

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

COURSE DESCRIPTION

Course Title: AP Chemistry

Course Number: 00336

Course Prerequisites: Completion of Advanced Inorganic and Advance Organic Chemistry with an average of 80% or higher or permission of the principal.

Course Description: Advanced Placement Chemistry provides able and motivated students with the opportunity to pursue college-level chemistry studies while still in high school. This course is a college-level laboratory program that enables students to receive college credit by passing the Advanced Placement Examination with appropriate scores in May of the school year. This course is taught to the AP College Board Standards found at <https://apcentral.collegeboard.org/courses/ap-chemistry/course>

Suggested Grade Level: Grades 11-12

Length of Course: Two Semesters

Units of Credit: 1

PDE Certification and Staffing Policies and Guidelines (CSPG) Required Teacher Certifications:

CSPG 34 Chemistry

To find the CSPG information, go to [CSPG](#)

Certification verified by the WCSD Human Resources Department: ☒ Yes ☐ No

WCSD STUDENT DATA SYSTEM INFORMATION

Course Level: AP (1) GPA +10%

Mark Types: Check all that apply.

☒ F – Final Average ☒ MP – Marking Period ☒ EXM – Final Exam

GPA Type: ☐ GPAEL-GPA Elementary ☐ GPAML-GPA for Middle Level ☐ NHS-National Honor Society

☒ UGPA-Non-Weighted Grade Point Average ☒ GPA-Weighted Grade Point Average

State Course Code: 03106

To find the State Course Code, go to [State Course Code](#), download the Excel file for SCED, click on SCED 6.0 tab, and choose the correct code that corresponds with the course.

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

TEXTBOOKS AND SUPPLEMENTAL MATERIALS

Board Approved Textbooks, Software, and Materials:

Title: Chemistry: A Molecular Approach
Publisher: Pearson
ISBN #: 978-0-13-442903-8
Copyright Date: 2017
WCSD Board Approval Date: 5/14/2018

Supplemental Materials: The College Board: AP Chemistry Course and Exam Description; Lab Books: Randall, Jack. Advanced Chemistry with Vernier. Oregon: Vernier Software and Technology, 2004. The College Board: AP Chemistry Guided Inquiry Experiments: Applying the Science Practices. 2013. Vonderbrink, Sally Ann. Laboratory Experiments for Advanced Placement Chemistry. Batavia: Flinn Scientific, Inc., 1995. **Podcast DVD Source:** The Flipped Chemistry Videos of Jon Bergmann & Aaron Sams

Curriculum Document

WCSD Board Approval:

Date Finalized: 1/10/2025
Date Approved: 2/10/2025
Implementation Year: 2025-2026

SPECIAL EDUCATION, 504, and GIFTED REQUIREMENTS

The teacher shall make appropriate modifications to instruction and assessment based on a student's Individual Education Plan (IEP), Chapter 15 Section 504 Plan (504), and/or Gifted Individual Education Plan (GIEP).

SCOPE AND SEQUENCE OF CONTENT AND CONCEPTS

Marking Period 1

- Atomic Structure and Properties
- Compound Structure and Properties
- Properties of Substances and Mixtures

Marking Period 2

- Chemical Reactions
- Kinetics

Marking Period 3

- Thermochemistry
- Equilibrium

Marking Period 4

- Acids and Bases
- Thermodynamics and Electrochemistry

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Standards/Eligible Content and Skills

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
The mole allows different units to be compared.	SCI.9-12.SPQ-1	MP1
Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.	SCI.9-12.SPQ-1.A	MP1
One cannot count particles directly while performing laboratory work. Thus, there must be a connection between the masses of substances reacting and the actual number of particles undergoing chemical changes.	SCI.9-12.SPQ-1.A.1	MP1
Avogadro's number ($N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$) provides the connection between the number of moles in a pure sample of a substance and the number of constituent particles (or formula units) of that substance.	SCI.9-12.SPQ-1.A.2	MP1
Expressing the mass of an individual atom or molecule in atomic mass units (amu) is useful because the average mass in amu of one particle (atom or molecule) or formula unit of a substance will always be numerically equal to the molar mass of that substance in grams.	SCI.9-12.SPQ-1.A.3	MP1
Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes.	SCI.9-12.SPQ-1.B	MP1
The mass spectrum of a sample containing a single element can be used to determine the identity of the isotopes of that element and the relative abundance of each isotope in nature.	SCI.9-12.SPQ-1.B.1	MP1
The average atomic mass of an element can be estimated from the weighted average of the isotopic masses using the mass of each isotope and its relative abundance.	SCI.9-12.SPQ-1.B.2	MP1
Chemical formulas identify substances by their unique combination of atoms.	SCI.9-12.SPQ-2	MP1
Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.	SCI.9-12.SPQ-2.A	MP1
Some pure substances are composed of individual molecules, while others consist of atoms or ions held together in fixed proportions as described by a formula unit.	SCI.9-12.SPQ-2.A.1	MP1
According to the law of definite proportions, the ratio of the masses of the constituent elements in any pure sample of that compound is always the same.	SCI.9-12.SPQ-2.A.2	MP1
The chemical formula that lists the lowest whole number ratio of atoms of the elements in a compound is the empirical formula.	SCI.9-12.SPQ-2.A.3	MP1
Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.	SCI.9-12.SPQ-2.B	MP1
While pure substances contain molecules or formula units of a single type, mixtures contain molecules or formula units of two or more types, whose relative proportions can vary.	SCI.9-12.SPQ-2.B.1	MP1
Elemental analysis can be used to determine the relative numbers of atoms in a substance and to determine its purity.	SCI.9-12.SPQ-2.B.2	MP1

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Atoms and molecules can be identified by their electron distribution and energy.	SCI.9-12.SAP-1	MP1
Represent the electron configuration of an element or ions of an element using the Aufbau principle.	SCI.9-12.SAP-1.A	MP1
The atom is composed of negatively charged electrons and a positively charged nucleus that is made of protons and neutrons.	SCI.9-12.SAP-1.A.1	MP1
Coulomb's law is used to calculate the force between two charged particles.	SCI.9-12.SAP-1.A.2	MP1
In atoms and ions, the electrons can be thought of as being in "shells (energy levels)" and "subshells (sublevels)," as described by the electron configuration. Inner electrons are called core electrons, and outer electrons are called valence electrons. The electron configuration is explained by quantum mechanics, as delineated in the Aufbau principle, and exemplified in the periodic table of the elements.	SCI.9-12.SAP-1.A.3	MP1
The relative energy required to remove an electron from different subshells of an atom or ion or from the same subshell in different atoms or ions (ionization energy) can be estimated through a qualitative application of Coulomb's law. This energy is related to the distance from the nucleus and the effective (shield) charge of the nucleus.	SCI.9-12.SAP-1.A.4	MP1
Explain the relationship between the photoelectron spectrum of an atom or ion and:	SCI.9-12.SAP-1.B	MP1
The energies of the electrons in a given shell can be measured experimentally with photoelectron spectroscopy (PES). The position of each peak in the PES spectrum is related to the energy required to remove an electron from the corresponding subshell, and the height of each peak is (ideally) proportional to the number of electrons in that subshell.	SCI.9-12.SAP-1.B.1	MP1
The electron configuration of the species.	SCI.9-12.SAP-1.B.1a	MP1
The interactions between the electrons and the nucleus.	SCI.9-12.SAP-1.B.1b	MP1
The periodic table shows patterns in electronic structure and trends in atomic properties.	SCI.9-12.SAP-2	MP1
Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity.	SCI.9-12.SAP-2.A	MP1
The organization of the periodic table is based on the recurring properties of the elements and explained by the pattern of electron configurations and the presence of completely or partially filled shells (and subshells) of electrons in atoms.	SCI.9-12.SAP-2.A.1	MP1
Trends in atomic properties within the periodic table (periodicity) can be qualitatively understood through the position of the element in the periodic table, Coulomb's law, the shell model, and the concept of shielding/effective nuclear charge. These properties include: Ionization energy, atomic and ionic radii, electron affinity, and electronegativity.	SCI.9-12.SAP-2.A.2	MP1
The periodicity is useful to predict/estimate values of properties in the absence of data.	SCI.9-12.SAP-2.A.3	MP1

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Explain the relationship between trends in the reactivity of elements and periodicity.	SCI.9-12.SAP-2.B	MP1
The likelihood that two elements will form a chemical bond is determined by the interactions between the valence electrons and nuclei of elements.	SCI.9-12.SAP-2.B.1	MP1
Elements in the same column of the periodic table tend to form analogous compounds.	SCI.9-12.SAP-2.B.2	MP1
Typical charges of atoms in ionic compounds are governed by their location on the periodic table and the number of valence electrons.	SCI.9-12.SAP-2.B.3	MP1
Atoms or ions bond due to interactions between them, forming molecules.	SCI.9-12.SAP-3	MP1
Explain the relationship between the type of bonding and the properties of the elements participating in the bond.	SCI.9-12.SAP-3.A	MP1
Electronegativity values for the representative elements increase going from left to right across a period and decrease going down a group. These trends can be understood qualitatively through the electronic structure of the atoms, the shell model, and Coulomb's law.	SCI.9-12.SAP-3.A.1	MP1
Valence electrons shared between atoms of similar electronegativity constitute a nonpolar covalent bond.	SCI.9-12.SAP-3.A.2	MP1
Valence electrons shared between atoms of unequal electronegativity constitute a polar covalent bond.	SCI.9-12.SAP-3.A.3	MP1
The atom with a higher electronegativity will develop a partial negative charge relative to the other atom in the bond.	SCI.9-12.SAP-3.A.3a	MP1
In single bonds, greater differences in electronegativity lead to greater bond dipoles.	SCI.9-12.SAP-3.A.3b	MP1
All polar bonds have some ionic character, and the difference between ionic and covalent bonding is not distinct but rather a continuum.	SCI.9-12.SAP-3.A.3c	MP1
The difference in electronegativity is not the only factor in determining if a bond should be designated as ionic or covalent. Generally, bonds between a metal and nonmetal are ionic, and bonds between two nonmetals are covalent. Examination of the properties of a compound is the best way to characterize the type of bonding.	SCI.9-12.SAP-3.A.4	MP1
In a metallic solid, the valence electrons from the metal atoms are considered to be delocalized and not associated with any individual atom.	SCI.9-12.SAP-3.A.5	MP1
Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength.	SCI.9-12.SAP-3.B	MP1
A graph of potential energy versus the distance between atoms is a useful representation for describing the interactions between atoms. Such graphs illustrate both the equilibrium bond length (the separation between atoms at which the potential energy is lowest) and the bond energy (the energy required to separate the atoms).	SCI.9-12.SAP-3.B.1	MP1
In a covalent bond, the bond length is influenced by both the size of the atom's core and the bond order (i.e., single, double, triple). Bonds with a higher order are shorter and have larger bond energies.	SCI.9-12.SAP-3.B.2	MP1

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Coulomb's law can be used to understand the strength of interactions between cations and anions.	SCI.9-12.SAP-3.B.3	MP1
Because the interaction strength is proportional to the charge on each ion, larger charges lead to stronger interactions.	SCI.9-12.SAP-3.B.3a	MP1
Because the interaction strength increases as the distance between the centers of the ions (nuclei) decreases, smaller ions lead to stronger interactions.	SCI.9-12.SAP-3.B.3b	MP1
Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constituent ions.	SCI.9-12.SAP.3.C	MP1
The cations and anions in an ionic crystal are arranged in a systematic, periodic 3-D array that maximizes the attractive forces among cations and anions while minimizing the repulsive forces.	SCI.9-12.SAP.3.C.1	MP1
Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance.	SCI.9-12.SAP.3.D	MP1
Metallic bonding can be represented as an array of positive metal ions surrounded by delocalized valence electrons (i.e., a "sea of electrons").	SCI.9-12.SAP.3.D.1	MP1
Interstitial alloys form between atoms of different radii, where the smaller atoms fill the interstitial spaces between the larger atoms (e.g., with steel in which carbon occupies the interstices in iron).	SCI.9-12.SAP.3.D.2	MP1
Substitutional alloys form between atoms of comparable radius, where one atom substitutes for the other in the lattice. (In certain brass alloys, other elements, usually zinc, substitute for copper.)	SCI.9-12.SAP.3.D.3	MP1
Molecular compounds are arranged based on Lewis diagrams and Valence Shell Electron Pair Repulsion (VSEPR) theory.	SCI.9-12.SAP.4	MP1
Represent a molecule with a Lewis diagram.	SCI.9-12.SAP.4.A	MP1
Lewis diagrams can be constructed according to an established set of principles.	SCI.9-12.SAP.4.A.1	MP1
Represent a molecule with a Lewis diagram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures.	SCI.9-12.SAP.4.B	MP1
In cases where more than one equivalent Lewis structure can be constructed, resonance must be included as a refinement to the Lewis structure. In many such cases, this refinement is needed to provide qualitatively accurate predictions of molecular structure and properties.	SCI.9-12.SAP.4.B.1	MP1
The octet rule and formal charge can be used as criteria for determining which of several possible valid Lewis diagrams provides the best model for predicting molecular structure and properties.	SCI.9-12.SAP.4.B.2	MP1
As with any model, there are limitations to the use of the Lewis structure model, particularly in cases with an odd number of valence electrons.	SCI.9-12.SAP.4.B.3	MP1
Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities:	SCI.9-12.SAP.4.C	MP1
VSEPR theory uses the Coulombic repulsion between electrons as a basis for predicting the arrangement of electron pairs around a central atom.	SCI.9-12.SAP.4.C.1	MP1

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Both Lewis diagrams and VSEPR theory must be used for predicting electronic and structural properties of many covalently bonded molecules and polyatomic ions, including the following: Molecular geometry, bond angles, relative bond energies based on bond order, relative bond lengths, presence of a dipole moment, and hybridization of valence orbitals of the molecule.	SCI.9-12.SAP.4.C.2	MP1
The terms “hybridization” and “hybrid atomic orbital” are used to describe the arrangement of electrons around a central atom. When the central atom is sp hybridized, its ideal bond angles are 180°; for sp ² hybridized atoms the bond angles are 120°; and for sp ³ hybridized atoms the bond angles are 109.5°.	SCI.9-12.SAP.4.C.3	MP1
Bond formation is associated with overlap between atomic orbitals. In multiple bonds, such overlap leads to the formation of both sigma and pi bonds. The overlap is stronger in sigma than pi bonds, which is reflected in sigma bonds having greater bond energy than pi bonds. The presence of a pi bond also prevents the rotation of the bond and leads to structural isomers.	SCI.9-12.SAP.4.C.4	MP1
Explain structural properties of molecules.	SCI.9-12.SAP.4.C.4a	MP1
Explain electron properties of molecules.	SCI.9-12.SAP.4.C.4b	MP1
Intermolecular forces can explain the physical properties of a material.	SCI.9-12.SAP.5	MP1
Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when:	SCI.9-12.SAP.5.A	MP1
London dispersion forces are a result of the Coulombic interactions between temporary, fluctuating dipoles. London dispersion forces are often the strongest net intermolecular force between large molecules.	SCI.9-12.SAP.5.A.1	MP1
Dispersion forces increase with increasing contact area between molecules and with increasing polarizability of the molecules.	SCI.9-12.SAP.5.A.1a	MP1
The polarizability of a molecule increases with an increasing number of electrons in the molecule; and the size of the electron cloud. It is enhanced by the presence of pi bonding.	SCI.9-12.SAP.5.A.1b	MP1
The term “London dispersion forces” should not be used synonymously with the term “van der Waals forces.”	SCI.9-12.SAP.5.A.1c	MP1
The dipole moment of a polar molecule leads to additional interactions with other chemical species.	SCI.9-12.SAP.5.A.2	MP1
Dipole-induced dipole interactions are present between a polar and nonpolar molecule. These forces are always attractive. The strength of these forces increases with the magnitude of the dipole of the polar molecule and with the polarizability of the nonpolar molecule.	SCI.9-12.SAP.5.A.2a	MP1
Dipole-dipole interactions are present between polar molecules. The interaction strength depends on the magnitudes of the dipoles and their relative orientation. Interactions between polar molecules are typically greater than those between nonpolar molecules of comparable size because these interactions act in addition to London dispersion forces.	SCI.9-12.SAP.5.A.2b	MP1
Ion-dipole forces of attraction are present between ions and polar molecules. These tend to be stronger than dipole-dipole forces.	SCI.9-12.SAP.5.A.2c	MP1

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
The relative strength and orientation dependence of dipole-dipole and ion-dipole forces can be understood qualitatively by considering the sign of the partial charges responsible for the molecular dipole moment, and how these partial charges interact with an ion or with an adjacent dipole.	SCI.9-12.SAP.5.A.3	MP1
Hydrogen bonding is a strong type of intermolecular interaction that exists when hydrogen atoms covalently bonded to the highly electronegative atoms (N, O, and F) are attracted to the negative end of a dipole formed by the electronegative atom (N, O, and F) in a different molecule, or a different part of the same molecule.	SCI.9-12.SAP.5.A.4	MP1
In large biomolecules, noncovalent interactions may occur between different molecules or between different regions of the same large biomolecule.	SCI.9-12.SAP.5.A.5	MP1
The molecules are of the same chemical species.	SCI.9-12.SAP.5.A.5a	MP1
The molecules are of two different chemical species.	SCI.9-12.SAP.5.A.5b	MP1
Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles.	SCI.9-12.SAP.5.B	MP1
Many properties of liquids and solids are determined by the strengths and types of intermolecular forces present.	SCI.9-12.SAP.5.B.1	MP1
Particulate-level representations, showing multiple interacting chemical species, are a useful means to communicate or understand how intermolecular interactions help to establish macroscopic properties.	SCI.9-12.SAP.5.B.2	MP1
Due to strong interactions between ions, ionic solids tend to have low vapor pressures, high melting points, and high boiling points.	SCI.9-12.SAP.5.B.3	MP1
In covalent network solids, atoms are covalently bonded together into a three-dimensional network (e.g., diamond) or layers of two-dimensional networks (e.g., graphite).	SCI.9-12.SAP.5.B.4	MP1
Molecular solids are composed of distinct, individual units of covalently bonded molecules attracted to each other through relatively weak intermolecular forces.	SCI.9-12.SAP.5.B.5	MP1
Metallic solids are good conductors of electricity and heat, due to the presence of free valence electrons.	SCI.9-12.SAP.5.B.6	MP1
In large biomolecules or polymers, noncovalent interactions may occur between different molecules or between different regions of the same large biomolecule.	SCI.9-12.SAP.5.B.7	MP1
Matter exists in three states: solid, liquid, and gas, and their differences are influenced by variances in spacing and motion of the molecules.	SCI.9-12.SAP.6	MP1
Represent the differences between solid, liquid, and gas phases using a particulate-level model.	SCI.9-12.SAP.6.A	MP1
Solids can be crystalline, where the particles are arranged in a regular three-dimensional structure, or they can be amorphous, where the particles do not have a regular, orderly arrangement.	SCI.9-12.SAP.6.A.1	MP1
The constituent particles in liquids are in close contact with each other, and they are continually moving and colliding.	SCI.9-12.SAP.6.A.2	MP1

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
The solid and liquid phases for a particular substance typically have similar molar volume because, in both phases, the constituent particles are in close contact at all times.	SCI.9-12.SAP.6.A.3	MP1
In the gas phase, the particles are in constant motion. Their frequencies of collision and the average spacing between them are dependent on temperature, pressure, and volume.	SCI.9-12.SAP.6.A.4	MP1
Gas properties are explained macroscopically—using the relationships among pressure, volume, temperature, moles, gas constant—and molecularly by the motion of the gas.	SCI.9-12.SAP.7	MP1
Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law.	SCI.9-12.SAP.7.A	MP1
The macroscopic properties of ideal gases are related through the ideal gas law: $PV = nRT$.	SCI.9-12.SAP.7.A.1	MP1
In a sample containing a mixture of ideal gases, the pressure exerted by each component (the partial pressure) is independent of the other components. Therefore, the total pressure of the sample is the sum of the partial pressures.	SCI.9-12.SAP.7.A.2	MP1
Graphical representations of the relationships between P , V , T , and n are useful to describe gas behavior.	SCI.9-12.SAP.7.A.3	MP1
Explain the relationship between the motion of particles and the macroscopic properties of gases with:	SCI.9-12.SAP.7.B	MP1
The kinetic molecular theory (KMT) relates the macroscopic properties of gases to motions of the particles in the gas. The Maxwell-Boltzmann distribution describes the distribution of the kinetic energies of particles at a given temperature.	SCI.9-12.SAP.7.B.1	MP1
All the particles in a sample of matter are in continuous, random motion. The average kinetic energy of a particle is related to its average velocity by the equation: $KE = \frac{1}{2}mv^2$.	SCI.9-12.SAP.7.B.2	MP1
The Kelvin temperature of a sample of matter is proportional to the average kinetic energy of the particles in the sample.	SCI.9-12.SAP.7.B.3	MP1
The Maxwell-Boltzmann distribution provides a graphical representation of the energies/velocities of particles at a given temperature.	SCI.9-12.SAP.7.B.4	MP1
The kinetic molecular theory (KMT).	SCI.9-12.SAP.7.B.4a	MP1
A particulate model.	SCI.9-12.SAP.7.B.4b	MP1
A graphical representation.	SCI.9-12.SAP.7.B.4c	MP1
Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes.	SCI.9-12.SAP.7.C	MP1
The ideal gas law does not explain the actual behavior of real gases. Deviations from the ideal gas law may result from interparticle attractions among gas molecules, particularly at conditions that are close to those resulting in condensation. Deviations may also arise from particle volumes, particularly at extremely high pressures.	SCI.9-12.SAP.7.C.1	MP1
Interactions between intermolecular forces influence the solubility and separation of mixtures.	SCI.9-12.SPQ-3	MP1

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Calculate the number of solute particles, volume, or molarity of solutions.	SCI.9-12.SPQ-3.A	MP1
Solutions, sometimes called homogeneous mixtures, can be solids, liquids, or gases. In a solution, the macroscopic properties do not vary throughout the sample. In a heterogeneous mixture, the macroscopic properties depend on location in the mixture.	SCI.9-12.SPQ-3.A.1	MP1
Solution composition can be expressed in a variety of ways; molarity is the most common method used in the laboratory.	SCI.9-12.SPQ-3.A.2	MP1
Using particulate models for mixtures:	SCI.9-12.SPQ-3.B	MP1
Particulate representations of solutions communicate the structure and properties of solutions, by illustration of the relative concentrations of the components in the solution and drawings that show interactions among the components.	SCI.9-12.SPQ-3.B.1	MP1
Represent interactions between components.	SCI.9-12.SPQ-3.B.1a	MP1
Represent concentrations of components.	SCI.9-12.SPQ-3.B.1b	MP1
Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles.	SCI.9-12.SPQ-3.C	MP1
The components of a liquid solution cannot be separated by filtration. They can, however, be separated using processes that take advantage of differences in the intermolecular interactions of the components.	SCI.9-12.SPQ-3.C.1	MP1
Chromatography (paper, thin-layer, and column) separates chemical species by taking advantage of the differential strength of intermolecular interactions between and among the components of the solution (the mobile phase) and with the surface components of the stationary phase.	SCI.9-12.SPQ-3.C.1a	MP1
Distillation separates chemical species by taking advantage of the differential strength of intermolecular interactions between and among the components and the effects these interactions have on the vapor pressures of the components in the mixture.	SCI.9-12.SPQ-3.C.1b	MP1
Substances with similar intermolecular interactions tend to be miscible or soluble in one another.	SCI.9-12.SPQ-3.C.2	MP1
Spectroscopy can determine the structure and concentration in a mixture of a chemical species.	SCI.9-12.SAP-8	MP1
Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with that region.	SCI.9-12.SAP-8.A	MP1
Differences in absorption or emission of photons in different spectral regions are related to the different types of molecular motion or electronic transition:	SCI.9-12.SAP-8.A.1	MP1
Microwave radiation is associated with transitions in molecular rotational levels.	SCI.9-12.SAP-8.A.1a	MP1
Infrared radiation is associated with transitions in molecular vibrational levels.	SCI.9-12.SAP-8.A.1b	MP1
Ultraviolet/visible radiation is associated with transitions in electronic energy levels.	SCI.9-12.SAP-8.A.1c	MP1

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule.	SCI.9-12.SAP-8.B	MP1
When a photon is absorbed (or emitted) by an atom or molecule, the energy of the species is increased (or decreased) by an amount equal to the energy of the photon.	SCI.9-12.SAP-8.B.1	MP1
The wavelength of the electromagnetic wave is related to its frequency and the speed of light by the equation: The energy of a photon is related to the frequency of the electromagnetic wave through Planck's equation ($E = h\nu$). $c = \lambda\nu$.	SCI.9-12.SAP-8.B.2	MP1
Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity.	SCI.9-12.SAP-8.C	MP1
The Beer-Lambert law relates the absorption of light by a solution to three variables according to the equation: The molar absorptivity ϵ describes how intensely a sample of molecules or ions absorbs light of a specific wavelength. The path length b and concentration c are proportional to the number of absorbing species. $A = \epsilon bc$.	SCI.9-12.SAP-8.C.1	MP1
In most experiments the path length and wavelength of light are held constant. In such cases, the absorbance is proportional only to the concentration of absorbing molecules or ions.	SCI.9-12.SAP-8.C.2	MP1
A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations.	SCI.9-12.TRA-1	MP2
Identify evidence of chemical and physical changes in matter.	SCI.9-12.TRA-1.A	MP2
A physical change occurs when a substance undergoes a change in properties but not a change in composition. Changes in the phase of a substance (solid, liquid, gas) or formation/separation of mixtures of substances are common physical changes.	SCI.9-12.TRA-1.A.1	MP2
A chemical change occurs when substances are transformed into new substances, typically with different compositions. Production of heat or light, formation of a gas, formation of a precipitate, and/or color change provide possible evidence that a chemical change has occurred.	SCI.9-12.TRA-1.A.2	MP2
Represent changes in matter with a balanced chemical or net ionic equation:	SCI.9-12.TRA-1.B	MP2
All physical and chemical processes can be represented symbolically by balanced equations.	SCI.9-12.TRA-1.B.1	MP2
Chemical equations represent chemical changes. Equations thus demonstrate that mass is conserved in chemical reactions.	SCI.9-12.TRA-1.B.2	MP2
Balanced molecular, complete ionic, and net ionic equations are differing symbolic forms used to represent a chemical reaction. The form used to represent the reaction depends on the context in which it is to be used.	SCI.9-12.TRA-1.B.3	MP2
For physical changes.	SCI.9-12.TRA-1.B.3a	MP2
For given information about the identity of the reactants and/or product.	SCI.9-12.TRA-1.B.3b	MP2
For ions in a given chemical reaction.	SCI.9-12.TRA-1.B.3c	MP2
Represent a given chemical reaction or physical process with a consistent particulate model.	SCI.9-12.TRA-1.C	MP2

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Balanced chemical equations in their various forms can be translated into symbolic particulate representations.	SCI.9-12.TRA-1.C.1	MP2
Explain the relationship between macroscopic characteristics and bond interactions for:	SCI.9-12.TRA-1.D	MP2
Processes that involve the breaking and/or formation of chemical bonds are typically classified as chemical processes. Processes that involve only changes in intermolecular interactions, such as phase changes, are typically classified as physical processes.	SCI.9-12.TRA-1.D.1	MP2
Sometimes physical processes involve the breaking of chemical bonds.	SCI.9-12.TRA-1.D.2	MP2
Chemical processes.	SCI.9-12.TRA-1.D.2a	MP2
Physical processes.	SCI.9-12.TRA-1.D.2b	MP2
When a substance changes into a new substance, or when its properties change, no mass is lost or gained.	SCI.9-12.SPQ-4	MP2
Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.	SCI.9-12.SPQ-4.A	MP2
Because atoms must be conserved during a chemical process, it is possible to calculate product amounts by using known reactant amounts, or to calculate reactant amounts given known product amounts.	SCI.9-12.SPQ-4.A.1	MP2
Coefficients of balanced chemical equations contain information regarding the proportionality of the amounts of substances involved in the reaction. These values can be used in chemical calculations involving the mole concept.	SCI.9-12.SPQ-4.A.2	MP2
Stoichiometric calculations can be combined with the ideal gas law and calculations involving molarity to quantitatively study gases and solutions.	SCI.9-12.SPQ-4.A.3	MP2
Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion.	SCI.9-12.SPQ-4.B	MP2
Titration may be used to determine the concentration of an analyte in solution.	SCI.9-12.SPQ-4.B.1	MP2
A substance can change into another substance through different processes, and the change itself can be classified by the sort of processes that produced it.	SCI.9-12.TRA-2	MP2
Identify a reaction as acid-base, oxidation-reduction, or precipitation.	SCI.9-12.TRA-2.A	MP2
Acid-base reactions involve transfer of one or more protons between chemical species.	SCI.9-12.TRA-2.A.1	MP2
Oxidation-reduction reactions involve transfer of one or more electrons between chemical species, as indicated by changes in oxidation numbers of the involved species.	SCI.9-12.TRA-2.A.2	MP2
In a redox reaction, electrons are transferred from the species that is oxidized to the species that is reduced.	SCI.9-12.TRA-2.A.5	MP2
Oxidation numbers may be assigned to each of the atoms in the reactants and products.	SCI.9-12.TRA-2.A.4	MP2
Precipitation reactions frequently involve mixing ions in aqueous solution to produce an insoluble or sparingly soluble ionic compound. All sodium, potassium, ammonium, and nitrate salts are soluble in water.	SCI.9-12.TRA-2.A.5	MP2

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Identify species as Brønsted-Lowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species.	SCI.9-12.TRA-2.B	MP2
By definition, a Brønsted-Lowry acid is a proton donor, and a Brønsted-Lowry base is a proton acceptor.	SCI.9-12.TRA-2.B.1	MP2
Only in aqueous solutions, water plays an important role in many acid-base reactions, as its molecular structure allows it to accept protons from and donate protons to dissolved species.	SCI.9-12.TRA-2.B.2	MP2
When an acid or base ionizes in water, the conjugate acid-base pairs can be identified and their relative strengths compared.	SCI.9-12.TRA-2.B.3	MP2
Represent a balanced redox reaction equation using half-reactions.	SCI.9-12.TRA-2.C	MP2
Balanced chemical equations for redox reactions can be constructed from half-reactions.	SCI.9-12.TRA-2.C.1	MP2
Some reactions happen quickly, while others happen more slowly and depend on reactant concentrations and temperature.	SCI.9-12.TRA-3	MP2
Explain the relationship between the rate of a chemical reaction and experimental parameters.	SCI.9-12.TRA-3.A	MP2
The kinetics of a chemical reaction is defined as the rate at which an amount of reactants is converted to products per unit of time.	SCI.9-12.TRA-3.A.1	MP2
The rates of change of reactant and product concentrations are determined by the stoichiometry in the balanced chemical equation.	SCI.9-12.TRA-3.A.2	MP2
The rate of a reaction is influenced by reactant concentrations, temperature, surface area, catalysts, and other environmental factors.	SCI.9-12.TRA-3.A.3	MP2
Represent experimental data with a consistent rate law expression.	SCI.9-12.TRA-3.B	MP2
Experimental methods can be used to monitor the amounts of reactants and/or products of a reaction and to determine the rate of the reaction.	SCI.9-12.TRA-3.B.1	MP2
The rate law expresses the rate of a reaction as proportional to the concentration of each reactant raised to a power.	SCI.9-12.TRA-3.B.2	MP2
The power of each reactant in the rate law is the order of the reaction with respect to that reactant. The sum of the powers of the reactant concentrations in the rate law is the overall order of the reaction.	SCI.9-12.TRA-3.B.3	MP2
The proportionality constant in the rate law is called the rate constant. The value of this constant is temperature dependent, and the units reflect the overall reaction order.	SCI.9-12.TRA-3.B.4	MP2
Comparing initial rates of a reaction is a method to determine the order with respect to each reactant.	SCI.9-12.TRA-3.B.5	MP2
Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time.	SCI.9-12.TRA-3.C	MP2
The order of a reaction can be inferred from a graph of concentration of reactant versus time.	SCI.9-12.TRA-3.C.1	MP2
If a reaction is first order with respect to a reactant being monitored, a plot of the natural log (ln) of the reactant concentration as a function of time will be linear.	SCI.9-12.TRA-3.C.2	MP2

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
If a reaction is second order with respect to a reactant being monitored, a plot of the reciprocal of the concentration of that reactant versus time will be linear.	SCI.9-12.TRA-3.C.3	MP2
The slopes of the concentration versus time data for zeroth, first, and second order reactions can be used to determine the rate constant for the reaction. First order: $\ln[A]_t - \ln[A]_0 = -kt$; Second order: $1/[A]_t - 1/[A]_0 = kt$; Zeroth order: $[A]_t - [A]_0 = -kt$	SCI.9-12.TRA-3.C.4	MP2
Half-life is a critical parameter for first order reactions because the half-life is constant and related to the rate constant for the reaction by the equation: $t_{1/2} = 0.693/k$.	SCI.9-12.TRA-3.C.5	MP2
Radioactive decay processes provide an important illustration of first order kinetics.	SCI.9-12.TRA-3.C.6	MP2
There is a relationship between the speed of a reaction and the collision frequency of particle collisions.	SCI.9-12.TRA-4	MP2
Represent an elementary reaction as a rate law expression using stoichiometry.	SCI.9-12.TRA-4.A	MP2
The rate law of an elementary reaction can be inferred from the stoichiometry of the molecules participating in a collision.	SCI.9-12.TRA-4.A.1	MP2
Elementary reactions involving the simultaneous collision of three or more particles are rare.	SCI.9-12.TRA-4.A.2	MP2
Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions.	SCI.9-12.TRA-4.B	MP2
For an elementary reaction to successfully produce products, reactants must successfully collide to initiate bond-breaking and bond-making events.	SCI.9-12.TRA-4.B.1	MP2
In most reactions, only a small fraction of the collisions leads to a reaction. Successful collisions have both sufficient energy to overcome energy barriers and orientations that allow the bonds to rearrange in the required manner.	SCI.9-12.TRA-4.B.2	MP2
The Maxwell-Boltzmann distribution curve describes the distribution of particle energies.	SCI.9-12.TRA-4.B.3	MP2
Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile.	SCI.9-12.TRA-4.C	MP2
Elementary reactions typically involve the breaking of some bonds and the forming of new ones.	SCI.9-12.TRA-4.C.1	MP2
The reaction coordinate is the axis along which the complex set of motions involved in rearranging reactants to form products can be plotted.	SCI.9-12.TRA-4.C.2	MP2
The energy profile gives the energy along the reaction coordinate, which typically proceeds from reactants, through a transition state, to products. The energy difference between the reactants and the transition state is the activation energy for the forward reaction.	SCI.9-12.TRA-4.C.3	MP2

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
The Arrhenius equation relates the temperature dependence of the rate of an elementary reaction to the activation energy needed by molecular collisions to reach the transition state.	SCI.9-12.TRA-4.C.4	MP2
Many chemical reactions occur through a series of elementary reactions. These elementary reactions when combined form a chemical equation.	SCI.9-12.TRA-5	MP2
Identify the components of a reaction mechanism.	SCI.9-12.TRA-5.A	MP2
A reaction mechanism consists of a series of elementary reactions, or steps, which occur in sequence. The components may include reactants, intermediates, products, and catalysts.	SCI.9-12.TRA-5.A.1	MP2
The elementary steps when combined should align with the overall balanced equation of a chemical reaction.	SCI.9-12.TRA-5.A.2	MP2
A reaction intermediate is produced by some elementary steps and consumed by others, such that it is present only while a reaction is occurring.	SCI.9-12.TRA-5.A.3	MP2
Experimental detection of a reaction intermediate is a common way to build evidence in support of one reaction mechanism over an alternative mechanism.	SCI.9-12.TRA-5.A.4	MP2
Identify the rate law for a reaction from a mechanism in which the first step is rate limiting.	SCI.9-12.TRA-5.B	MP2
For reaction mechanisms in which each elementary step is irreversible, or in which the first step is rate limiting, the rate law of the reaction is set by the molecularity of the slowest elementary step (i.e., the rate-limiting step).	SCI.9-12.TRA-5.B.1	MP2
Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting.	SCI.9-12.TRA-5.C	MP2
If the first elementary reaction is not rate limiting, approximations (such as steady state) must be made to determine a rate law expression.	SCI.9-12.TRA-5.C.1	MP2
Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile.	SCI.9-12.TRA-5.D	MP2
Knowledge of the energetics of each elementary reaction in a mechanism allows for the construction of an energy profile for a multistep reaction.	SCI.9-12.TRA-5.D.1	MP2
The speed at which a reaction occurs can be influenced by a catalyst.	SCI.9-12.ENE-1	MP2
Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism.	SCI.9-12.ENE-1.A	MP2
In order for a catalyst to increase the rate of a reaction, the addition of the catalyst must increase the number of effective collisions and/or provide a reaction path with a lower activation energy relative to the original reaction coordinate.	SCI.9-12.ENE-1.A.1	MP2
In a reaction mechanism containing a catalyst, the net concentration of the catalyst is constant.	SCI.9-12.ENE-1.A.2	MP2
Some catalysts accelerate a reaction by binding to the reactant(s).	SCI.9-12.ENE-1.A.3	MP2
Some catalysts involve covalent bonding between the catalyst and the reactant(s).	SCI.9-12.ENE-1.A.4	MP2

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
In surface catalysis, a reactant or intermediate binds to, or forms a covalent bond with, the surface.	SCI.9-12.ENE-1.A.5	MP2
Changes in a substance's properties or change into a different substance requires an exchange of energy.	SCI.9-12.ENE-2	MP3
Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation.	SCI.9-12.ENE-2.A	MP3
Temperature changes in a system indicate energy changes.	SCI.9-12.ENE-2.A.1	MP3
Energy changes in a system can be described as endothermic and exothermic processes such as the heating or cooling of a substance, phase changes, or chemical transformations.	SCI.9-12.ENE-2.A.2	MP3
When a chemical reaction occurs, the energy of the system either decreases (exothermic reaction), increases (endothermic reaction), or remains the same.	SCI.9-12.ENE-2.A.3	MP3
The formation of a solution may be an exothermic or endothermic process, depending on the relative strengths of intermolecular/interparticle interactions before and after the dissolution process.	SCI.9-12.ENE-2.A.4	MP3
Represent a chemical or physical transformation with an energy diagram.	SCI.9-12.ENE-2.B	MP3
A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process.	SCI.9-12.ENE-2.B.1	MP3
Explain the relationship between the transfer of thermal energy and molecular collisions.	SCI.9-12.ENE-2.C	MP3
The particles in a warmer body have a greater average kinetic energy than those in a cooler body.	SCI.9-12.ENE-2.C.1	MP3
Collisions between particles in thermal contact can result in the transfer of energy. This process is called "heat transfer," "heat exchange," or "transfer of energy as heat."	SCI.9-12.ENE-2.C.2	MP3
Eventually, thermal equilibrium is reached as the particles continue to collide. At thermal equilibrium, the average kinetic energy of both bodies is the same, and hence, their temperatures are the same.	SCI.9-12.ENE-2.C.3	MP3
Calculate the heat q absorbed or released by a system undergoing heating/cooling based on the amount of the substance, the heat capacity, and the change in temperature.	SCI.9-12.ENE-2.D	MP3
The heating of a cool body by a warmer body is an important form of energy transfer between two systems. The amount of heat transferred between two bodies may be quantified by the heat transfer equation: Calorimetry experiments are used to measure the transfer of heat. $q = mc\Delta T$.	SCI.9-12.ENE-2.D.1	MP3
The first law of thermodynamics states that energy is conserved in chemical and physical processes.	SCI.9-12.ENE-2.D.2	MP3
The transfer of a given amount of thermal energy will not produce the same temperature change in equal masses of matter with differing specific heat capacities.	SCI.9-12.ENE-2.D.3	MP3
Heating a system increases the energy of the system, while cooling a system decreases the energy of the system.	SCI.9-12.ENE-2.D.4	MP3

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
The specific heat capacity of a substance and the molar heat capacity are both used in energy calculations.	SCI.9-12.ENE-2.D.5	MP3
Chemical systems change their energy through three main processes: heating/cooling, phase transitions, and chemical reactions.	SCI.9-12.ENE-2.D.6	MP3
Explain changes in the heat q absorbed or released by a system undergoing a phase transition based on the amount of the substance in moles and the molar enthalpy of the phase transition.	SCI.9-12.ENE-2.E	MP3
Energy must be transferred to a system to cause a substance to melt (or boil). The energy of the system therefore increases as the system undergoes a solid-to-liquid (or liquid-to-gas) phase transition. Likewise, a system releases energy when it freezes (or condenses). The energy of the system decreases as the system undergoes a liquid-to-solid (or gas-to-liquid) phase transition. The temperature of a pure substance remains constant during a phase change.	SCI.9-12.ENE-2.E.1	MP3
Calculate the heat q absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and the molar enthalpy of reaction.	SCI.9-12.ENE-2.F	MP3
The enthalpy change of a reaction gives the amount of heat energy released (for negative values) or absorbed (for positive values) by a chemical reaction at constant pressure.	SCI.9-12.ENE-2.F.1	MP3
The energy exchanged in a chemical transformation is required to break and form bonds.	SCI.9-12.ENE-3	MP3
Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction.	SCI.9-12.ENE-3.A	MP3
During a chemical reaction, bonds are broken and/or formed, and these events change the potential energy of the system.	SCI.9-12.ENE-3.A.1	MP3
The average energy required to break all of the bonds in the reactant molecules can be estimated by adding up the average bond energies of all the bonds in the reactant molecules. Likewise, the average energy released in forming the bonds in the product molecules can be estimated. If the energy released is greater than the energy required, the reaction is exothermic. If the energy required is greater than the energy released, the reaction is endothermic.	SCI.9-12.ENE-3.A.2	MP3
Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation.	SCI.9-12.ENE-3.B	MP3
Tables of standard enthalpies of formation can be used to calculate the standard enthalpies of reactions.	SCI.9-12.ENE-3.B.1	MP3
Represent a chemical or physical process as a sequence of steps.	SCI.9-12.ENE-3.C	MP3
When a reaction is reversed, the enthalpy change stays constant in magnitude but becomes reversed in mathematical sign. When two (or more) reactions are added to obtain an overall reaction, the individual enthalpy changes of each reaction are added to obtain the net enthalpy of the overall reaction.	SCI.9-12.ENE-3.C.1	MP3
Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps.	SCI.9-12.ENE-3.D	MP3

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
When the products of a reaction are at a different temperature than their surroundings, they exchange energy with the surroundings to reach thermal equilibrium. Thermal energy is transferred to the surroundings from the products of an exothermic reaction. Thermal energy is transferred from the surroundings to the products of an endothermic reaction.	SCI.9-12.ENE-3.D.1	MP3
Some reactions can occur in both forward and reverse directions, sometimes proceeding in each direction simultaneously.	SCI.9-12.TRA-6	MP3
Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations.	SCI.9-12.TRA-6.A	MP3
Many observable processes are reversible.	SCI.9-12.TRA-6.A.1	MP3
When equilibrium is reached, no observable changes occur in the system. Reactants and products are simultaneously present, and the concentrations or partial pressures of all species remain constant.	SCI.9-12.TRA-6.A.2	MP3
The equilibrium state is dynamic. The forward and reverse processes continue to occur at equal rates, resulting in no net observable change.	SCI.9-12.TRA-6.A.3	MP3
Graphs of concentration, partial pressure, or rate of reaction versus time for simple chemical reactions can be used to understand the establishment of chemical equilibrium.	SCI.9-12.TRA-6.A.4	MP3
Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions.	SCI.9-12.TRA-6.B	MP3
If the rate of the forward reaction is greater than the reverse reaction, then there is a net conversion of reactants to products. If the rate of the reverse reaction is greater than that of the forward reaction, then there is a net conversion of products to reactants. An equilibrium state is reached when these rates are equal.	SCI.9-12.TRA-6.B.1	MP3
A system at equilibrium depends on the relationships between concentrations, partial pressures of chemical species, and equilibrium constant K.	SCI.9-12.TRA-7	MP3
Represent the reaction quotient Q_c or Q_p , for a reversible reaction, and the corresponding equilibrium expressions K_c or K_p .	SCI.9-12.TRA-7.A	MP3
The reaction quotient Q_c describes the relative concentrations of reaction species at any time. For gas phase reactions, the reaction quotient may instead be written in terms of pressures as Q_p . The reaction quotient tends toward the equilibrium constant such that at equilibrium $K_c = Q_c$ and $K_p = Q_p$.	SCI.9-12.TRA-7.A.1	MP3
The reaction quotient does not include substances whose concentrations (or partial pressures) are independent of the amount, such as for solids and pure liquids.	SCI.9-12.TRA-7.A.2	MP3
Calculate K_c or K_p based on experimental observations of concentrations or pressures at equilibrium.	SCI.9-12.TRA-7.B	MP3

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Equilibrium constants can be determined from experimental measurements of the concentrations or partial pressures of the reactants and products at equilibrium.	SCI.9-12.TRA-7.B.1	MP3
Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium.	SCI.9-12.TRA-7.C	MP3
Some equilibrium reactions have very large K values and proceed essentially to completion. Others have very small K values and barely proceed at all.	SCI.9-12.TRA-7.C.1	MP3
Represent a multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction.	SCI.9-12.TRA-7.D	MP3
When a reaction is reversed, K is inverted.	SCI.9-12.TRA-7.D.1	MP3
When the stoichiometric coefficients of a reaction are multiplied by a factor c, K is raised to the power c.	SCI.9-12.TRA-7.D.2	MP3
When reactions are added together, the K of the resulting overall reaction is the product of the Ks for the reactions that were summed.	SCI.9-12.TRA-7.D.3	MP3
Since the expressions for K and Q have identical mathematical forms, all valid algebraic manipulations of K also apply to Q.	SCI.9-12.TRA-7.D.4	MP3
Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant.	SCI.9-12.TRA-7.E	MP3
The concentrations or partial pressures of species at equilibrium can be predicted given the balanced reaction, initial concentrations, and the appropriate K.	SCI.9-12.TRA-7.E.1	MP3
Represent a system undergoing a reversible reaction with a particulate model.	SCI.9-12.TRA-7.F	MP3
Particulate representations can be used to describe the relative numbers of reactant and product particles present prior to and at equilibrium, and the value of the equilibrium constant.	SCI.9-12.TRA-7.F.1	MP3
Systems at equilibrium respond to external stresses to offset the effect of the stress.	SCI.9-12.TRA-8	MP3
Identify the response of a system at equilibrium to an external stress, using Le Châtelier's principle.	SCI.9-12.TRA-8.A	MP3
Le Châtelier's principle can be used to predict the response of a system to stresses such as addition or removal of a chemical species, change in temperature, change in volume/pressure of a gas-phase system, or dilution of a reaction system.	SCI.9-12.TRA-8.A.1	MP3
Le Châtelier's principle can be used to predict the effect that a stress will have on experimentally measurable properties such as pH, temperature, and color of a solution.	SCI.9-12.TRA-8.A.2	MP3
Explain the relationships between Q, K, and the direction in which a reversible reaction will proceed to reach equilibrium.	SCI.9-12.TRA-8.B	MP3
A disturbance to a system at equilibrium causes Q to differ from K, thereby taking the system out of equilibrium. The system responds by bringing Q back into agreement with K, thereby establishing a new equilibrium state.	SCI.9-12.TRA-8.B.1	MP3

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Some stresses, such as changes in concentration, cause a change in Q only. A change in temperature causes a change in K . In either case, the concentrations or partial pressures of species redistribute to bring Q and K back into equality.	SCI.9-12.TRA-8.B.2	MP3
The dissolution of a salt is a reversible process that can be influenced by environmental factors such as pH or other dissolved ions.	SCI.9-12.SPQ-5	MP3
Calculate the solubility of a salt based on the value of K_{sp} for the salt.	SCI.9-12.SPQ-5.A	MP3
The dissolution of a salt is a reversible process whose extent can be described by K_{sp} , the solubility-product constant.	SCI.9-12.SPQ-5.A.1	MP3
The solubility of a substance can be calculated from the K_{sp} for the dissolution process. This relationship can also be used to predict the relative solubility of different substances.	SCI.9-12.SPQ-5.A.2	MP3
The solubility rules can be quantitatively related to K_{sp} , in which K_{sp} values >1 correspond to soluble salts.	SCI.9-12.SPQ-5.A.3	MP3
Identify the solubility of a salt, and/or the value of K_{sp} for the salt, based on the concentration of a common ion already present in solution.	SCI.9-12.SPQ-5.B	MP3
The solubility of a salt is reduced when it is dissolved into a solution that already contains one of the ions present in the salt. The impact of this "common-ion effect" on solubility can be understood qualitatively using Le Châtelier's principle or calculated from the K_{sp} for the dissolution process.	SCI.9-12.SPQ-5.B.1	MP3
Identify the qualitative effect of changes in pH on the solubility of a salt.	SCI.9-12.SPQ-5.C	MP3
The solubility of a salt is pH sensitive when one of the constituent ions is a weak acid or base. These effects can be understood qualitatively using Le Châtelier's principle.	SCI.9-12.SPQ-5.C.1	MP3
Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process.	SCI.9-12.SPQ-5.D	MP3
The free energy change (ΔG°) for dissolution of a substance reflects a number of factors: the breaking of the intermolecular interactions that hold the solid together, the reorganization of the solvent around the dissolved species, and the interaction of the dissolved species with the solvent.	SCI.9-12.SPQ-5.D.1	MP3
The chemistry of acids and bases involves reversible proton-transfer reactions, with equilibrium concentrations being related to the strength of the acids and bases involved.	SCI.9-12.SAP-9	MP4
Calculate the values of pH and pOH , based on K_w and the concentration of all species present in a neutral solution of water.	SCI.9-12.SAP-9.A	MP4
The concentrations of hydronium ion and hydroxide ion are often reported as pH and pOH , respectively.	SCI.9-12.SAP-9.A.1	MP4
Water autoionizes with an equilibrium constant K_w .	SCI.9-12.SAP-9.A.2	MP4
In pure water, $pH = pOH$ is called a neutral solution. At 25°C , $pK_w = 14.0$ and thus $pH = pOH = 7.0$.	SCI.9-12.SAP-9.A.3	MP4
The value of K_w is temperature dependent, so the pH of pure, neutral water will deviate from 7.0 at temperatures other than 25°C .	SCI.9-12.SAP-9.A.4	MP4

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base.	SCI.9-12.SAP-9.B	MP4
Molecules of a strong acid (e.g., HCl, HBr, HI, HClO ₄ , H ₂ SO ₄ , and HNO ₃) will completely ionize in aqueous solution to produce hydronium ions.	SCI.9-12.SAP-9.B.1	MP4
When dissolved in solution, strong bases (e.g., group I and II hydroxides) completely dissociate to produce hydroxide ions.	SCI.9-12.SAP-9.B.2	MP4
Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base.	SCI.9-12.SAP-9.C	MP4
Weak acids react with water to produce hydronium ions.	SCI.9-12.SAP-9.C.1	MP4
A solution of a weak acid involves equilibrium between an un-ionized acid and its conjugate base. The equilibrium constant for this reaction is K_a , often reported as pK_a . The pH of a weak acid solution can be determined from the initial acid concentration and the pK_a .	SCI.9-12.SAP-9.C.2	MP4
Weak bases react with water to produce hydroxide ions in solution.	SCI.9-12.SAP-9.C.3	MP4
A solution of a weak base involves equilibrium between an un-ionized base and its conjugate acid. The equilibrium constant for this reaction is K_b , often reported as pK_b . The pH of a weak base solution can be determined from the initial base concentration and the pK_b .	SCI.9-12.SAP-9.C.4	MP4
The percent ionization of a weak acid (or base) can be calculated from its pK_a (pK_b) and the initial concentration of the acid (base).	SCI.9-12.SAP-9.C.5	MP4
Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases.	SCI.9-12.SAP-9.D	MP4
When a strong acid and a strong base are mixed, they react quantitatively in a reaction represented by the equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$. The pH of the resulting solution may be determined from the concentration of excess reagent.	SCI.9-12.SAP-9.D.1	MP4
When a weak acid and a strong base are mixed, they react quantitatively in a reaction represented by the equation: $HA(aq) + OH^-(aq)$ is in equilibrium to $A^-(aq) + H_2O(l)$.	SCI.9-12.SAP-9.D.2	MP4
When a weak base and a strong acid are mixed, they will react quantitatively in a reaction represented by the equation: $B(aq) + H_3O^+(aq)$ is in equilibrium to $HB^+(aq) + H_2O(l)$.	SCI.9-12.SAP-9.D.3	MP4
When a weak acid and a weak base are mixed, they will react to an equilibrium state whose reaction may be represented by the equation: $HA(aq) + B(aq)$ is in equilibrium to $A^-(aq) + HB^+(aq)$.	SCI.9-12.SAP-9.D.4	MP4
Explain results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components.	SCI.9-12.SAP-9.E	MP4
An acid-base reaction can be carried out under controlled conditions in a titration.	SCI.9-12.SAP-9.E.1	MP4
At the equivalence point, the number of moles of titrant added is equal to the number of moles of analyte originally present.	SCI.9-12.SAP-9.E.2	MP4
For titrations of weak acids/bases, it is useful to consider the point halfway to the equivalence point, that is, the half-equivalence point.	SCI.9-12.SAP-9.E.3	MP4

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
For polyprotic acids, titration curves can be used to determine the number of acidic protons.	SCI.9-12.SAP-9.E.4	MP4
Explain the relationship between the strength of an acid or base and the structure of the molecule or ion.	SCI.9-12.SAP-9.F	MP4
The protons on a molecule that will participate in acid-base reactions, and the relative strength of these protons, can be inferred from the molecular structure.	SCI.9-12.SAP-9.F.1	MP4
Strong acids (such as HCl, HBr, HI, HClO ₄ , H ₂ SO ₄ , and HNO ₃) have very weak conjugate bases that are stabilized by electronegativity, inductive effects, resonance, or some combination thereof.	SCI.9-12.SAP-9.F.1a	MP4
Carboxylic acids are one common class of weak acid.	SCI.9-12.SAP-9.F.1b	MP4
Strong bases (such as group I and II hydroxides) have very weak conjugate acids.	SCI.9-12.SAP-9.F.1c	MP4
Common weak bases include nitrogenous bases such as ammonia as well as carboxylate ions.	SCI.9-12.SAP-9.F.1d	MP4
Electronegative elements tend to stabilize the conjugate base relative to the conjugate acid, and so increase acid strength.	SCI.9-12.SAP-9.F.1e	MP4
A buffered solution resists changes to its pH when small amounts of acid or base are added.	SCI.9-12.SAP-10	MP4
Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pK _a of the conjugate acid or the pK [subscript b] of the conjugate base.	SCI.9-12.SAP-10.A	MP4
The protonation state of an acid or base (i.e., the relative concentrations of HA and A ⁻) can be predicted by comparing the pH of a solution to the pK _a of the acid in that solution.	SCI.9-12.SAP-10.A.1	MP4
Acid-base indicators are substances that exhibit different properties (such as color) in their protonated versus deprotonated state, making that property respond to the pH of a solution.	SCI.9-12.SAP-10.A.2	MP4
Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution.	SCI.9-12.SAP-10.B	MP4
A buffer solution contains a large concentration of both members in a conjugate acid-base pair.	SCI.9-12.SAP-10.B.1	MP4
Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer.	SCI.9-12.SAP-10.C	MP4
The pH of the buffer is related to the pK _a of the acid and the concentration ratio of the conjugate acid-base pair.	SCI.9-12.SAP-10.C.1	MP4
Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and conjugate base components of the solution.	SCI.9-12.SAP-10.D	MP4
Increasing the concentration of the buffer components (while keeping the ratio of these concentrations constant) keeps the pH of the buffer the same but increases the capacity of the buffer to neutralize added acid or base.	SCI.9-12.SAP-10.D.1	MP4

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
When a buffer has more conjugate acid than base, it has a greater buffer capacity for addition of added base than acid. When a buffer has more conjugate base than acid, it has a greater buffer capacity for addition of added acid than base.	SCI.9-12.SAP-10.D.2	MP4
Some chemical or physical processes cannot occur without intervention.	SCI.9-12.ENE-4	MP4
Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes.	SCI.9-12.ENE-4.A	MP4
Entropy increases when matter becomes more dispersed.	SCI.9-12.ENE-4.A.1	MP4
Entropy increases when energy is dispersed.	SCI.9-12.ENE-4.A.2	MP4
Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process.	SCI.9-12.ENE-4.B	MP4
The entropy change for a process can be calculated from the absolute entropies of the species involved before and after the process occurs.	SCI.9-12.ENE-4.B.1	MP4
Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔG° .	SCI.9-12.ENE-4.C	MP4
The Gibbs free energy change for a chemical process in which all the reactants and products are present in a standard state (as pure substances, as solutions of 1.0 M concentration, or as gases at a pressure of 1.0 atm (or 1.0 bar)) is given the symbol ΔG° .	SCI.9-12.ENE-4.C.1	MP4
The standard Gibbs free energy change for a chemical or physical process is a measure of thermodynamic favorability.	SCI.9-12.ENE-4.C.2	MP4
The standard Gibbs free energy change for a physical or chemical process may also be determined from the standard Gibbs free energy of formation of the reactants and products.	SCI.9-12.ENE-4.C.3	MP4
In some cases, it is necessary to consider both enthalpy and entropy to determine if a process will be thermodynamically favored.	SCI.9-12.ENE-4.C.4	MP4
Knowing the values of ΔH° and ΔS° for a process at a given temperature allows ΔG° to be calculated directly.	SCI.9-12.ENE-4.C.5	MP4
In general, the temperature conditions for a process to be thermodynamically favored ($\Delta G^\circ < 0$) can be predicted from the signs of ΔH° and ΔS° as shown in the table below: In cases where $\Delta H^\circ < 0$ and $\Delta S^\circ > 0$, no calculation of ΔG° is necessary to determine that the process is thermodynamically favored ($\Delta G^\circ < 0$). In cases where $\Delta H^\circ > 0$ and $\Delta S^\circ < 0$ no calculation of ΔG° is necessary to determine that the process is thermodynamically unfavored ($\Delta G^\circ > 0$).	SCI.9-12.ENE-4.C.6	MP4
Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate.	SCI.9-12.ENE-4.D	MP4
Many processes that are thermodynamically favored do not occur to any measurable extent, or they occur at extremely slow rates.	SCI.9-12.ENE-4.D.1	MP4
Processes that are thermodynamically favored, but do not proceed at a measurable rate, are under "kinetic control."	SCI.9-12.ENE-4.D.2	MP4
The relationship between ΔG° and K can be used to determine favorability of a chemical or physical transformation.	SCI.9-12.ENE-5	MP4

WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Explain whether a process is thermodynamically favored using the relationships between K , ΔG° , and T .	SCI.9-12.ENE-5.A	MP4
The phrase “thermodynamically favored” ($\Delta G^\circ < 0$) means that the products are favored at equilibrium ($K > 1$).	SCI.9-12.ENE-5.A.1	MP4
The equilibrium constant is related to free energy by the equations $\Delta G^\circ = -RT \ln K$.	SCI.9-12.ENE-5.A.2	MP4
Connections between K and ΔG° can be made qualitatively through estimation. When ΔG° is near zero, the equilibrium constant will be close to 1. When ΔG° is much larger or much smaller than RT , the value of K deviates strongly from 1.	SCI.9-12.ENE-5.A.3	MP4
Processes with $\Delta G^\circ < 0$ favor products (i.e., $K > 1$) and those with $\Delta G^\circ > 0$ favor reactants (i.e., $K < 1$).	SCI.9-12.ENE-5.A.4	MP4
Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes.	SCI.9-12.ENE-5.B	MP4
An external source of energy can be used to make a thermodynamically unfavorable process occur. Examples include:	SCI.9-12.ENE-5.B.1	MP4
Electrical energy to drive an electrolytic cell or charge a battery.	SCI.9-12.ENE-5.B.1a	MP4
Light to drive the overall conversion of carbon dioxide to glucose in photosynthesis.	SCI.9-12.ENE-5.B.1b	MP4
A desired product can be formed by coupling a thermodynamically unfavorable reaction that produces that product to a favorable reaction (e.g., the conversion of ATP to ADP in biological systems).	SCI.9-12.ENE-5.B.2	MP4
Electrical energy can be generated by chemical reactions.	SCI.9-12.ENE-6	MP4
Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell.	SCI.9-12.ENE-6.A	MP4
Each component of an electrochemical cell (electrodes, solutions in the half-cells, salt bridge, voltage/current measuring device) plays a specific role in the overall functioning of the cell. The operational characteristics of the cell (galvanic vs. electrolytic, direction of electron flow, reactions occurring in each half-cell, change in electrode mass, evolution of a gas at an electrode, ion flow through the salt bridge) can be described at both the macroscopic and particulate levels.	SCI.9-12.ENE-6.A.1	MP4
Galvanic, sometimes called voltaic, cells involve a thermodynamically favored reaction, whereas electrolytic cells involve a thermodynamically unfavored reaction. Visual representations of galvanic and electrolytic cells are tools of analysis to identify where half-reactions occur and in what direction current flows.	SCI.9-12.ENE-6.A.2	MP4
For all electrochemical cells, oxidation occurs at the anode and reduction occurs at the cathode.	SCI.9-12.ENE-6.A.3	MP4
Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell.	SCI.9-12.ENE-6.B	MP4

WARREN COUNTY SCHOOL DISTRICT		
PLANNED INSTRUCTION		
Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Electrochemistry encompasses the study of redox reactions that occur within electrochemical cells.	SCI.9-12.ENE-6.B.1	MP4
The standard cell potential of electrochemical cells can be calculated by identifying the oxidation and reduction half-reactions and their respective standard reduction potentials.	SCI.9-12.ENE-6.B.2	MP4
ΔG° (standard Gibbs free energy change) is proportional to the negative of the cell potential for the redox reaction from which it is constructed.	SCI.9-12.ENE-6.B.3	MP4
Explain the relationship between deviations from standard cell conditions and changes in the cell potential.	SCI.9-12.ENE-6.C	MP4
In a real system under nonstandard conditions, the cell potential will vary depending on the concentrations of the active species.	SCI.9-12.ENE-6.C.1	MP4
Equilibrium arguments such as Le Châtelier's principle do not apply to electrochemical systems, because the systems are not in equilibrium.	SCI.9-12.ENE-6.C.2	MP4
The standard cell potential E° corresponds to the standard conditions of $Q = 1$. As the system approaches equilibrium, the magnitude (i.e., absolute value) of the cell potential decreases, reaching zero at equilibrium (when $Q = K$).	SCI.9-12.ENE-6.C.3	MP4
Algorithmic calculations using the Nernst equation are insufficient to demonstrate an understanding of electrochemical cells under nonstandard conditions.	SCI.9-12.ENE-6.C.4	MP4
Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell.	SCI.9-12.ENE-6.D	MP4
Faraday's laws can be used to determine the stoichiometry of the redox reaction occurring in an electrochemical cell with respect to the following: Number of electrons transferred, mass of material deposited on or removed from an electrode, current, time elapsed, or charge of ionic species.	SCI.9-12.ENE-6.D.1	MP4

ASSESSMENTS

PDE Academic Standards, Assessment Anchors, and Eligible Content: The teacher must be knowledgeable of the PDE Academic Standards, Assessment Anchors, and Eligible Content and incorporate them regularly into planned instruction.

Formative Assessments: The teacher will utilize a variety of assessment methods to conduct in-process evaluations of student learning.

Effective formative assessments for this course include: Bell ringers, exit tickets, notice and wonderings, progress checks, quizzes, lab assignments, teacher questioning, class discussions, peer assessments, and model trackers.

Summative Assessments: The teacher will utilize a variety of assessment methods to evaluate student learning at the end of an instructional task, lesson, and/or unit.

Effective summative assessments for this course include: Lab reports, CER responses, chapter tests, district marking period assessments, culminating tasks, and projects.