**High School Domains Model Course 1 – Chemistry**

*Narrative and Rationale:* This Chemistry model course map is the first in a three-year course sequence that uses a customized version of the Modified High School Domains Model from NGSS Appendix K as the instructional year end goals. The four bundles in this model are characterized by the overarching ideas that materials gained from natural resources are composed of atoms with characteristic chemical and physical properties, and that those properties affect the way that natural resources are formed and used. Using phenomena related to the formation of elements and materials as a way to connect bundles allows for students not only to master PEs, but also to develop a deeper understanding of the crosscutting concepts (CCCs) that they built throughout their K-8 experiences in science.

This course model is written with the assumption that it will come first in a high school sequence of Chemistry, Physics, and Biology courses, each with Earth and Space Sciences and Engineering Design integrated into the courses. This Chemistry course model is intended to lay the foundation for all other high school courses, and assumes that students enter high school with proficiency in the middle school DCIs, Science and Engineering Practices, and crosscutting concepts from the NGSS.

This model gives students the opportunity to deepen their understanding and use of the Science and Engineering Practices (SEPs). It places special emphasis on developing and using models, planning and carrying out investigations, and constructing explanations and designing solutions. The SEPs emphasized here contribute to students’ understanding of both the CCCs and DCIs they explore. Students continue to grow in their capabilities with science and engineering practices over the course of the year and the level of sophistication at which they are able to engage in them, over time.

The bundles in this domains model guide students through the use of the SEPs, CCCs, and DCIs to answer the essential questions for each unit listed in the bundles below. It is important to note that the practices and crosscutting concepts described are intended as end-of-instructional unit expectations and not curricular designations. Additional practices and crosscutting concepts should be used throughout instruction toward each bundle.

<table>
<thead>
<tr>
<th>Bundle 1: Where do the different elements come from?</th>
<th>Bundle 2: Why do we use gasoline for energy?</th>
<th>Bundle 3: How can we get energy to flow from one place to another?</th>
<th>Bundle 4: How and where do we get the materials we need?</th>
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<td><strong>HS-PS1-1.</strong> 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. ¹</td>
<td><strong>HS-PS1-2.</strong> 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.</td>
<td><strong>HS-PS2-5.</strong> Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.</td>
<td><strong>HS-PS1-5.</strong> 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.</td>
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<td><strong>HS-PS1-8.</strong> 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.</td>
<td><strong>HS-PS1-4.</strong> 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.</td>
<td><strong>HS-PS3-1.</strong> 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.</td>
<td><strong>HS-PS1-6.</strong> Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*</td>
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<td><strong>HS-ESS1-1.</strong> Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun’s core to release energy that eventually reaches Earth in the form of radiation.</td>
<td><strong>HS-PS1-7.</strong> Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.</td>
<td><strong>HS-PS3-3.</strong> Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*</td>
<td><strong>HS-ESS2-5.</strong> Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.¹</td>
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<td><strong>HS-ESS1-3.</strong> Communicate scientific ideas about the way stars, over their life cycle, produce elements.</td>
<td><strong>HS-LS2-5.</strong> Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. ¹</td>
<td><strong>HS-PS3-4.</strong> Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within</td>
<td><strong>HS-ESS3-2.</strong> Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*</td>
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¹ Natural resources are formed and used.

² Natural resources are composed of atoms with characteristic chemical and physical properties, and those properties affect the way that natural resources are formed and used. Using phenomena related to the formation of elements and materials as a way to connect bundles allows for students not only to master PEs, but also to develop a deeper understanding of the crosscutting concepts (CCCs) that they built throughout their K-8 experiences in science.
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<td>HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. <strong>HS-ESS3-6.</strong> Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.</td>
<td>a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).</td>
<td><strong>HS-ETS1-1.</strong> Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</td>
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1. The bundle only includes part of this PE; the PE is not fully assessable in a unit of instruction leading to this bundle.
PSL.A as found in HS-PS1-1
• Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
• 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.

PSL.A as found in HS-PS1-2
• 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.

PSL.B as found in HS-PS1-2 and HS-PS1-7
• 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.

PSL.B as found in HS-PS1-4
• 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.

PSL.B as found in HS-PS2-5
• Nuclear energy may mean energy stored in a battery or energy transmitted by electric currents.

PSL.C as found in HS-PS3-1
• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

PSL.C as found in HS-PS3-4
• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

PSL.D as found in HS-LS2-5
• The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.

PSL.D as found in HS-ESS1-4
• Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.

ESSA as found in HS-ESS1-4
• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.

ESSA as found in HS-ESS1-5
• The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
• Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

ESSB as found in HS-ESS2-6
• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

ESSB as found in HS-ESS3-1
• The study of stars’ variations in brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.

ESSC as found in HS-ESS3-5
• Though the magnitudes of human impacts are greater than they have ever been, too are human abilities to model, predict, and manage current and future impacts.

ESSD as found in HS-ESS4-5
• Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

ESSD as found in HS-ESS4-6
• Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

ETS as found in HS-ETS1-1
• 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.

ETS as found in HS-ETS1-2
• 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.

ETS as found in HS-ETS1-4
• 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.

ETS as found in HS-ETS1-6
• 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.