support students who fail to master unit Formative and Summative assessments.

Supplemental Resources:

Hydrolysis
Using a Hoffman apparatus to separate H_2O into H_2 and O_2, students can observe that the rate of H_2 production is double that of O_2 production because of the proportion of mole ratios.

Reaction Rates

Endo- & Exothermic Rxn Activation Energy Animations

<u>PH Chem</u>, Teacher Demo, TE p 546, "Use of Heat & Catalyst in a Reaction"

MnO_2 Catalysis
Observe and explain how MnO_2 greatly increases the rate of decomposition of H_2O_2 to H_2O and O_2. Note that the MnO_2 continues to function in this way with fresh H_2O_2 because it is not changed itself.

5. What will we do if students already know it?
Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

EDUCATIONAL SERVICES

Department:	**Science**		
Course Title:	**Advanced Chemistry**	Course Number:	**0320**
Unit Title:	Unit 9: Chemical Equilibrium		

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

- Describe and give analogies of dynamic equilibrium where changes are always occurring, but overall numbers remain constant.
- Explain that equilibrium occurs in chemical reactions when forward and reverse reactions are both occurring at the same rate.
- Explain that even though reactants and products are still being formed and consumed, the concentrations of

each reactant and product remain constant over time at equilibrium

- Explain that LeChatelier's principle states that when an equilibrium is stressed or disturbed, the system will shift to relieve the stress and create a new equilibrium balance.
- Cite ways to disturb equilibrium and the corrective shifts that occur.
- Explain that if the concentration of a reactant in a system at dynamic equilibrium is decreased, products will be consumed to produce more of that reactant.
- Explain that since heat is a reactant in endothermic reactions, increasing the temperature (adding heat) will shift an endothermic reaction toward the products.
- Explain that endothermic reactions are exothermic in the reverse direction.
- Explain that for reactions with gaseous reactants or products, an increase in pressure will shift the equilibrium toward the smaller number of moles of gas, alleviating the pressure stress.
- Explain that if both sides of an equilibrium have an equal number of moles of gas, changing the pressure will not affect the equilibrium.
- Explain that increasing pressure by adding an inert gas, such as argon, will not change the partial pressures of reactant or product gases and will therefore have no effect on the equilibrium.

- *Explain that since concentrations remain constant in a system at chemical equilibrium, a mathematical constant can be used to describe the equilibrium.*
- *Write an equilibrium expression for the balanced equation of a system at equilibrium:*

$$aA + bB \rightleftharpoons cC + dD$$

in the following form:

$$Keq = \frac{[C]^c\ [D]^d}{[A]^a\ [B]2^b}$$

- *Recall that when calculating Keq, only gaseous substances and aqueous solutions are considered.*
- *Explain that a large Keq means that there are more products than reactants, which shows that the forward reaction goes nearly to completion and little reverse reaction occurs.*
- *Explain that a small Keq means that the reverse reaction goes almost to completion, or little forward reaction occurs.*
- *Explain the Ksp is the solubility product that describes equilibrium for salts in solution.*

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of what happens during equilibrium on the molecular level and be able to predict effects due to changes based on Le Chatelier's principle.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Equilibrium & Le Chatlier's Principle Lab [see p. 47]

PH Chem, Lab 38, p 237, "Disturbing Equilibrium"

PH Chem, Small-Scale Lab 29, p 203, "Le Chatlier's Principle and Chemical Equilibrium"

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments.

Supplemental Resources:

Equilibrium Java Applet

Le Chatelier's Principle

PH Chem, Lab 39, p 243, "A Solubility Product Constant"

5. What will we do if students already know it?
Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

EL DORADO UNION HIGH SCHOOL DISTRICT

EDUCATIONAL SERVICES

Department:	**Science**		
Course Title:	**Advanced Chemistry**	Course Number:	**0320**
Unit Title:	Unit 10: Organic Chemistry and Biochemistry		

Content Area Standards (Please identify the source): List content standards students will master in this unit.

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-6. Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

F6143A 10/31/11; Rev. 11/5/15

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

Define polymers as large molecules made up of smaller groups of atoms, including carbon, connected together.

- Recall that proteins, nucleic acids, and starch are polymeric molecules.
- Explain that all polymeric molecules are made up of various combinations of a relatively small number of simple subunits.
- Identify specific polymeric molecules and the subunits that comprise them (i.e., starch and its simple sugar subunits).

- *Recall that each name for an organic molecule is made up of a prefix and a suffix.*
- *Recall that the prefix tells the number of carbons in the longest continuous chain within the molecule.*
- *Recall the prefixes for the first ten simple hydrocarbons:*
  meth- *one carbon*
  eth- *two carbons*
  prop- *three carbons*
  but- *four carbons*
  (etc.)
- *Recall that the suffix indicates the kind of bond between carbon atoms:*
  -ane *single bonds*
  -ene *double bonds*
  -yne *triple bonds*
- *Explain that benzene, C_6H_6, is a flat hexagonally shaped molecule of six carbons bonded by alternate single and double bonds.*
- *Explain that many compounds can be built by substitutions on straight-chain hydrocarbons and benzene rings.*
- Explain that carbon's four bonding electrons and four vacancies available to form bonds give it the ability to form stable covalent bonds – single or multiple – with other carbon atoms and with atoms of other elements.
- Explain how the presence of single, double, and triple bonds determines the geometry (and flexibility) of carbon-based molecules.
- Recall that there is an enormous diversity of carbon-based compounds: over 16 million are known.
- Recall simple hydrocarbon molecules, like methane and ethane.
- Recall biological polymers, like proteins and nucleic acids.
- Recall manufactured polymers, like polyester, nylon, and polyethylene.
- Recall that proteins are large, single-stranded polymers often made up of thousands of relatively small subunits called **amino acids**.
- Explain that the bond attaching two amino acids, known as a **peptide bond**, is identical for any pair of amino acids.
- Explain that the variation in the composition of different amino acids and the order in which they are connected gives protein molecules their unique shapes and properties.
- Explain that the shape and properties of a protein determine its functions, which are essential to the life of an organism.
- Recall that the blueprint for building protein molecules is deoxyribonucleic acid (DNA).
- Explain that biotechnology and molecular biology are advancing rapidly as more is learned about DNA, amino acid sequences, and the resulting shapes and functions of proteins.

Instructional Strategies: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of organic chemistry and nomenclature.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Organic Synthesis Lab [see p. 47]

PH Chem, Class Activity, p 727, "Halocarbon Structures and Names"

Ethical Analysis Essay or Debate of Current Issue (possible)
[See description on p. 45, in Maj. Writ. Assig. and Perf-Based Projects sections.]

PH Chem, Teacher Demo, TE p 751, "Making Nylon"

PH Chem, Small-Scale LAB, p 753, "Polymers"

PH Chem, Lab 50, p 299, "Esters of Carboxylic Acids"

Creating Structures
Given names of various organic compounds, like ethylenediaminetetraacetate (EDTA), pairs of students compete to come up with the correct structures.

Polymer Lab- Rubber Bouncy Balls

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments.

Supplemental Resources:

Polymers by David A. Katz

Polymer Properties
Use molecular models to investigate how single bonds can rotate and double bonds lock a specific geometry. Investigate the structures of soft and rigid plastics, noting how the type carbon bonding present causes those properties.

Material Science & Technology

Denature of De Beast
Research how proteins denature when over-heated (cooking) or exposed to acids (ceviche)

5. What will we do if students already know it?
Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.

EDUCATIONAL SERVICES

Department: **Science**

Course Title: **Advanced Chemistry** Course Number: **0320**

Unit Title: Unit 11: Nuclear Processes

Content Area Standards (Please identify the source): List content standards students will master in this unit.

The students will demonstrate mastery of the following content standards:

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author make and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical process.

WHST.9-12. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or typing a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale in infer the strength of electrical forces between particles.

HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the process of fission, fusion, and radioactive decay.

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Unit Outline: A detailed descriptive summary of all topics covered in the unit. Explain what the students will learn, know and be able to do.

- Explain why there must be a very strong force holding the protons and neutrons of an atomic nucleus together.
- Explain that the **strong nuclear force** must be stronger that electrostatic repulsion.
- Explain that the strong nuclear force acts protons, between neutrons, and between protons and neutrons.
- Explain that the strong nuclear force has a very limited range (comparable to the size of an atomic nucleus) so that the attraction only occurs when protons and neutrons are next to each other as they are within a nucleus.

- Explain how atomic nuclei can be changed by natural or human means.
  - Describe **fusion** reactions as two nuclei coming together and merging to form a heavier nucleus.
  - *Explain that fusion occurs naturally in stars or in man-made particle accelerators. (LBUSD)*
  - Describe **fission** reactions as a heavy nucleus splitting apart to form two (or more) lighter nuclei.
  - *Explain that fission occurs naturally during the radioactive decay of unstable elements or in man-made fission reactors. (LBUSD)*
- Explain that although the total number of nucleons (protons and neutrons) remains the same after a fission or fusion reaction, there is a small loss of mass, which is converted into energy.
- Explain that the equation, $\mathbf{E=mc^2}$, gives the relationship between the "lost " mass and the energy released by a nuclear reaction.
- Explain that nuclear reactions involve more than one million times greater energy than chemical reactions.
- Define the <u>binding energy</u> of a nucleus as the amount of energy released when a nucleus is formed from protons and neutrons, *OR* the amount of energy that would be required to separate all the nucleons in a nucleus.
- Define isotopes of an element as atoms with the same number of protons (and therefore the same element), but different numbers of neutrons (giving them different masses).
- Explain that isotopes occur in nature and can be made by humans.
- Explain that isotopes can be stable or unstable.
- Explain that less stable isotopes (**parent isotopes**) undergo radioactive decay to produce more stable isotopes of another element (**daughter products**), which can be either stable or radioactive.
- Explain that radioactive isotopes found in nature either have a long half-life, or are the daughter product of a parent with a long half-life.

Identify the naturally occurring radioactive isotopes.

- Explain that high energy, radioactive isotopes transform to more stable isotopes by emitting particles from the nucleus.
- Identify the three most common types of radioactive decay:

-helium-4 nuclei	-alpha radiation
-electrons or positrons	-beta radiation
-high energy -electromagnetic rays	-gamma radiation

- Write equations and determine the products for radioactive decay.
- Explain that alpha decay produces nuclei with two fewer protons and two fewer neutrons. For example:

$$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\alpha \text{ (or } {}^{4}_{2}\mathrm{He})$$

- Explain why beta decay produces nuclei with the same number of nucleons, but with one more proton or one less proton. For example:

$$^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}\beta \text{ (or } {}^{0}_{-1}\mathrm{e})$$

$$^{234}_{91}\mathrm{Pa} \rightarrow {}^{234}_{92}\mathrm{U} + {}^{0}_{-1}\beta \text{ (or } {}^{0}_{-1}\mathrm{e})$$

Explain that the nuclei produced by alpha and beta decay often emit gamma rays, which do not change the number of nucleons in the isotope, but bring the nucleus to a lower energy state.

- Explain that alpha, beta, and gamma rays are **ionizing radiation** because they produce trails of ions of atoms and molecules as they pass through.
- Explain that these changes at the atomic level can cause damage in the surrounding materials.
- Recall that the energy of particles emitted by radioactive decay is typically on the order of 1MeV (equal to 1.6×10^{-13} joule), which is enough energy to ionize up to a half million atoms.

α

- Recall that alpha particles ($^{4}_{2}\alpha$) have the shortest ranges and are stopped by matter that is only a few millimeters thick or even paper.
- Explain that alpha particles deposit all their energy along a relatively short path, creating a great deal of ionization damage along that short path.
- Explain that alpha radiation is dangerous if ingested or inhaled.
- Recall that radon-222 is a naturally occurring alpha radiation hazard in some regions.

β

- Recall that beta particles ($^{0}_{-1}\beta$ or $^{0}_{+1}\beta$) have longer ranges than alpha particles and typically penetrate several centimeters into matter.
- Recall that beta particles are about 2000 times smaller than protons and are either negatively charged electrons or their antimatter counterpart, positively charged positrons.
- Explain that beta particles are high-energy electrons that are moving too fast to be constrained by the normal principles of electrical conductivity until matter stops them.
- Explain that the longer ranges of beta particles mean that beta particles will deposit their energy and spread ionization over a greater distance of material.

γ

- Recall that gamma rays can penetrate matter up to several meters thick.
- Recall that gamma rays are high-energy photons with no electric charge and no rest mass.
- Explain that gamma rays travel unimpeded until they strike an electron or nucleus, which absorbs all or some of its energy and ionizes neighboring atoms.
- Explain that living organisms can be protected from ionizing radiation by shielding and increasing distance from radiation sources
- *Explain that radioactive decay transforms the initial (parent) nuclei of a substance into more stable (daughter) nuclei at a rate that gives a characteristic half-life.*
- *Define half-life as the time required for one-half of the parent atoms to decay to daughter atoms.*
- *Explain that one-half of the remaining parent atoms at any given observation point will decay to produce daughter atoms in the next half-life period.*
- *Explain that it is only possible to predict the proportion of atoms that will undergo decay, not the actual number of atoms (i.e., 50% of parent atoms remain after one half-life, 25% remain after two half-lives).*
- *Explain that the intensity of radiation coming off of a radiation source is related to the half-life and can be used to extrapolate the number of radioactive parent atoms originally present.*
- *Recall that protons and neutrons are made up of particles called **quarks**.*
- *Recall that quarks come in six different types, but only the <u>up quark</u> and the <u>down quark</u> are involved in normal matter.*
- *Recall that all common matter in the material is made up of just three fundamental particles: the up quark, the down quark, and the electron.*

<u>Instructional Strategies</u>: Indicate how the Instructional Strategies support the delivery of the curriculum and the course goals. Indicate how assignments support the Anchor Standards.

Students will participate in labs, activities and direct instruction that will show student understanding of basic nuclear changes and the nature of radioactivity.

The following are potential labs and activity ideas which may be included in the course curriculum (other relevant labs and activities not listed here may be included at instructor´s discretion):

Isotope Lab

Ethical Analysis Essay or Debate of Current Issue (possible)
[See description on p. 45, in Maj. Writ. Assig. and Perf-Based Projects sections.]

PH Chem, Small-Scale Lab, p 287, "Half Lives and Reaction Rates"

PH Chem, Inquiry Activity, p 798, "Simulating Radioactive Decay"

Decay Race

- Groups of students select one member to compete for them. Teacher gives a starting element and rapidly gives a series of α, β, and the occasional γ emission. Students are rewarded who determine the final product correctly the most times.

Assessments: Describe the Formative and Summative assessments that will be used to demonstrate learning and mastery of the standards.

Frequent checks for understanding will be used. These may take the form of warm-ups, games, quizzes, investigations, self and peer evaluation, research and engineering projects, and classroom presentations.

Interventions: Describe methods used to support students who fail to master unit Formative and Summative assessments.

ABCs of Nuclear Science

Fusion Basics

Radionuclide (Radioisotope)

Radioactive Basics

PH Chem, Lab 52, p 311, "Radioactivity and Radiation"

Risks & Benefits
Students research and discuss the risks and benefits of medical and industrial uses made from the ionizing radiation of nuclear reactions.

Penetration and Shielding Observations
Use video to demonstrate the penetration ability of the different forms of ionizing radiation and how proper shielding is engineered. This can be accompanied by Geiger counter observations and measurements using weak radiation sources.

Ionizing Radiation

Interactive Atom Builder

Decay

5. What will we do if students already know it?
Students will assist in mentoring, peer teaching, conducting independent projects approved by the instructor.