PASSAIC COUNTY TECHNICAL-VOCATIONAL SCHOOLS

AP Chemistry

Course # 0175

5 credits

2019

I. Course Description:

This AP Chemistry course is designed to be the equivalent of the general chemistry course usually taken during the first year of college. For some students, this course enables them to undertake as freshmen, second-year work in the chemistry sequence in college or to register for courses in other fields where general chemistry is a prerequisite. This course is structured around the six big ideas articulated in the AP Chemistry curriculum provided by the College Board. Students should attain a depth of understanding of the fundamentals of chemistry and reasonable competence in dealing with chemical problems. The course will also allow students to develop their ability to think clearly and to express their ideas, orally and in writing, with clarity and logic. Furthermore, the laboratory work will be equivalent to a first-year college chemistry course and will require a higher degree of technique, analysis, and accuracy than what is expected of first-year high school chemistry students. A special emphasis will be placed on the seven science practices set forth by the College Board, which capture important aspects of the work that scientists engage in, with learning objectives that combine content with inquiry and reasoning skills. This course is open to all students that have completed a year of high school chemistry and who understand, and are willing to do this, much time will be required outside the class studying, doing homework, writing reports, and finishing lab work if needed.

II. Units of Instruction:

Content Area:	AP Chemistry	**Grade(s)**	11, 12
Unit Plan Title:	Atomic Structure and Properties (Unit 1)		
NJSL Standard(s) Addressed			
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. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.] **RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)			

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts

Developing and Using Models Modeling in 9-12 builds on K-8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model to predict the relationships between systems or between components of a system (HS-PS1-1)	**PS1.A: Structure and Properties of Matter** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1)

Learning Objectives

Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept [SPQ-1.A]
Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes [SPQ-1.B]
Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance [SPQ-2.A]
Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture [SPQ-2.B]
Represent the electron configuration of an element or ions of an element using the Aufbau principle [SAP-1.A]
Explain the relationship between the photoelectron spectrum of an atom or ion and:

a. The electron configuration of the species
b. The interactions between the electrons and the nucleus [SAP-1.B]

Explain the relationship between trends in atomic properties of elements and the electronic structure and periodicity [SAP-2.A]
Explain the relationship between trends in the reactivity of elements and periodicity [SAP-2.B]

Essential Questions (3-5)

1. How does an atom's electron configuration affect its properties?
2. How does the photoelectric effect support the particle nature of light?
3. How can the electron be depicted as a wave?

Anchor Text

Chemistry: The Central Science, Twelfth Edition, Brown, Lemay, Bursten, Murphy, Woodward, Published @2012 Pearson Education, Inc.
ISBN13: 9780133447736, ISBN10: 0133447731

Informational Texts (3-5)

Barron's Preparation Guide, 9th edition Published: ISSN:2150-3362, ISBN: 978-1-4380-1066-3
Princeton Review, Cracking the AP Chemistry Exam, 2019 Edition Published: ISBN-13: 978-1524758004, ISBN-10: 1524758000
Sterling Test Prep, 9th edition, Published: ISBN-13: 978-1947556058, ISBN-10: 1947556053

Short Texts (1-3)

Suggested Formative & Summative Assessments

Formative: Homework, classwork, quizzes,
Summative: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments

Resources (websites, Blackboard, documents, etc.)

Canvas (PowerPoint, reference sheets, handouts, video links)

Labs

Lab assignments: Periodic Trends, Spectroscopy

Suggested Time Frame:	9-10 days

Content Area:	AP Chemistry	Grade(s)	11, 12
Unit Plan Title:	Molecular and Ionic Compound Structure and Properties (Unit 2)		
NJSL Standard(s) Addressed			

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. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

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. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),(HS-PS1-5)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)

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. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

MP.2 Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

MP.4 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

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. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)

HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-4)

HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-4)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts

Developing and Using Models Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2)	**PS1.A: Structure and Properties of Matter** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1- 1) **PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-2) These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2) **Energy and Matter** Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

	the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)	

Learning Objectives:

Explain the relationship between the type of bonding and the properties of the elements participating in the bond [SAP-3.A]
Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength. [SAP-3.B]
Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constituent ions [SAP-3.C]
Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance [SAP-3.D]
Represent a molecule with a Lewis Diagram [SAP-4.A]
Represent a molecular with a Lewis Diagram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures [SAP-4.B]
Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities:

a. Explain structural properties of molecules.
b. Explain electron properties of molecules. [SAP-4.C]

Essential Questions (3-5)

1. Differentiate between a molecular and ionic bond.
2. How can the properties of an ionic substance be attributed to its structure?
3. How can the properties of a molecular substance be attributed to its structure?

Anchor Text

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<u>Sterling Test Prep</u>, 9th edition, Published: ISBN-13: 978-1947556058, ISBN-10: 1947556053
Short Texts (1-3)
Suggested Formative & Summative Assessments
Formative: Homework, classwork, quizzes **Summative**: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments
Resources (websites, Blackboard, documents, etc.)
Canvas (PowerPoint, reference sheets, handouts, video links-khan academy, phet simulations)
Labs
Lab assignments: Molecular models

Suggested Time Frame:	12-13 days

Content Area:	AP Chemistry	**Grade(s)**	11, 12
Unit Plan Title:	Intermolecular Forces and Properties (Unit 3)		
NJSLStandard(s) Addressed			
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. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.] **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. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]			

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
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. (HS-PS1-3),(HS-PS1-5)
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated 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-PS1-3),(HS-PS1-6)
WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)
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. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) Planning and Carrying Out Investigations Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual,	**PS1.A: Structure and Properties of Matter** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) The structure and interactions of matter at the bulk scale are determined by electrical	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-3)

mathematical, physical, and empirical models. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)	forces within and between atoms. (HS-PS1-3) **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1),(secondary to HS-PS1-3)	
Learning Objectives:		

Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when:

a. The molecules are of the same chemical species.
b. The molecules are of two different chemical species. [SAP-5.A]

Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles [SAP-5.B]

Represent the differences between solid, liquid, and gas phases using a particulate-level model [SAP-6.A]

Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law [SAP-7.A]

Explain the relationship between the motion of particles and the macroscopic properties of gases with:

a. The kinetic molecular theory (KMT)
b. A particulate model
c. A graphical representation [SAP-7.B]

Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes. [SAP-7.C]

Calculate the number of solute particles, volume, or molarity of solutions [SPQ-3.A]

Using particulate models for mixtures:

a. Represent interactions between components.
b. Represent concentrations of components. [SPQ-3.B]

Explain the relationship between the solubility of ionic and molecular compounds in aqueous and non-aqueous solvents, and the intermolecular interactions between particles. [SPQ-3.C]

Explain the relationship between the solubility of ionic and molecular compounds in aqueous and non-aqueous solvents, and the intermolecular interactions between particles. [SPQ-3.C]

Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with that region. [SAP-8.A]

Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule. [SAP-8.B]

Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity. [SAP-8.C]

Essential Questions (3-5)

1. Why does water have a high boiling point (use the concept of IMF)?
2. How do intermolecular forces determine the phase of matter?
3. When will a substance change from one phase into another?

Anchor Text

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Sterling Test Prep, 9th edition, Published: ISBN-13: 978-1947556058, ISBN-10: 1947556053

Short Texts (1-3)

Suggested Formative & Summative Assessments

Formative: Homework, classwork, quizzes
Summative: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments

Resources (websites, Blackboard, documents, etc.)

Canvas (PowerPoint, reference sheets, handouts, video links-Khan academy, phet simulations)

Labs

Lab assignments: Chromatography, determination of the molecular mass of a volatile liquid

Suggested Time Frame:	14-15 days

Content Area:	AP Chemistry	**Grade(s)**	11, 12
Unit Plan Title:	Chemical Reactions (Unit 4)		

NJSLS Standard(s) Addressed

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. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]
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. [Clarification Statement: Examples of chemical reactions could

include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]

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. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]

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. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the	**PS1.B: Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HSPS1-4),(HS-PS1-5)	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2), (HS-PS1-5) **Energy and Matter** The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)

assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)		

Learning Objectives

Identify evidence of chemical and physical changes in matter [TRA-1.A]
Represent changes in matter with a balanced chemical or net ionic equation:
a. For physical changes.
b. For given information
c. For ions in a given [TRA-1.B]
Represent a given chemical reaction or physical process with a consistent particulate model. [TRA-1.C]
Explain the relationship between macroscopic characteristics and bond interactions for:
a. Chemical processes.
b. Physical processes. [TRA-1.D]
Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process. [SPQ-4.A]
Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion. [SPQ-4.B]
Identify a reaction as acid-base, oxidation-reduction, or precipitation. [TRA-2.A]
Identify species as Brønsted Lowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species. [TRA-2.B]
Represent a balanced redox reaction equation using half-reactions. [TRA-2.C]

Essential Questions (3-5)

1. How can you tell that a reaction has taken place?
2. What is meant by a redox reaction?
3. How can you distinguish between a physical and chemical process?

Anchor Text

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Short Texts (1-3)
Suggested Formative & Summative Assessments
Formative: Homework, classwork, quizzes **Summative**: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments
Resources (websites, Blackboard, documents, etc.)
Canvas (PowerPoint, reference sheets, handouts, video links-Khan academy)
Labs
Lab assignments: Net Ionic Equations, Activity series, Copper reaction

Suggested Time Frame:	14-15 days

Course	AP Chemistry	**Grade(s)**	11, 12
Unit Plan Title:	Kinetics (Unit 5)		
NJSLS Standard(s) Addressed			
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. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]			

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. [Clarification Steatement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]
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. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]
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. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]
HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts

Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8) Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical representations of phenomena to support claims. (HS-PS1-7) Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent studentgenerated sources	**PS1.A: Structure and Properties of Matter** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) **PS1.B: Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HSPS1-4),(HS-PS1-5) The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HSPS1-5) **Energy and Matter** The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Connections to Nature of Science** Scientific Knowledge Assumes an Order and Consistency in Natural Systems Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

of evidence consistent with scientific ideas, principles, and theories. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)		

Learning Objectives
Explain the relationship between the rate of a chemical reaction and experimental parameters. [TRA-3.A] Represent experimental data with a consistent rate law expression. [TRA-3.B] Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time. [TRA-3.C] Represent an elementary reaction as a rate law expression using stoichiometry. [TRA-4.A] Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions. [TRA-4.B] Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile. [TRA-4.C] Identify the components of a reaction mechanism. [TRA-5.A] Identify the rate law for a reaction from a mechanism in which the first step is rate limiting. [TRA-5.B]

Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting. [TRA-5.C]
Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile. [TRA-5.D]
Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism. [ENE-1.A]

Essential Questions (3-5)

1. How is the rate of a reaction determined?
2. What factors determine the rate of a reaction?
3. What role do rates play in a chemical reaction?

Anchor Text

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ISBN13: 9780133447736, ISBN10: 0133447731

Informational Texts (3-5)

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Sterling Test Prep, 9th edition, Published: ISBN-13: 978-1947556058, ISBN-10: 1947556053

Short Texts (1-3)

Suggested Formative & Summative Assessments

Formative: Homework, classwork, quizzes
Summative: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments

Resources (websites, Blackboard, documents, etc.)

Canvas (PowerPoint, reference sheets, handouts, video links)

Labs

Lab assignments: Determination of Rate Law, Clock Reaction

Suggested Time Frame:	11 Days

¸	AP Chemistry	Grade(s)	11, 12
Unit Plan Title:	Thermodynamics (Unit 6)		

NJSLS Standard(s) Addressed

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. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]
HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]
HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. Develop a model based on evidence to illustrate the relationships between systems	**PS1.A: Structure and Properties of Matter** A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) **PS1.B: Chemical Reactions**	**Energy and Matter** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)

or between components of a system. (HS-PS1-4) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.	Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4) **PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4) Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a	Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1) **Connections to Nature of Science** Scientific Knowledge Assumes an Order and Consistency in Natural Systems Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)	spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1) Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-4)	

Learning Objectives
Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation. [ENE-2.A] Represent a chemical or physical transformation with an energy diagram. [ENE-2.B] Explain the relationship between the transfer of thermal energy and molecular collisions. [ENE-2.C] 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. [ENE-2.D] 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. [ENE-2.E] 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. [ENE-2.F]

Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction. [ENE-3.A]
Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation. [ENE-3.B]
Represent a chemical or physical process as a sequence of steps. [ENE-3.C]
Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps. [ENE-3.D]

Essential Questions (3-5)

1. How is a calorimeter used to measure energy that is absorbed or released?
2. What does enthalpy change mean in terms of a chemical process?
3. How is Hess's law applied to calculate enthalpy change?

Anchor Text

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Short Texts (1-3)

Suggested Formative & Summative Assessments

Formative: Homework, classwork, quizzes
Summative: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments

Resources (websites, Blackboard, documents, etc.)

Canvas (PowerPoint, reference sheets, handouts, video links)

Labs

Lab assignments: Calorimetry, Hess's Law

Suggested Time Frame:	14 Days

Course	AP Chemistry	Grade(s)	11, 12
Unit Plan Title:	Equilibrium (Unit 7)		

Learning Objectives

Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations. [TRA-6.A]
Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions. [TRA-6.B]
Represent the reaction quotient Qc or Qp , for a reversible reaction, and the corresponding equilibrium expressions Kc = Qc or K p = Qp . [TRA-7.A]
Calculate Kc or K p based on experimental observations of concentrations or pressures at equilibrium.[TRA-7.B]
Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium. [TRA-7.C]
Represent a multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction. [TRA-7.D]
Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant.[TRA-7.E]
Represent a system undergoing a reversible reaction with a particulate model. [TRA-7.F]
Identify the response of a system at equilibrium to an external stress, using Le Châtelier's principle. [TRA-8.A]
Explain the relationships between Q, K, and the direction in which a reversible reaction will proceed to reach equilibrium. [TRA-8.B]
Calculate the solubility of a salt based on the value of K sp for the salt. [SPQ-5.A]
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. [SPQ-5.B]
Identify the qualitative effect of changes in pH on the solubility of a salt. [SPQ-5.C]
Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process. [SPQ-5.D]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear	**PS1.B: Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HSPS1-5) **Energy and Matter**

functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical representations of phenomena to support claims. (HS-PS1-7) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent studentgenerated sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)	changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-5) In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-7) **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (secondary to HS-PS1-6)	The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

NJSLS Standard(s) Addressed
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. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]

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.* [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]
HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem ving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

Essential Questions (3-5)

1. What factors will affect the rate of a reaction?
2. How does an equilibrium reaction compare to other reactions?
3. What causes reactions to occur at different rates?

Anchor Text

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Short Texts (1-3)

Suggested Formative & Summative Assessments

Formative: Homework, classwork, quizzes
Summative: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments

Resources (websites, Blackboard, documents, etc.)	
Canvas (PowerPoint, reference sheets, handouts, video links)	
Labs	
Lab assignments: LeChatelier's Principle, Calculating the equilibrium constant for a reaction	
Suggested Time Frame:	14-16 Days

Course	AP Chemistry	**Grade(s)**	11, 12
Unit Plan Title:	Acids and Bases (Unit 8)		

Learning Objectives

Calculate the values of pH and pOH, based on Kw and the concentration of all species present in a neutral solution of water. [SAP-9.A]
Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base. [SAP-9.B]
Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base. [SAP-9.C]
Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases. [SAP-9.D]
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. [SAP-9.E]
Explain the relationship between the strength of an acid or base and the structure of the molecule or ion. [SAP-9.F]
Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or the pKb of the conjugate base. [SAP-10.A]
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. [SAP-10.B]
Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer. [SAP-10.C]
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. [SAP-10.D]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking	**PS1.B: Chemical Reactions**	**Patterns**

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical representations of phenomena to support claims. (HS-PS1-7) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent studentgenerated sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)	Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-5) In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-7) **ETS1.C:** Optimizing the Design Solution Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (secondary to HS-PS1-6)	Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-5) **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) **Connections to Nature of Science** **Scientific Knowledge** Assumes an Order and Consistency in Natural Systems Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

NJSLS Standard(s) Addressed

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. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]

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.* [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

Essential Questions (3-5)

1. How are acids and bases formed and what impact do they have on the materials of our world?
2. What is the relationship between pKa and pH?
3. How does your body maintain pH balance?
4. How are reactions involving acids and bases related to pH?

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Short Texts (1-3)
Suggested Formative & Summative Assessments
Formative: Homework, classwork, quizzes **Summative**: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments
Resources (websites, Blackboard, documents, etc.)
Canvas (PowerPoint, reference sheets, handouts, video links-Khan academy, phet simulation)
Labs
Lab assignments: Ka of an acid, Titration of an acid/base

Suggested Time Frame:	14-15 Days

	AP Chemistry	**Grade(s)**	11, 12
Unit Plan Title:	Applications of Thermodynamics (Unit 9)		

Learning Objectives

Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes. [ENE-4.A]
Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process. [ENE-4.B]
Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔGo . [ENE-4.C]
Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate. [ENE-4.D]
Explain whether a process is thermodynamically favored using the relationships between K, ΔGo , and T. [ENE-5.A]
Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes. [ENE-5.B]
Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell. [ENE-6.A]
Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell. [ENE-6.B]

Explain the relationship between deviations from standard cell conditions and changes in the cell potential. [ENE-6.C] Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell. [ENE-6.D]		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of	**PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2) These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)	**Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4) Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1) **Energy and Matter** Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2) **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)	**PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1) Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.(HS-PS3-4)	

NJSLS Standard(s) Addressed

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]
HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]
HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]

Essential Questions (3-5)

1. Why does everything in the universe move towards a state of disorder?
2. How does an internal combustion engine work?
3. How are cell potentials calculated?

Anchor Text

Chemistry: The Central Science, Twelfth Edition, Brown, Lemay, Bursten, Murphy, Woodward, Published @2012 Pearson Education, Inc. ISBN13: 9780133447736, ISBN10: 0133447731
Informational Texts (3-5)
Barron's Preparation Guide, 9th edition Published: ISSN:2150-3362, ISBN: 978-1-4380-1066-3 Princeton Review, Cracking the AP Chemistry Exam, 2019 Edition Published: ISBN-13: 978-1524758004, ISBN-10: 1524758000 Sterling Test Prep, 9th edition, Published: ISBN-13: 978-1947556058, ISBN-10: 1947556053
Short Texts (1-3)
Suggested Formative & Summative Assessments
Formative: Homework, classwork, quizzes **Summative**: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments
Resources (websites, Blackboard, documents, etc.)
Canvas (PowerPoint, reference sheets, handouts, video links-Khan academy, phet solution)
Labs
Lab assignments: Electrochemical cells, Redox titration

Suggested Time Frame:	10-13 Days

	AP Chemistry	**Grade(s)**	11, 12
Unit 10	AP Chemistry Independent Research		

Learning Objectives
Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept [SPQ-1.A] Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes [SPQ-1.B] Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance [SPQ-2.A] Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture [SPQ-2.B] Represent the electron configuration of an element or ions of an element using the Aufbau principle [SAP-1.A]

Explain the relationship between the photoelectron spectrum of an atom or ion and:

a. The electron configuration of the species
b. The interactions between the electrons and the nucleus [SAP-1.B]

Explain the relationship between trends in atomic properties of elements and the electronic structure and periodicity [SAP-2.A]
Explain the relationship between trends in the reactivity of elements and periodicity [SAP-2.B]
Explain the relationship between the type of bonding and the properties of the elements participating in the bond [SAP-3.A]
Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength. [SAP-3.B]
Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constituent ions [SAP-3.C]
Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance [SAP-3.D]
Represent a molecule with a Lewis Diagram [SAP-4.A]
Represent a molecular with a Lewis Diagram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures [SAP-4.B]
Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities:

a. Explain structural properties of molecules.
b. Explain electron properties of molecules. [SAP-4.C]

Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when:

c. The molecules are of the same chemical species.
d. The molecules are of two different chemical species. [SAP-5.A]

Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles [SAP-5.B]
Represent the differences between solid, liquid, and gas phases using a particulate-level model [SAP-6.A]
Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law [SAP-7.A]
Explain the relationship between the motion of particles and the macroscopic properties of gases with:

d. The kinetic molecular theory (KMT)
e. A particulate model
f. A graphical representation [SAP-7.B]

Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes. [SAP-7.C]
Calculate the number of solute particles, volume, or molarity of solutions [SPQ-3.A]
Using particulate models for mixtures:

c. Represent interactions between components.
d. Represent concentrations of components. [SPQ-3.B]

Explain the relationship between the solubility of ionic and molecular compounds in aqueous and non-aqueous solvents, and the intermolecular interactions between particles. [SPQ-3.C]
Explain the relationship between the solubility of ionic and molecular compounds in aqueous and non-aqueous solvents, and the intermolecular interactions between particles. [SPQ-3.C]
Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with that region. [SAP-8.A]
Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule. [SAP-8.B]
Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity. [SAP-8.C]
Identify evidence of chemical and physical changes in matter [TRA-1.A]
Represent changes in matter with a balanced chemical or net ionic equation:
a. For physical changes.
b. For given information
c. For ions in a given [TRA-1.B]
Represent a given chemical reaction or physical process with a consistent particulate model. [TRA-1.C]
Explain the relationship between macroscopic characteristics and bond interactions for:
a. Chemical processes.
b. Physical processes. [TRA-1.D]
Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process. [SPQ-4.A]
Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion. [SPQ-4.B]
Identify a reaction as acid-base, oxidation-reduction, or precipitation. [TRA-2.A]
Identify species as Brønsted Lowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species. [TRA-2.B]
Represent a balanced redox reaction equation using half-reactions. [TRA-2.C]
Explain the relationship between the rate of a chemical reaction and experimental parameters. [TRA-3.A]
Represent experimental data with a consistent rate law expression. [TRA-3.B]
Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time. [TRA-3.C]
Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes. [ENE-4.A]
Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process. [ENE-4.B]
Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔGo . [ENE-4.C]
Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate. [ENE-4.D]
Explain whether a process is thermodynamically favored using the relationships between K, ΔGo , and T. [ENE-5.A]

Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes. [ENE-5.B]
Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell. [ENE-6.A]
Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell. [ENE-6.B]
Explain the relationship between deviations from standard cell conditions and changes in the cell potential. [ENE-6.C]
Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell. [ENE-6.D]
Represent an elementary reaction as a rate law expression using stoichiometry. [TRA-4.A]
Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions. [TRA-4.B]
Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile. [TRA-4.C]
Identify the components of a reaction mechanism. [TRA-5.A]
Identify the rate law for a reaction from a mechanism in which the first step is rate limiting. [TRA-5.B]
Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting. [TRA-5.C]
Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile. [TRA-5.D]
Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism. [ENE-1.A]
Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation. [ENE-2.A]
Represent a chemical or physical transformation with an energy diagram. [ENE-2.B]
Explain the relationship between the transfer of thermal energy and molecular collisions. [ENE-2.C]
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. [ENE-2.D]
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. [ENE-2.E]
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. [ENE-2.F]
Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction. [ENE-3.A]
Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation. [ENE-3.B]
Represent a chemical or physical process as a sequence of steps. [ENE-3.C]
Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps. [ENE-3.D]
Calculate the values of pH and pOH, based on Kw and the concentration of all species present in a neutral solution of water. [SAP-9.A]
Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base. [SAP-9.B]

Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base. [SAP-9.C]
Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases. [SAP-9.D]
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. [SAP-9.E]
Explain the relationship between the strength of an acid or base and the structure of the molecule or ion. [SAP-9.F]
Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or tb of the conjugate base. [SAP-1plain 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. [SAP-10.B]
Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer. [SAP-10.C]
Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and conjugate base

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2) • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8) • Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)	**PS1.A: Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-2) *(Note: This Disciplinary Core Idea is also addressed by HS-PS1-1.)* • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2),(HS-PS1-5) HS-PS1-1),(HS-PS1-3) • **Energy and Matter** • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Structure and Function** • Investigating or designing new systems or structures requires a detailed

Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4) (HS-PS1-3) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.	columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),*(secondary to HS-PS2-6)* • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) **PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5) • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)	examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7) **Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4) Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1) **Energy and Matter**

• Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)	**PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1),(secondary to HS-PS1-3),*(HS-PS2-6) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS1-6)* **PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2)	Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2) **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)	These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1) Uncontrolled systems always evolve toward more stable states— that is, toward	

	more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.(HS-PS3-4)	

NJSLS Standard(s) Addressed

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. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),(HS-PS1-5)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)

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. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

MP.4 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

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. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)

HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-4)

HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-4)

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. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

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. (HS-PS1-3),(HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated 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-PS1-3),(HS-PS1-6)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

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. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

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. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]

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. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]

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. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

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. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]

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.* [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

Essential Questions (3-5)

1. How does an atom's electron configuration affect its properties?
2. How does the photoelectric effect support the particle nature of light?
3. How can the electron be depicted as a wave?
4. Differentiate between a molecular and ionic bond.
5. How can the properties of an ionic substance be attributed to its structure?
6. How can the properties of a molecular substance be attributed to its structure?\
7. Why does water have a high boiling point (use the concept of IMF)?
8. How do intermolecular forces determine the phase of matter?
9. When will a substance change from one phase into another?
10. How can you tell that a reaction has taken place?
11. What is meant by a redox reaction?
12. How can you distinguish between a physical and chemical process?
13. How is the rate of a reaction determined?
14. What factors determine the rate of a reaction?
15. What role do rates play in a chemical reaction?
16. How is a calorimeter used to measure energy that is absorbed or released?
17. What does enthalpy change mean in terms of a chemical process?
18. How is Hess's law applied to calculate enthalpy change?
19. What factors will affect the rate of a reaction?
20. How does an equilibrium reaction compare to other reactions?

21. What causes reactions to occur at different rates?
22. How are acids and bases formed and what impact do they have on the materials of our world?
23. What is the relationship between pKa and pH?
24. How does your body maintain pH balance?
25. How are reactions involving acids and bases related to pH?
26. Why does everything in the universe move towards a state of disorder?
27. How does an internal combustion engine work?
28. How are cell potentials calculated?

Anchor Text

Chemistry: The Central Science, Twelfth Edition, Brown, Lemay, Bursten, Murphy, Woodward, Published @2012 Pearson Education, Inc. ISBN13: 9780133447736, ISBN10: 0133447731

Informational Texts (3-5)

Barron's Preparation Guide, 9th edition Published: ISSN:2150-3362, ISBN: 978-1-4380-1066-3
Princeton Review, Cracking the AP Chemistry Exam, 2019 Edition Published: ISBN-13: 978-1524758004, ISBN-10: 1524758000
Sterling Test Prep, 9th edition, Published: ISBN-13: 978-1947556058, ISBN-10: 1947556053

Short Texts (1-3)

Suggested Formative & Summative Assessments

Formative: Homework, classwork, quizzes
Summative: Exam which consists of both multiple choice and open-ended questions, as well as laboratory assignments

Resources (websites, Blackboard, documents, etc.)

Canvas (PowerPoint, reference sheets, handouts, video links-Khan academy, phet simulation)

Labs

Carolina Investigations for AP Chemistry

Suggested Time Frame:	9 weeks

III. Methods of Student Evaluation

Formal Assessments

- Unit tests
- Marking Period Post Assessments
- Class participation
- Creative assignments
- Homework and classwork assignments
- Reports and presentations
- Research methodology
- Technological applications
- Multiple choice exams
- Quizzes (announced and unannounced)
- Essays/Research Stimulation Tasks
- Formal lab reports
- Scientific journal reviews
- Projects
- Short answer and problem solving tests and quizzes
- Tests and quizzes

Informal Assessments

- Instructor's observations of note-taking, and organization of notebooks and assignments
- Cooperative learning activities, including labs
- Creative project assignments
- Laboratory behavior
- Observing citizenship and appropriate social responses
- Instructor's observations of time management skills

IV. Instructional Strategies

- Discussion
- Reading
- Writing
- Projects
- Lab assignments
- Graphing activity
- Use of technology
- Brainstorming
- Answering various question types (multiple choice, written response)
- Answering various methods (oral or written)
- Peer tutoring
- Direct instruction/listening skills
- Peer learning (Collaborative projects)
- Simulations
- Rephrasing questions

V. Textbook

Chemistry: The Central Science, Twelfth Edition, Brown, Lemay, Bursten, Murphy, Woodward, Published @2012 Pearson Education, Inc.
ISBN13: 9780133447736, ISBN10: 0133447731

VI. Scope and Sequence

Key: I = Introduced; D= Explored in Depth, R=Reinforced **Suggested Grade Levels**

Skill/Concepts to be Learned	9	10	11	12
1.A Describe the components of and quantitative information from models and representations that illustrate particulate-level properties only.	I	DR	DR	DR

1.B Describe the components of and quantitative information from models and representations that illustrate both particulate-level and macroscopiclevel properties.	**I**	**DR**	**DR**	**DR**
2.A Identify a testable scientific question based on an observation, data, or a model.	**I**	**DR**	**DR**	**DR**
2.B Formulate a hypothesis or predict the results of an experiment.	**I**	**DR**	**DR**	**DR**
2.C Identify experimental procedures that are aligned to a scientific question (which may include a sketch of a lab setup).	**I**	**DR**	**DR**	**DR**
2.D Make observations or collect data from representations of laboratory setups or results, while attending to precision where appropriate.	**I**	**DR**	**DR**	**DR**
2.E Identify or describe potential sources of experimental error.		**IDR**	**IDR**	**IDR**
2.F Explain how modifications to an experimental procedure will alter results.		**IDR**	**IDR**	**IDR**
3.A Represent chemical phenomena using appropriate graphing techniques, including correct scale and units.		**IDR**	**IDR**	**IDR**
3.B Represent chemical substances or phenomena with appropriate diagrams or models (e.g., electron configuration).		**IDR**	**IDR**	**IDR**
3.C Represent visually the relationship between the structures and interactions across multiple levels or scales (e.g., particulate to macroscopic).		**IDR**	**IDR**	**IDR**
4.A Explain chemical properties or phenomena (e.g., of atoms or molecules) using given chemical theories, models, and representations		**IDR**	**IDR**	**IDR**
4.B Explain whether a model is consistent with chemical theories.		**IDR**	**IDR**	**IDR**
4.C Explain the connection between particulate-level and macroscopic properties of a substance using models and representations.		**IDR**	**IDR**	**IDR**

4.D Explain the degree to which a model or representation describes the connection between particulate-level properties and macroscopic properties.		**IDR**	**IDR**	**IDR**
5.A Identify quantities needed to solve a problem from given information (e.g., text, mathematical expressions, graphs, or tables).		**IDR**	**IDR**	**IDR**
5.B Identify an appropriate theory, definition, or mathematical relationship to solve a problem.		**IDR**	**IDR**	**IDR**
5.C Explain the relationship between variables within an equation when one variable changes.		**IDR**	**IDR**	**IDR**
5.D Identify information presented graphically to solve a problem.		**IDR**	**IDR**	**IDR**
5.E Determine a balanced chemical equation for a given chemical phenomenon.		**IDR**	**IDR**	**IDR**
5.F Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (e.g., performing dimensional analysis and attending to significant figures).		**IDR**	**IDR**	**IDR**
6.A Make a scientific claim.		**IDR**	**IDR**	**IDR**
6.B Support a claim with evidence from experimental data.		**IDR**	**IDR**	**IDR**
6.C Support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules.		**IDR**	**IDR**	**IDR**
6.D Provide reasoning to justify a claim using chemical principles or laws, or using mathematical justification.		**IDR**	**IDR**	**IDR**
6.E Provide reasoning to justify a claim using connections between particulate and macroscopic scales or levels.		**IDR**	**IDR**	**IDR**
6.F Explain the connection between experimental results and chemical concepts, processes, or theories.		**IDR**	**IDR**	**IDR**

6.G Explain how potential sources of experimental error may affect the experimental results.		**IDR**	**IDR**	**IDR**

VII: Pacing Chart

Unit 1: Atomic Structure and Properties --Mass spectroscopy -Dual Nature of light and electrons -Atomic Emission spectra and Bohr model -Photoelectric effect -Configurations -Periodic Trends (Radii, Ionization energy, Electron affinity, Electronegativity	9-10 days (40 min/per) * 10 = 400 min September
Unit 2: Molecular and Ionic Compound Structure and Properties -Energetics of Ionic Bond Formation (Lattice energies) -Bond Polarity -Lewis Structures and Formal Charge -Molecular geometry -Resonance -Molecule Polarity -Strength of covalent bonds -Exceptions to the octet rule -Hybridization	12-13 days (40 min/per) * 13 = 520 min September-October

Unit 3: Intermolecular forces and Properties -Intermolecular forces -Properties of solids -Solids, Liquids, Gases -Ideal Gas Law -Kinetic Molecular Theory -Deviations from the ideal gas law -Concentration of solutions -Chromatography -Solubility	14-15 days (40min/per)* 15 =600 min October-November
Unit 4: Chemical Reactions -Net Ionic Equations -Representation of reactions -Stoichiometry -Titration introduction -Types of reactions -Redox reactions	14-15 days (40 min/per) * 15 = 600 min December
Unit 5: Kinetics -Reaction rate -Rate law determination -Reaction Orders -Differential rate law vs. Integrated rate law -Determination of order from graph -The Collision Model -Reaction mechanism -Catalysis	13-14 (40 min/per) *14 = 560 min January
Unit 6: Thermodynamics -Energy diagrams -Enthalpy -Calorimetry -Energy of phase changes -Bond enthalpies -Hess's Law	10-11 (40 min/per) * 11 = 440 min January

-Bond Strength	
Unit 7: Equilibrium -predicting shift due to stress -The Law of Mass Action -Understanding and Working with constants -Q vs. K -Calculation of equilibrium constant -Titrations -Solubility equilibria	14-16 (40 min/per) * 16 = 660 min January-February
Unit 8: Acids and Bases -pH and pOH of strong acids and bases -Weak acid and base equilibria -Acid/base reactions and buffers -Acid/base titrations -Molecular structure of acids and bases -pH and pKa -properties of buffers -Henderson-Hasselbalch equation	14-15 (40 min/per) * 15 =600 min March
Unit 9: Applications of Thermodynamics -Entropy -Gibb's Free Energy -Redox Reactions -Voltaic cells -Batteries -Electrolysis	10-13 (40 min/per) *13 =520 min March

Review -Includes Practice Exams	April
Independent Research -Projects (various topics) -Labs (Inquiry)	May-June

VIII: Student Handout

Course Description:

This AP Chemistry course is designed to be the equivalent of the general chemistry course usually taken during the first year of college. For some students, this course enables them to undertake as freshmen, second-year work in the chemistry sequence in college or to register for courses in other fields where general chemistry is a prerequisite. This course is structured around the six big ideas articulated in the AP Chemistry curriculum provided by the College Board. Students should attain a depth of understanding of the fundamentals of chemistry and reasonable competence in dealing with chemical problems. The course will also allow students to develop their ability to think clearly and to express their ideas, orally and in writing, with clarity and logic. Furthermore, the laboratory work will be equivalent to a first-year college chemistry course and will require a higher degree of technique, analysis, and accuracy than what is expected of first-year high school chemistry students. A special emphasis will be placed on the seven science practices set forth by the College Board, which capture important aspects of the work that scientists engage in, with learning objectives that combine content with inquiry and reasoning skills. This course is open to all students that have completed a year of high school chemistry and who understand, and are willing to do this, much time will be required outside the class studying, doing homework, writing reports, and finishing lab work if needed.

Proficiencies:

1. The mole allows different units to be compared. SPQ-1

2. Chemical formulas identify substances by their unique combination of atoms. SPQ-2
3. Atoms and molecules can be identified by their electron distribution and energy. SAP-1
4. The periodic table shows patterns in electronic structure and trends in atomic properties. SAP-2
5. Atoms or ions bond due to interactions between them, forming molecules. SAP-3
6. Molecular compounds are arranged based on Lewis diagrams and Valence Shell Electron Pair Repulsion (VSEPR) theory. SAP-4
7. Intermolecular forces can explain the physical properties of a material. SAP-5
8. Matter exists in three states: solid, liquid, and gas, and their differences are influenced by variances in spacing and motion of the molecules. SAP-6
9. Gas properties are explained macroscopically—using the relationships among pressure, volume, temperature, moles, gas constant—and molecularly by the motion of the gas. SAP-7
10. Interactions between intermolecular forces influence the solubility and separation of mixtures. SPQ-3
11. Spectroscopy can determine the structure and concentration in a mixture of a chemical species. SAP-8
12. A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations. TRA-1
13. When a substance changes into a new substance, or when its properties change, no mass is lost or gained. SPQ-4
14. 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. TRA-2
15. Some reactions happen quickly, while others happen more slowly and depend on reactant concentrations and temperature. TRA-3
16. There is a relationship between the speed of a reaction and the collision frequency of particle collisions. TRA-4
17. Many chemical reactions occur through a series of elementary reactions. These elementary reactions when combined form a chemical equation. TRA-5
18. The speed at which a reaction occurs can be influenced by a catalyst. ENE-1
19. Changes in a substance's properties or change into a different substance requires an exchange of energy. ENE-2
20. The energy exchanged in a chemical transformation is required to break and form bonds. ENE-3
21. Some reactions can occur in both forward and reverse directions, sometimes proceeding in each direction simultaneously. TRA-6
22. A system at equilibrium depends on the relationships between concentrations, partial pressures of chemical species, and equilibrium constant K. TRA-7
23. Systems at equilibrium respond to external stresses to offset the effect of the stress. TRA-8
24. The dissolution of a salt is a reversible process that can be influenced by environmental factors such as pH or other dissolved ions. SPQ-5
25. 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. SAP-9

26. A buffered solution resists changes to its pH when small amounts of acid or base are added. SAP-10
27. Some chemical or physical processes cannot occur without intervention. ENE-4
28. The relationship between $\Delta G°$ and K can be used to determine favorability of a chemical or physical transformation. ENE-5
29. Electrical energy can be generated by chemical reactions. ENE-6