A Correlation of

Pearson
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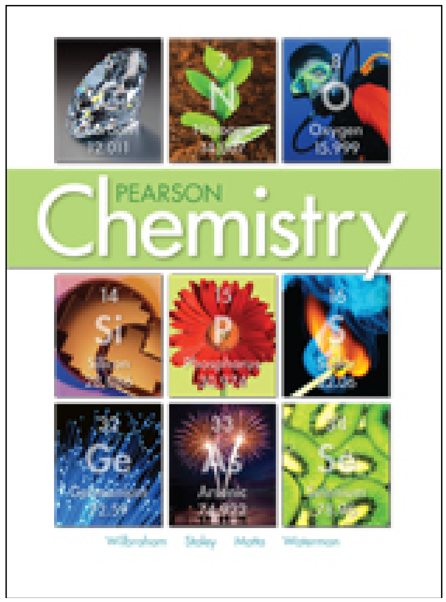

To the

Next Generation Science Standards

Physical Science Standards
Engineering and Technology Standards

MAY 2013
Grades 9-12

Dear Educator,

Pearson is committed to offering its complete support as classrooms transition to the new Next Generation Science Standards.* Ready-to-use solutions for today and a forward-thinking plan for tomorrow connect teacher education and development; curriculum content and instruction; and assessment. We'll be here every step of the way to provide the easiest possible transition to the Next Generation Science Standards with a coherent, phased approach to implementation.

Pearson has long-standing relationships with contributors and authors who have been involved with the development and review of the Next Generation Science Frameworks and subsequent Next Generation Science Standards. As such, the spirit and pedagogical approach of the Next Generation Science Standards initiative is embedded in all of our programs, such as ***Pearson Chemistry.***

The planning and development of ***Pearson Chemistry*** was informed by the same foundational research as A Framework for K12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Specifically, our development teams used Project 2061, the National Science Education Standards (1996) developed by the National Research Council, as well as the Science Anchors Project 2009 developed by the National Science Teachers Association to inform the development of this program. As a result, students make connections throughout the program to concepts that cross disciplines; practice science and engineering skills; and build on their foundational knowledge of key science ideas.

Pearson Chemistry combines proven and tested content with cutting-edge digital support and hands-on learning opportunities. This program provides you with everything you need to engage and motivate your students, as well as the tools to support the varied types of learners in your classroom.

Pearson Chemistry is built on a learning model that connects curriculum, instruction, and assessment to the "Big Ideas" of chemistry that develops deep understanding.

Pearson Chemistry provides all of the problem-solving and math support that students need to be successful in the course, with ample opportunity for practice both in the Student Edition and in the program's digital resources.

Pearson Chemistry helps you meet the unique learning styles of each student in your classroom with a variety of resources. A variety of assessment opportunities helps you monitor student progress ensure student success on high-stakes tests.

Pearsonchem.com provides cutting-edge digital content that engages students and teachers – anytime, anywhere, with numerous practice opportunities and visual support, including interactive art and animations. Online tutors step students through chemistry and math problems, expanding learning beyond the classroom.

The following document demonstrates how ***Pearson Chemistry*** **©2012** supports the Next Generation Science Standards for Grades 9-12. Correlation references are to the Student Edition (SE) and Teacher Edition (TE).

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to the Next Generation Science Standards, May 2013
Grades 9-12

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HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

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.]

PEARSON CHEMISTRY: Students are introduced to the patterns of electrons in atoms in Lesson 5.2 (pp. 134-137). In Lesson 6.1 (pp. 160-166) students are introduced to how the periodic table is organized and that elements with similar properties are in the same column in the periodic table. The classification of elements into groups based on their electron configuration, and the information that can be obtained from the periodic table in order to predict the properties of an element are presented in Lesson 6.2 (pp. 167-173). In Lesson 6.3 (pp. 174-182) periodic trends are explained, including atomic size, electronegativity, and ionization energy.

Students **use** the periodic table as a **model** to **predict** properties of elements: Students **use** the periodic table to **write** electron configurations (Q9, p. 173). Students **make** a 3-D model to relate electronegativity to the position of an element in the periodic table (Small-Scale Lab, p. 184). Students **relate** color to electron configuration (Small-Scale Lab, p. 200).

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.]

PEARSON CHEMISTRY: The five types of chemical reactions are presented in Lesson 11.2 (pp. 356-367). Students learn about reactions in aqueous solutions and the prediction of the formation of a precipitate in Lesson 11.3 (pp. 369-374).

Students **construct an explanation** for the outcome of simple chemical reactions: Students **construct an explanation** for the prediction of a precipitate (Q30, p. 373). Students **explain** the classification of reactions (Performance Tasks, p. 375).

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.]

PEARSON CHEMISTRY: In Lesson 7.2 (pp. 201-207) students learn how ionic bonding affects the crystal structure and properties of ionic compounds. In Lesson 7. 3 (pp. 209-212) students learn how metallic bonding affects the crystal structure and properties of metals. In Lesson 8.1 (pp. 222-224) students learn how molecular bonding affects the properties of molecular compounds. In Lesson 8.1 (pp. 224-225) students compare the structures and properties of molecule compounds to ionic compounds. In Lesson 8.2 (pp. 236-237) students learn how the strength of covalent bonds is related to bond dissociation energy. In Lesson 8.4 (pp. 247-253) students learn how intermolecular attractions affect the properties of substances. In Lessons 13.1 (p. 420), 13.2 (p. 425) and 13.3 (p. 431) students learn how intermolecular attractions affect the properties of solids, liquids, and gases.

Students **conduct an investigation** to **compare** the conductivity of substances (Quick Lab, p. 207). Students **plan and conduct investigations** to **infer** differences in polarity through paper chromatography (Small-Scale Lab, p. 254).

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.]

PEARSON CHEMISTRY: Lesson 8. 2 (pp. 236-237) introduces bond dissociation energy. Lesson 17.2 (pp. 562-568) teaches students how to measure and express the enthalpy of a reaction. Collision theory, activation energy, and the comparison of the energy of reactants and products are introduced in Lesson 18.1 (pp. 596-601). Lesson 18.5 (pp. 627-634) teaches students about free energy and spontaneous reactions.

Students **develop a model** of a spontaneous reaction (TE Performance Task, p. 636).

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.]

PEARSON CHEMISTRY: Lesson 18.1 (pp. 596-597) explains the effects of collisions on reaction rates. Lesson 18.1 (p. 598) explains the effects of temperature and concentration on reaction rates. Lesson 18.3 (pp. 612-615) explains the effects of concentration and temperature on equilibrium.

Students **apply scientific principles and evidence** in order to **solve** the chapter mystery, *Explosive Sugar* (p. 593).

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 Chatlier'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.]

PEARSON CHEMISTRY: The concepts of reversible reactions and equilibrium are presented in Lesson 18.3 (pp. 609-611). Students learn about Le Chatelier's principle in Lesson 18.3 (pp. 612-615).

Students **specify a change in conditions** that would affect equilibrium (Q17, 18 p. 615; Q68, p. 638)

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.]

PEARSON CHEMISTRY: The law of conservation of mass is explained in Lesson 2.4 (p. 50). Students are introduced to balancing chemical equations in Lesson 11.1 (pp. 346-354). Students learn to write and balance the five different types of chemical reactions in Lesson 11.2 (pp. 356-367). Students learn to write and balance reactions in aqueous solution in Lesson 11.3 (pp. 369-373). Students are introduced to stoichiometry in Lesson 12.1 (pp. 384-389). In Lesson 12.2 (pp. 390-398) students learn how to use mole ratios and molar mass to solve stoichiometric calculations.

Students **use mathematical representations** to **show** that atoms and mass are conserved in a chemical reaction**:** In the sample problems of Lesson 11.1 (pp. 349-353) students **balance** the atoms in the reactants and products of a chemical reaction. In the sample problems and Lesson Check of Lesson 11.2 (pp. 359-367), students **show** that the mass of the reactants equals the mass of the products. In the sample problems and Lesson Check of Lesson 12.2 (pp. 391-398), students **solve** for unknown quantities using mole ratios and molar mass conversions.

HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]

PEARSON CHEMISTRY: Nuclear reactions and radioactive decay are introduced in Lesson 25.1 (pp. 876-879). Students learn about the process of radioactive decay in Lesson 25.2 (pp. 880-886). Students learn about fission and fusion in Lesson 25.3 (pp. 888-891).

Students **develop a model** of radioactive decay in the Small-Scale Lab Radioactivity and Half-Lives (p. 887). Students **develop a model** of radiation intensity in the Quick Lab Inverse-Square Relationships (p. 896).

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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) **HS-PS1-4** **TE:** 636, Performance Task **HS-PS1-8** **SE / TE:** 887, Small-Scale Lab: Radioactivity and Half-Lives 896, Quick Lab: Inverse-Square Relationships **TE:** 889, Teacher Demo 898, Performance Tasks ▪ Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) **SE:** 184, Small-Scale Lab: Periodicity in Three Dimensions **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, 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)	**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) **SE / TE:** 105-109, Structure of the Nuclear Atom 128-132, Revising the Atomic Model 134-137, Electron Arrangement in Atoms ▪ 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) **SE / TE:** 162, Today's Periodic Table 162, Today's Periodic Table 168-169, Figure 6.9: Periodic Table 170, Electron Configurations in groups 171, Figure 6.11: Representative Elements 172, Figure 6.13: Electron Configurations 173, Sample Problem 6.1 173, Lesson Check 6.2: Q12, 13, 15, 16 ▪ 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) **HS-PS1-3** **SE / TE:** 200, Small-Scale Lab: Electron Configurations of Ions 201-207, Ionic Bonds and Ionic Compounds	**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),(HS-PS-3),(HS-PS1-5) **HS-PS-1** **SE / TE:** 174-182, Periodic Trends **TE:** 185, Performance Tasks **HS-PS-2** **SE / TE:** 361, Activity Series of Metals 366-367, Classifying Reactions **HS-PS-3** **SE / TE:** 200, Small-Scale Lab: Electron Configurations of Ions 201-207, Ionic Bonds and Ionic Compounds 209-212, Bonding in Metals 236-237, Bond Dissociation Energies 238, Quick Lab: Strengths of Covalent Bonds **HS-PS1-5** **SE / TE:** 236-237, Bond Dissociation Energies 593, Chapter Mystery 596-597, Collision Theory 598, Factors Affecting Reaction Rates 612-615, Factors Affecting Equilibrium

SE / TE:
200, Small-Scale Lab: Electron Configurations of Ions
254, Small-Scale Lab: Paper Chromatography of Food Dyes

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)

SE / TE:
352-353, Describing Chemical Reactions: Sample Problems 11.2, 11.3
354, Describing Chemical Reactions: Lesson Check Q10, 11
359-365, Types of Chemical Reactions: Samples Problems 11.4 – 11.7
367, Types of Chemical Reactions: Lesson Check Q21, 23

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)

SE / TE:
593, Chapter Mystery
598, Figure 18.6
641, Q111
TE:
598, Critical Thinking

207, Quick Lab: Solutions Containing Ions
209-212, Bonding in Metals
236-237, Bond Dissociation Energies
238, Quick-Lab: Strengths of Covalent Bonds
239, Powder Coating
250-251, Attractions Between Molecules
252, Intermolecular Attractions and Molecular Properties
252, Figure 8.28: Diamond
253, Table 8.5: Characteristics of Ionic and Molecular Compounds
420, Kinetic Theory and a Model for Gases
425, A Model for Liquids
431, A Model for Solids

TE:
210, Teacher Demo
213, Performance Tasks
235, Paramagnetism
250, Teacher Demo
251, Apply Concepts
251, Draw a Diagram
252, Teacher Demo

- Stable forms of matter are those in which the electric and magnetic field energy is minimized. 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)

SE / TE:
236-237, Bond Dissociation Energies

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)

HS-PS1-4
SE / TE:
236-237, Bond Dissociation Energies
596-597, Collision Theory

HS-PS1-5
SE / TE:
236-237, Bond Dissociation Energies

Energy and Matter
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

SE / TE:
876-879, Types of radiation
880-881, Nuclear Stability and Decay
899, Math Tutor

TE Only:
876, Focus on ELL
879, Evaluate

- The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)

SE / TE:
50, Conservation of Mass
346-354, Balancing Chemical Equations
356-367, Types of Chemical Reactions
369-373, Reactions in Aqueous Solution
384-389, The Arithmetic of Equations
390-398, Chemical Calculations

- 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)

SE / TE:
562-568, Measuring and Expressing Enthalpy Changes
594-601, Rates of Reaction
627-634, Free Energy and Entropy

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)

SE / TE:
612-615, Factors Affecting Equilibrium
627-634, Free Energy and Entropy

▪ 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) **SE / TE:** 373, Q30 ▪ 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) **SE / TE:** 592, 641 Chapter Mystery: Explosive Sugar	596-597, Collision Theory 598, Factors Affecting Reaction Rates 612-615, Factors Affecting Equilibrium **PearsonChem.com:** Kinetic Art: Collision Theory **TE:** 599, Teacher Demo ▪ 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) **SE / TE:** 609-611, Reversible Reactions 612-615, Factors Affecting Equilibrium ▪ 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) **<u>HS-PS1-2:</u>** **SE / TE:** 50, Conservation of Mass 346-354, Balancing Chemical Equations 356-367, Types of Chemical Reactions 369-373, Reactions in Aqueous Solution 374, Small-Scale Lab: Precipitations Reactions: Formations of Solids 384-389, The Arithmetic of Equations 390-398, Chemical Calculations 399, Small-Scale Lab: Analysis of Baking Soda 400-408, Limiting Reagent and Percent Yield **TE:** 349, Balancing Chemical Equations 351, Misconception Alert 351, Check for Understanding 352, Balancing Chemical Equations 352, Teacher Demo 359, Misconception Alert 392, Teacher Demo 408, Stoichiometric Showdown	--- **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) **SE / TE:** 50, Conservation of Mass 346-354, Balancing Chemical Equations 356-367, Types of Chemical Reactions 369-373, Reactions in Aqueous Solution 384-389, The Arithmetic of Equations 390-398, Chemical Calculations 400-408, Limiting Reagent and Percent Yield **TE:** 349, Apply Concepts

	<u>HS-PS1-7:</u> **SE / TE:** 346-354, Describing Chemical Reactions 356-367, Types of Chemical Reactions **PS1.C: Nuclear Processes** ▪ Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8) **SE / TE:** 876, Radioactivity 877-879, Types of Radiation 877, Figure 25.2: Alpha Decay 878, Figure 25.3: Beta Decay 880-881, Nuclear Stability and Decay 882-884, Half-Life 885-886, Transmutation Reactions 888, Nuclear Fission 888, Figure 25.11: Fission of Uranium 891, Nuclear Fusion 891, Figure 25.14: Fusion in the Sun **TE:** 877, Explain –Radioactivity 877, Misconception Alert 877, Explain –Types of Radiation 878, Explore –Teacher Demo 878, Check for Understanding 889, Explain –Nuclear Fission 889, Explore –Teacher Demo **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) **SE / TE:** 612-615, Factors Affecting Equilibrium	

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]

PEARSON CHEMISTRY: Explanations and models of ionic compounds that explain their properties are located throughout Chapter 7 (pp. 192-219). The molecular structure of carbohydrates is introduced in Lesson 24.2 (pp. 841-843). The molecular structure of amino acids and proteins is introduced in Lesson 24.3 (pp. 844-848). The molecular structure of lipids is introduced in Lesson 24.4 (pp. 850-853). The molecular structure of nucleic acids is introduced in Lesson 24.5 (pp. 854-861). Students learn about ions and ionic bonding in Lessons 7.1 and 7.2 (pp. 194-208). The relationship of the structure of ionic compounds to the properties of ionic compounds is explained in Lesson 7.2 (pp. 204-207). The relationship of the molecular structure of metals to the properties of metals is explained in Lesson 7.3 (pp. 209-212). Students learn about the structure of molecular compounds in Lesson 8.1 and 8.2 (pp. 222-238). The relationship of bond polarity and intermolecular attractions to the properties of molecular compounds is explained in Lesson 8.4 (pp. 247-253). The correlation between the structure and properties of water is explained in terms of electrical forces in Lesson 15.1 (pp. 488-492).

Students **communicate scientific and technical information** about the molecular-level structure: Students **relate** the properties and structures of starch and cellulose (p. 843, Q13). Students **relate** the properties and structure of metals (p. 212, Q26; p. 216, Qs 81, 83; p. 217, Q94). Students **relate** the properties and structure of polar molecules (p. 257, Q68). Students **relate** the properties and structure of water (p. 493, Q7).

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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-PS2-5) **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ▪ Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)	**PS2.A: Forces and Motion** ▪ Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) ▪ Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS-PS2-2) ▪ If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) **PS2.B: Types of Interactions** ▪ Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) ▪ Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5)	**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-PS2-4) **Cause and Effect** ▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1),(HS-PS2-5) ▪ Systems can be designed to cause a desired effect. (HS-PS2-3) **Systems and System Models** ▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2) **Structure and Function** ▪ Investigating or designing new systems or structures requires a detailed 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) **SE/TE:** 239, Powder Coating

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 describe explanations. (HS-PS2-2),(HS-PS2-4) **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 ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **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) **TE:** 213, Performance Tasks: Quenching 255, Performance Tasks: What Did It? --- **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ▪ Theories and laws provide explanations in science. (HS-PS2-1),(HS-PS2-4) ▪ Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)	▪ 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. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3) **HS-PS2-6** **SE / TE:** 201-203, Formation of Ionic Compounds 202, Figure 7.7: Formation of Sodium Chloride 204-206, Properties of Ionic Compounds 209-210, Metallic Bonds and Metallic Properties 209, Figure 7.12: Comparing Metals and Ionic Compounds 226-231, The Octet Rule in Covalent Bonding 232-233, Coordinate Covalent Bonds 240-241, Molecular Orbitals 242-243, VSEPR Theory 244-246, Hybrid Orbitals 247-250, Bond Polarity 250, Figure 8.24: Polar Molecules in an Electric Field 250-251, Attractions Between Molecules 250, Figure 8.25: Dipole Interactions 251, Figure 8.26: Hydrogen Bonds in Water 252, Intermolecular Attractions and Molecular Properties 252, Figure 8.28: Diamond 488-491, Water in the Liquid State 489, Figure 15.2: Polarity of H_2O 489, Figure 15.3: Hydrogen Bonding in Water 490, Figure 15.4: Surface Tension of Water 491, Quick Lab: Surface Tension 492-493, Water in the Solid State 492, Figure 15.6: Structure of ice 494-495, Solutions 495, Figure 15.8: Solvation on an Ionic Solid **TE:** 248, Explain – Bond Polarity 251, Explain – Draw a Diagram 489, Explain – Use Visuals, Apply Concepts 490, Explain – Use Visuals	

	492, Check for Understanding 495, Explain – Use Visuals **PS3.A: Definitions of Energy** ▪ ...and "electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5) **ETS1.A: Defining and Delimiting Engineering Problems** ▪ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3) **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-PS2-3)	

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-PS3 Energy

Students who demonstrate understanding can:

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields. [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.]

PEARSON CHEMISTRY: Atomic spectra and the quantization of energy are explained in Lesson 5.3 (pp. 138-148). The kinetic theory of gases is introduced in Lesson 13.1 (pp. 420-424). The effects of the energy of moving particles on the properties of liquids are explained in Lesson 13.2 (pp. 425-430). The gas laws and the energy of gas particles are discussed in Lesson 14.2 (pp. 456-463). Nuclear Radiation is introduced in Lesson 25.1 (pp. 876-879).

Students **develop and use a model** of atomic emission spectra in the Small-Scale Lab *Atomic Emission Spectra* (p. 149). Students **develop and use** a model to explain kinetic theory in the Performance Task *Comic Strip* (TE p. 442).

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]

PEARSON CHEMISTRY: Electrochemical processes and voltaic cells are explained in Lesson 21.1 (pp. 728-736). Electrolytic cells are explained in Lesson 21.3 (pp. 745-751).

Students **build a device** to convert chemical energy to electrical energy in the Chemistry & You *A Lemon Battery* (p. 744).

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.]

PEARSON CHEMISTRY: Thermochemistry, heat, and heat capacity are introduced in Lesson 17.1 (pp. 556-561).

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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),(HS-PS3-5) **<u>HS-PS3-2</u>** **SE / TE:** 149, Atomic Emission Spectra	**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),(HS-PS3-2) **<u>HS-PS3-2</u>** **SE / TE:** 138-149, Atomic Emission Spectra and the Quantum Mechanical Model	**Cause and Effect** ▪ Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5) **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) **SE / TE:** 562-563, Calorimetry

TE:
442, Performance Task: Comic Strip

PearsonChem.com:
Kinetic Art: The Hydrogen Emission Spectra

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.

- 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.

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)

SE / TE:
732-736, Using Voltaic Cells as Energy Sources

TE:
753, Performance Task: Electroplating

420–424, The Nature of Gases
425-430, The Nature of Liquids
436-441, Changes of State
454, Temperature
458-459, Charles' Law
460-461, Gay-Lussac's Law
475, Small-Scale Lab: Diffusion
876-879, Nuclear Radiation

TE Only:
454, Extend, Balls in Sports
459, Critical Thinking

- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3)

- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as either motions of particles or energy 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)

<u>HS-PS3-4</u>
SE / TE:
556, Energy Transformations

- 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.C: Relationship Between Energy and Forces

- When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

- 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

- 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-PS3-3)

- 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)

SE / TE:
138-149, Atomic Emission Spectra and the Quantum Mechanical Model
420–424, The Nature of Gases
425-430, The Nature of Liquids

Connections to Engineering, Technology, and Applications of Science
Influence of Science, Engineering, and Technology on Society and the Natural World

- Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)

SE / TE:
732-736, Using Voltaic Cells as Energy Sources
750-751, Using Electrolysis in Metal Processing

TE:
753, Performance Task: Electroplating

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 law Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)
s are consistent. (HS-PS3-1)

	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-PS3-3),(HS-PS3-4) **SE / TE:** 728-736, Voltaic Cells 732-736, Using Voltaic Cells as Energy Sources **ETS1.A: Defining and Delimiting Engineering Problems** ▪ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS3-3)	

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]

PEARSON CHEMISTRY: Electromagnetic radiation and frequency, wavelength and speed of light are introduced in Lesson 5.3 (pp. 138-141).

Students **use mathematical representations** to **study** the relationships of the frequency, wavelength, and speed of light (p. 141; p. 146, Q3; p. 148, Q24; p. 149)

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.]

PEARSON CHEMISTRY: Wave properties and electromagnetic radiation are explained in Lesson 5.3 (pp. 138-142). Students learn about photons and how light acts as a particle in Lesson 5.3 (pp. 142-144; p. 148, Q20).

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

PEARSON CHEMISTRY: The effect of UV radiation on human tissue is introduced in the Elements Handbook (p. R41). The effect of gamma radiation on matter is introduced in Lesson 25.1 (pp. 877, 879).

Students have the opportunity to **research** the consequences of over-exposure to alpha, beta, and gamma radiation in Lesson 25.4 (TE p. 897).

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assesments are limited to qualitative information. Assessments do not include band theory.]

PEARSON CHEMISTRY: Students learn about devices that detect radiation in Lesson 25.4 (pp. 894-895). Students learn about the practical uses of radioisotopes in Lesson 25.4 (pp. 896-897).

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

A Correlation of
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to the Next Generation Science Standards, May 2013
Grades 9-12

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. ▪ Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2) **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 or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1) **SE / TE:** 138-141, Light and Emission Spectra 146, Chemistry & You: Light Emitting Diodes 151, Math Tune-Up: Atomic Emission Spectra and Photons **TE:** 753, Performance Task: Electroplating **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science. ▪ Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3) **TE:** 139, Light as a Particle 143, Connect to Physics 147, Quantum Mechanics: Interpret Data	**PS3.D: Energy in Chemical Processes** ▪ Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) **PS4.A: Wave Properties** ▪ The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) **SE / TE:** 138-141, Light and Emission Spectra ▪ Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5) ▪ [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) **PS4.B: Electromagnetic Radiation** ▪ Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) **SE / TE:** 138-139, Light and Atomic Emission Spectra 142-143, The Quantum Concept and Photons ▪ When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4) **SE / TE:** 894, Detecting Radiation 879, Gamma Radiation R41, Transition Metals: Sunscreens ▪ Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)	**Cause and Effect** ▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1) **SE / TE:** 140, Atomic Emission Spectra ▪ Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4) **SE / TE:** 894, Detecting Radiation 879, Gamma Radiation R41, Transition Metals: Sunscreens ▪ Systems can be designed to cause a desired effect. (HS-PS4-5) **Systems and System Models** ▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3) **Stability and Change** ▪ Systems can be designed for greater or lesser stability. (HS-PS4-2) --- **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** ▪ Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5) **Influence of Engineering, Technology, and Science on Society and the Natural World** ▪ Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5) **HS-PS4-5** **SE / TE:** 894-895, Detecting Radiation 896-897, Using Radiation ▪ Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)

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. ▪ Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4) **TE:** 894, Engage: Build Background 897, Extend: Connect to Medicine ▪ Communicate technical information or ideas (e.g. about phenomena and/or 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-PS4-5) -- **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ▪ A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)	**PS4.C: Information Technologies and Instrumentation** ▪ Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5) **SE / TE:** 894-895, Detecting Radiation 896-897, Using Radiation	

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Grades 9-12

HS-ETS1 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

PEARSON CHEMISTRY: The process of reverse osmosis desalination as a solution for obtaining drinkable water is explained in the Chemistry & You feature *Reverse Osmosis Desalination* (pp. 502-503). The global challenge of reducing air pollution caused by automobile emissions is discussed in the Chemistry & You feature *Natural Gas Vehicles* (pp. 476-477).

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

PEARSON CHEMISTRY: The real-world problem of acid rain, including stone monument erosion is explored in the Chemistry & You feature *Stone Erosion* (p. 671). Students investigate the effects of a weak acid on chalk as a simulation of stone erosion in the On Your Own feature (p. 671). Further awareness of the problem is elicited in the Elements Handbook (p. R23).

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

PEARSON CHEMISTRY: The process of reverse osmosis desalination is explained in the Chemistry & You feature *Reverse Osmosis Desalination* (pp. 502-503). The process of single-stream recycling is introduced in the Chemistry & You feature *Recycled Mixtures* (pp. 52-53). The process of bioremediation to clean up oil spills is introduced in the Chemistry & You feature *Bioremediation* (p. 784).

Students **evaluate** the utilization of reverse osmosis for water filtration in the 21st Century Learning feature of Lesson 15.2 (TE p. 502). Students **evaluate** the feasibility of recycling in a rural community in the 21st Century Learning feature of Lesson 2.4 (TE p. 52).

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. ▪ Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **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. ▪ Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2)	**ETS1.A: Defining and Delimiting Engineering Problems** ▪ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) ▪ Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **SE/TE:** 502-503, Chemistry & You: Reverse Osmosis Desalination 476-477, Chemistry & You: Natural Gas Vehicles	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** ▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3) **<u>HS-ETS1-1</u>** **SE/TE:** 476-477, Chemistry & You: Natural Gas Vehicles 502, Chemistry & You: Reverse Osmosis Desalination 502, Chemistry & You: Reverse Osmosis Desalination –Pros & Cons **TE:** 502, Chemistry & You 503, Explain 503, Differentiated Instruction

▪ Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3) **TE:** 52, 21st Century Learning 502, 21st Century Learning	**ETS1.B: Developing Possible Solutions** ▪ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) **SE / TE:** 502-503, Chemistry & You: Reverse Osmosis Desalination 784, Chemistry & You: Bioremediation **TE:** 502, 21st Century Learning 503, Explain: Make a Connection 503, Extend: Connect to Environmental Science **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. (HS-ETS1-2)	**<u>HS-ETS1-3</u>** **SE / TE:** 502-503, Chemistry & You: Reverse Osmosis Desalination 784, Chemistry & You: Bioremediation **TE:** 502-503, 21st Century Learning