Chemistry in the Earth System Course of Study

Title of Course: **Chemistry in the Earth System Course of Study**	
Course Author(s): **Marissa Peck, Mary Buchanan, Simon McBride**	Schools where the course will be taught: **Tamalpais High School, Redwood High School, Sir Francis Drake High School, Tamiscal and San Andreas.**
Length of Course: **1 year**	Subject Area and Discipline: **Science/Chemistry**
Grade Levels: **10-12th grade**	Is this course an integrated course? **Yes** with Earth Science ? **Yes**
Is this course being submitted for possible UC honors designation? **No**	Are you seeking UC approval? If so, in what area (A-G)? **Yes, UC D**
Prerequisites (required or recommended): **PhUn or Living Earth**	Co-requisites (required or recommended): **Algebra 1 and PhUn and Living Earth**
Check all that apply: ❑ *UC A-G course X ❑ *Graduation Requirement X ❑ Elective ❑ Honors/AP ❑ ROP Board Approved: 1/28/20 UC Approved: 2/20/20	

Introduction

Chemistry in the Earth System is a laboratory science course integrating core ideas from the disciplines of chemistry and earth science. Using engaging phenomena central to these fields of science, students develop an understanding of disciplinary core ideas including: the structure and properties of matter as well as its interactions, chemical reactions, conservation of energy and energy transfer, forces of attraction within and between compounds, and human impacts on the earth's atmosphere, geosphere, hydrosphere and global climate. Students will engage in the work of scientists, using science and engineering practices, as a way to learn. They will then demonstrate their understanding of the content as well as the important cross-cutting concepts that link all science disciplines. This three-dimensional approach to instruction develops conceptual understanding with a focus on application. Chemistry in the Earth System is aligned

with the Next Generation Science Standards and the California Science Framework which are the California adopted standards in science.

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td colspan="3">Unit 1: Combustion</td></tr>
<tr><td rowspan="6">ESTABLISHED LEARNING GOALS (e.g. standards at the local, state and/or national level)
● PS1-4
● PS1-7
● PS3-1
● PS3-4
● ESS2-6</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…

Describe the combustion of a hydrocarbon and describe how changes in Earth's systems have impacted the natural cycle of wildfire.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that…
(click on the PEs listed under the Established learning goals for more details)
● Patterns
● Energy and Matter
● Scientific Knowledge Assumes an Order and Consistency in Natural Systems</td><td>ESSENTIAL QUESTIONS

● What is combustion?
● How do the atoms in a fuel rearrange when they burn?
● What is released when wildfires burn?
● How can we model heat?
● How do we quantify the heat released by combustion?
● Why have wildfires in California become more destructive?
● What are the benefits and consequences of forest fire?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know…

● PS1.A: Structure and Properties of Matter
● PS2.B: Types of Interactions
● PS1.B: Chemical Reactions</td><td>Students will be skilled at…

● Planning and Carrying Out Investigations
● Using mathematical and computational thinking</td></tr>
</table>

<table>
<tr><td></td><td>PS3.A: Definitions of Energy
ESS2.D: Weather and Climate</td><td>Developing and using models</td></tr>
<tr><td colspan="3">Summary of Key Learning: Students begin by exploring recent wildfire events in California. They develop a list of questions about how fire (combustion) works. In the Candle Lab, the model of a burning candle is used as a simple example of combustion for students to begin to answer the questions they generated and understand the process of combustion. The Candle Lab should give students a clear idea of the “stuff” of combustion-- the reactants and products. It will be followed by a calorimetry lab, which explores the energy aspect of combustion. This lab will also introduce the ideas of measurement. The unit will conclude with a final project that brings together the phenomena of wildfire, the combustion of a candle and the measurement of energy. In this project, students will research a wildfire topic that is of interest to them and apply what they’ve learned over the course of the unit to present their findings to other students. Students will also complete a written assessment at the end of the unit.</td></tr>
<tr><th colspan="3">Stage 2 - Evidence</th></tr>
<tr><td rowspan="2">Learning Goals Measured:
*can be referenced by number
PS1-4
PS1-7
PS3-1
PS3-2
ESS2-6</td><td colspan="2">Success Criteria (e.g. Learning progression, rubric, proficiency scale, etc.)
Students are able to identify the reactants and products of a combustion reaction
Students demonstrate understanding of calorimetry through $q=mC\Delta T$ calculations
Students show proper measurement technique through use of units and significant figures
Students are able to identify safety and appropriate lab behavior
Students demonstrate their understanding that wildfires are an example of a natural process altered by our changing climate and that wildfires trigger the release of CO_2 into the atmosphere as the result of a combustion reaction
Students will plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
Unit 1 Assessment outcomes</td></tr>
<tr><td colspan="2">Sample Assessment (e.g. Performance tasks, anchor of student work, common assessment etc.)
Common Unit Assessment</td></tr>
</table>

Stage 3 – Learning Plan	
Learning Goals Addressed: **can be referenced by number* Calorimetry Lab: ● PS1-4 ● PS3-1 ● PS3-2 ● ESS2-6 Candle Lab: ● PS1-4 ● PS1-7 ● ESS2-6	**Sample Assignment:** A brief summary of one assignment that explains what a student produces, how the student completes the assignment, and what the student learns. Make connections to unit learning goals (2-4 sentences). ● Calorimetry Lab: Students are assigned a fuel. They design a procedure to determine how much energy is released by that fuel. They do multiple trials to optimize their procedure and generate reproducible data. Students then collect class data and compare fuel sources. The student will practice engineering design and use mathematical and computational thinking to analyze their data.
	Sample Lab: Provide an example of a teacher-supervised, hands on laboratory activity that involve inquiry, observation, analysis and write-up. Briefly describe the activity and how it directly relates to and supports the students learning outcomes of this unit (2-4 sentences) ● Candle Lab (Part 1, Part 2, Teacher Notes): Students observe a burning candle as an example of a combustion reaction, a simplified version of a wildfire. They begin by creating a model of a burning candle based on their previous knowledge. Next they perform a series of experiments to determine the reactants and products of a combustion reaction. They they revise their model to show how a candle works.
	Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended). ● Consistent use of assessments: pre-assessments to know student prior knowledge, formative assessments to check in where students are in their learning and summative assessments to determine if they got it. ● Language Development:(access HMH online ELL resources) ○ Spanish Periodic Table ○ Glossary of new vocabulary given to students, various strategies can be used such as: ■ 5 box chart or a frayer model to define terms, give an example, draw an image, identify a similar term, and write a phrase.

	■ 2 column charts-comparing terms by adding phrases from readings/texts to identify meanings of terms. ■ Word Quests- students find new terms in readings, write the terms in the first column, write the sentence that the terms is found in the second column and in the last column, write their own sentence using the term ■ Use the emerge, expand, bridge approach to new terms (see HMH online tools) ● Sentence starters to get students using appropriate language to communicate understanding of content. ● Strategic student grouping: ○ grouping students for labs and other in-class projects based on skill level (whether that's similar or mixed groupings) helps students have needs met either through cooperation with peers or by allowing the teacher to provide more targeted guidance ● Cornell notes with sentence starters and fill in the blanks: ○ Helps students with more effective note taking technique. Encourages students to go back and review their notes. ● Graphic organizers: ○ Helps students organize the information that they collect in lab, practice worksheets or during in-class projects. Ex. Thinking Maps (Magnesium) ● Spiraled lessons: ○ Students encounter the same information in multiple contexts to help reinforce learning and encourage application. ● Math scaffolds: ○ Use of data tables to organize mathematical information from word problems and experiments ○ Use of graph choice chart to guide students in graphing. Post on classroom walls, use for assessments. ○ Equation templates aid students in applying units and substituting in appropriate experimental values with example problems completed ○ Inclusion of challenge problems and extension options for accelerated students. ○ Visual supports for students in order to manipulate algebraic equations and other most utilized problem

<table>
<tr><td></td><td>solving skills in calculations. Make laminated copies for the classroom.</td></tr>
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<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td colspan="3">Unit 2: Waste - the classification and separation of matter</td></tr>
<tr><td rowspan="4">ESTABLISHED LEARNING GOALS (e.g. standards at the local, state and/or national level)
*can be referenced by number

• PS1-1
• PS1-7
• ETS1-4
• ESS3-2</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…
• Separate out mixtures of elements and compounds according to their properties.
• Identify chemical and physical properties as well as chemical and physical changes
• Categorize compounds as either ionic, covalent or polar covalent
• Recognize melting point and boiling points as an indication of particle bond strength.
• Categorize elements as either metals, nonmetals or metalloids.
• Explain how mass spectroscopy data shows relative atomic masses and proves the presence of isotopes.
• Write out nuclide notation for a given isotope
• Describe how elements can be identified from their spectroscopic signatures.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
(click on the PEs listed under the Established learning goals for more details)

• Patterns
• Energy and Matter
• Scientific Knowledge Assumes an Order and Consistency in Natural Systems
• Systems and System Models</td><td>ESSENTIAL QUESTIONS

• How can we separate mixtures of matter into their components?
• How can we apply separation of mixtures to environmental recovery efforts after natural disasters?</td></tr>
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<table>
<tr><td rowspan="4"></td><td>Influence of Science, Engineering, and Technology on Society and the Natural World
Science Addresses Questions About the Natural and Material World</td><td>How can we classify matter in a way that is useful?
Can we break matter down into more reusable forms?
What properties is it useful to categorize matter by?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know...</td><td>Students will be skilled at...</td></tr>
<tr><td>PS1.A: Structure and Properties of Matter
PS1.B: Chemical Reactions
ESS2.D: Weather and Climate
ESS3.D: Global Climate Change
ESS3.A: Natural Resources
ETS1.B: Developing Possible Solutions</td><td>Developing and Using Models
Constructing Explanations and Designing Solutions
Using Mathematics and Computational Thinking
Engaging in Argument from Evidence</td></tr>
<tr><td colspan="3">Summary of Key Learning: After wildfires there are mixtures of substances that must be dealt with. In these mixtures are the substances that we surround ourselves with; rocks, glass, plastics, metal, wood, semiconductors, alloys, organic matter, etc. All of this gives us an opportunity to think critically about the materials we use on a daily basis, how we can separate these materials out so that we might use them again or if we should reconsider their use all together. Students will understand that we classify matter as either pure substances or mixtures. Specifically during this unit, students will participate in activities which lead them to the understanding that:
Matter can occupy different states depending on the conditions.
Mixtures can be separated by physical methods.
Elements can be obtained by chemical means from compounds.
Elements can be classified as either a metal, non-metal, or metalloid but that there is a blurring of properties and that exceptions are common.
Based on this understanding, students will plan a method for the extraction of an element from a compound.

In part 2 of this unit, students will learn how we identify elements using trace signatures from light and mass spectroscopy. Mass spectroscopy allows for the identification of atoms and molecules by their molar mass and reveals the presence of isotopes. Absorption and emission spectra allow scientists to identify unknown compounds by their signature spectra. Absorption and emission spectra are due to electrons absorbing and emitting light as well as bonds</td></tr>
</table>

absorbing some energies. Students will be tasked with using their understanding of spectra and emission to identify an unknown element.

In the performance task for this unit, students will perform a decontamination of water project (Foul Water Lab), where they propose a solution, based on their learning, for removing contaminants from a sample of water.

Stage 2 - Evidence

Learning Goals Measured: *can be referenced by number*	Success Criteria (e.g.. Learning progression, rubric, proficiency scale, etc.)
• PS1-1 • PS1-7 • ETS1-4 • ESS3-2	Students can: • Use data to classify substances as covalent, ionic or polar covalent • Separate out compounds based on physical properties. • Separate and classify elements based on physical properties as either a metal, metalloid, or nonmetal. • Use chemical or physical properties to propose a way to separate or identify substances. • Calculate percent abundance of isotopes from mass spectroscopy data. • Identify an element from it's signature emission or absorption spectra • Write out nuclide notation for any atom Unit 2 Assessment outcomes
	Sample Assessment (e.g. Performance tasks, anchor of student work, common assessment etc.) Common assessment

Stage 3 – Learning Plan

Learning Goals Addressed: *can be referenced by number*	**Sample Assignment:**
Separation Lab: • PS1-1 • PS1-7	Separation Lab: Students will use knowledge of the physical and chemical properties of substances to use appropriate methods to separate matter. Students will complete a short lab write-up that includes purpose and procedures and closes with a CER.
Foul Water Lab:	**Sample Lab:**

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PS1-1
PS1-7
ETS1-4
ESS3-2

</td>
<td>Foul Water Lab: Students are presented with a mixture of polluted water and challenged with the task of making it clean again. They will learn to use the processes of oil/water separation, filtration, distillation and adsorption. The students will apply their knowledge of ionic, covalent and metallic substances to explain how these processes work by developing a Claim, Evidence, Reasoning for each process.</td>
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<tr>
<td>Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended).

Consistent use of assessments: pre-assessments to know student prior knowledge, formative assessments to check in where students are in their learning and summative assessments to determine if they got it.
Language Development:(access HMH online ELL resources)

Spanish/French Periodic Table
Glossary of new vocabulary given to students, various strategies can be used such as:

5 box chart or a frayer model to define terms, give an example, draw an image, identify a similar term, and write a phrase.
2 column charts-comparing terms by adding phrases from readings/texts to identify meanings of terms.
Word Quests- students find new terms in readings, write the terms in the first column, write the sentence that the terms is found in the second column and in the last column, write their own sentence using the term
Use the emerge, expand, bridge approach to new terms (see HMH online tools)

Sentence starters to get students using appropriate language to communicate understanding of content.
Strategic student grouping:

grouping students for labs and other in-class projects based on skill level (whether that's similar or mixed groupings) helps students have needs met either through cooperation with peers or by allowing the teacher to provide more targeted guidance

Cornell notes with sentence starters and fill in the blanks:

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</table>

	◦ Helps students with more effective note taking technique. Encourages students to go back and review their notes. • Graphic organizers: ◦ Helps students organize the information that they collect in lab, practice worksheets or during in-class projects. • Spiraled lessons: ◦ Students encounter the same information in multiple contexts to help reinforce learning and encourage application. • Math scaffolds: ◦ Use of data tables to organize mathematical information from word problems and experiments ◦ Use of graph choice chart to guide students in graphing. Post on classroom walls, use for assessments. ◦ Equation templates aid students in applying units and substituting in appropriate experimental values with example problems completed ◦ Inclusion of challenge problems and extension options for accelerated students. ◦ Visual supports for students in order to manipulate algebraic equations and other most utilized problem solving skills in calculations. Make laminated copies for the classroom.

Stage 1 Desired Results	
Unit 3: Material Resources	
ESTABLISHED LEARNING GOALS (e.g. standards at the local, state and/or national level) **can be referenced by number* • PS1-2 • PS1-3 • PS1-7 • PS2-6	***Transfer*** *Students will be able to independently use their learning to…* • utilize the structure of and electrical attractions between particles to explain the properties of various types of matter. • mathematically model connections between the mass of substances and a quantitative representation of substances at the atomic and molecular level. • Predict the amount of an element that can be extracted from a compound using percent by mass and the law of conservation of matter

	Meaning Making	
	UNDERSTANDINGS *Students will understand that… (click on the PEs listed under the Established learning goals for more details)* ● Patterns ● Energy and Matter ● Scientific Knowledge Assumes an Order and Consistency in Natural Systems ● Structure and Function ● Cause and Effect	ESSENTIAL QUESTIONS ● How can different kinds of bonding impact the properties of substances? ● How can you use the periodic table to predict the types of bonds substances will form? ● How can interactions between molecules be modeled? ● How do forces between particles affect the properties of materials?
	Acquisition	
	Students will know… ● PS1.A: Structure and Properties of Matter ● PS1.B: Chemical Reactions ● PS2.B: Types of Interactions ● PS3.C: Relationship Between Energy and Forces	*Students will be skilled at…* ● Planning and Carrying Out Investigations ● Using Mathematics and Computational Thinking ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena ● Obtaining, Evaluating, and Communicating Information ● Developing and Using Models
Summary of Key Learning:		
Stage 2 - Evidence		
Learning Goals Measured: **can be referenced by number* ● PS1-2 ● PS1-3 ● PS1-7 ● PS2-6	**Success Criteria** (e.g.. Learning progression, rubric, proficiency scale, etc.) ● Students use at least two different formats (including oral, graphical, textual and mathematical) to communicate scientific and technical information, including fully describing the structure, properties, nomenclature and design of the chosen material(s). ● Students use the mole to convert between the atomic and macroscopic scale in the analysis	

	• Calculate the amount of an element in a compound from the chemical formula • Calculate empirical and molecular formula for a compound given percent by mass and molar mass data • Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including bulk properties of a substance (e.g., melting point and boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between particles. Unit 3 Assessment outcomes
	Sample Assessment Short Performance Assessment: (PS1-3) As an intern at the Road Runner Ice Melt Company, your supervisor has given you the task of finding the most effective chemical at preventing ice from forming on winter roads. Using the appropriate equipment above (not all are required), plan an investigation to gather evidence to determine which of the 5 chemicals is the best choice to salt icy winter roads.
Stage 3 – Learning Plan	
Learning Goals Addressed: **can be referenced by number* • PS1-2 • PS1-3 • PS1-7 • PS2-6	**Sample Assignment:** A brief summary of one assignment that explains what a student produces, how the student completes the assignment, and what the student learns. Make connections to unit learning goals (2-4 sentences). Writing Ionic Compound Formulas Using this process-oriented activity, students will develop the skills necessary to write and name most ionic compound. In the process, they will notice the patterns used and be able to apply them to new situations.
	Sample Lab: **Properties of solids lab** Modeling structure lab

	Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended). ● Consistent use of assessments: pre-assessments to know student prior knowledge, formative assessments to check in where students are in their learning and summative assessments to determine if they got it. ● Language Development:(access HMH online ELL resources) ○ Spanish Periodic Table ○ Glossary of new vocabulary given to students, various strategies can be used such as: ■ 5 box chart or a frayer model to define terms, give an example, draw an image, identify a similar term, and write a phrase. ■ 2 column charts-comparing terms by adding phrases from readings/texts to identify meanings of terms. ■ Word Quests- students find new terms in readings, write the terms in the first column, write the sentence that the terms is found in the second column and in the last column, write their own sentence using the term ■ Use the emerge, expand, bridge approach to new terms (see HMH online tools) ● Sentence starters to get students using appropriate language to communicate understanding of content. ● Strategic student grouping: ○ grouping students for labs and other in-class projects based on skill level (whether that's similar or mixed groupings) helps students have needs met either through cooperation with peers or by allowing the teacher to provide more targeted guidance ● Cornell notes with sentence starters and fill in the blanks: ○ Helps students with more effective note taking technique. Encourages students to go back and review their notes. ● Graphic organizers: ○ Helps students organize the information that they collect in lab, practice worksheets or during in-class projects. ● Spiraled lessons:

	○ Students encounter the same information in multiple contexts to help reinforce learning and encourage application. ● Math scaffolds: ○ Use of data tables to organize mathematical information from word problems and experiments ○ Use of graph choice chart to guide students in graphing. Post on classroom walls, use for assessments. ○ Equation templates aid students in applying units and substituting in appropriate experimental values with example problems completed ○ Inclusion of challenge problems and extension options for accelerated students. ○ Visual supports for students in order to manipulate algebraic equations and other most utilized problem solving skills in calculations. Make laminated copies for the classroom.

Stage 1 Desired Results		
Unit 4: Chemical Reactions		
ESTABLISHED LEARNING GOALS (e.g. standards at the local, state and/or national level) **can be referenced by number* ● PS1-2 ● PS1-4 ● PS1-7 ● ESS2-6	***Transfer***	
	Students will be able to independently use their learning to... Predict and model the five most common types of reactions that transform the matter around us into the products that we use and interact with in our lives. This includes the processing of mineral resources, the extraction of energy from fuels and the synthesis of the synthetic, plastic stuff we use in our lives.	
	Meaning Making	
	UNDERSTANDINGS *Students will understand that...* *(click on the PEs listed under the Established learning goals for more details)*	ESSENTIAL QUESTIONS ● How does the law of conservation of mass apply to chemical reactions at both the

	• Patterns • Energy and Matter • Scientific Knowledge Assumes an Order and Consistency in Natural Systems	macroscopic and atomic scales. • How do substances combine or change to make new substances? • How does one characterize and explain these reactions and make predictions about them? • How does characterizing reactions help one make predictions? • In what ways can the changes in chemical reactions be quantified in terms of reactants and products? • What are the sources of energy in chemical systems and processes? • How can we model the patterns of energy flow in a chemical reaction?
	Acquisition	
	Students will know... *(click on the PEs listed under the Established learning goals for more details)* • PS1.A: Structure and Properties of Matter • PS1.B: Chemical Reactions • PS2.B: Types of Interactions • ESS2.D: Weather and Climate	*Students will be skilled at...* *(click on the PEs listed under the Established learning goals for more details)* • Planning and Carrying Out Investigations • Developing and Using Models • Constructing Explanations and Designing Solutions • Using Mathematics and Computational Thinking • Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Summary of Key Learning: In this unit, students will study the five main reaction types occurring in the world around them. These include synthesis (synthesis of polymers or esters), decomposition (explosives), single replacement (smelting of ores), double replacement (neutralization of acids or bases, precipitation of wastes), and combustion (energy resources). Students will learn how to model these reactions with chemical formulas in chemical equations that model the Law of Conservation of Mass. Using their understanding of atomic and molecular structures, predictions will be made regarding the products produced in a given chemical reaction. Students will also learn to model the mathematical relationships between reactants and products and energy through the process of mole relationships and stoichiometry. Finally, this knowledge will be applied to the chemical changes undergone by carbon as is cycles through the geosphere, atmosphere, and hydrosphere.

Stage 2 - Evidence	
Learning Goals Measured: **can be referenced by number* • PS1-2 • PS1-4 • PS1-7 • ESS2-6	**Success Criteria** • 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. PS1.B • Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision.PS1.B • Given a chemical reaction, students i. use mathematical representations to predict the relative number of atoms in the reactants versus the products at the atomic molecular scale; and ii. calculate the mass of any component of a reaction, given any other component. (Balancing Equations) • Students describe how the mathematical representations (e.g., stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore mass, are conserved during a chemical reaction. • Students describe how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number). • Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. Unit 4 Assessment outcomes

	Sample Assessment (e.g. Performance tasks, anchor of student work, common assessment etc.) In this chemical reactions assessment, students will complete both a written exam as well as a practical laboratory based CER activity. In the lab activity, students will perform a reaction and then write a Claim, Evidence, Reasoning response to explain the type of reaction, the energy change of the reaction, and to model the reaction with a complete and balanced chemical equation.
Stage 3 – Learning Plan	
Learning Goals Addressed: **can be referenced by number* • PS1-2	**Sample Assignment:** A brief summary of one assignment that explains what a student produces, how the student completes the assignment, and what the student learns. Make connections to unit learning goals (2-4 sentences). Context: Students have been presented with notes and demonstrations that provide information about the five main types of chemical reactions. In this constructivist lesson, small groups of students will be presented with 40 different numbered chemical reactions on strips of paper. Students are challenged to classify the reactions into the five categories. Teacher moves among groups asking questions to help students make explicit what criteria are being used to categorize the reactions. When ready, each group is assigned to place 1 group of reactions on white board under the appropriate reaction type heading(all reaction strips are duplicated on large file folder strips that can be placed on the white board with magnets). Discussion will clarify characteristics of each type and patterns are pointed out. A few reactions are then classified by the group for a final check of understanding.
	Sample Lab: Provide an example of a teacher supervised, hands on laboratory activity that involve inquiry, observation, analysis and write-up. Briefly describe the activity and how it directly relates to and supports the students learning outcomes of this unit (2-4 sentences)

• PS1-2 • PS1-4	In the Investigating Types of Chemical Reactions, students will explore reactions that have been discussed in class. Students will perform several reactions and determine the type of reaction, whether it is endothermic or exothermic, and create a balanced chemical reaction for each.
	Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended). ● Consistent use of assessments: pre-assessments to know student prior knowledge, formative assessments to check in where students are in their learning and summative assessments to determine if they got it. ● Language Development:(access HMH online ELL resources) ○ Spanish Periodic Table ○ Glossary of new vocabulary given to students, various strategies can be used such as: ■ 5 box chart or a frayer model to define terms, give an example, draw an image, identify a similar term, and write a phrase. ■ 2 column charts-comparing terms by adding phrases from readings/texts to identify meanings of terms. ■ Word Quests- students find new terms in readings, write the terms in the first column, write the sentence that the terms is found in the second column and in the last column, write their own sentence using the term ■ Use the emerge, expand, bridge approach to new terms (see HMH online tools) ● Sentence starters to get students using appropriate language to communicate understanding of content. ● Strategic student grouping: ○ grouping students for labs and other in-class projects based on skill level (whether that's similar or mixed groupings) helps students have needs met either through cooperation with peers or by allowing the teacher to provide more targeted guidance ● Cornell notes with sentence starters and fill in the blanks:

	○ Helps students with more effective note taking technique. Encourages students to go back and review their notes. ● Graphic organizers: ○ Helps students organize the information that they collect in lab, practice worksheets or during in-class projects. ● Spiraled lessons: ○ Students encounter the same information in multiple contexts to help reinforce learning and encourage application. ● Math scaffolds: ○ Use of data tables to organize mathematical information from word problems and experiments ○ Use of graph choice chart to guide students in graphing. Post on classroom walls, use for assessments. ○ Equation templates aid students in applying units and substituting in appropriate experimental values with example problems completed ○ Inclusion of challenge problems and extension options for accelerated students. ○ Visual supports for students in order to manipulate algebraic equations and other most utilized problem solving skills in calculations. Make laminated copies for the classroom.

Stage 1 Desired Results	
Unit 5: Heat and Energy in the Earth Systems	
ESTABLISHED LEARNING GOALS (e.g. standards at the local, state and/or national level) **can be referenced by number* ● PS1-5 ● PS3-2 ● ESS2-4 ● ETS1-4	***Transfer*** *Students will be able to independently use their learning to…* Utilize the kinetic molecular theory to model how energy is transferred within and between physical and chemical systems. Particular focus will be paid to global climate change and how greenhouse gases absorb and hold energy.

	Meaning Making	
	UNDERSTANDINGS *Students will understand that…* *(click on the PEs listed under the Established learning goals for more details)* ● Systems and System Models ● Scientific Knowledge Assumes an Order and Consistency in Natural Systems ● Energy and Matter ● Interdependence of Science, Engineering, and Technology	ESSENTIAL QUESTIONS ● How can energy be used to control chemical reactions? ● What cause and effect mechanisms explain how a reaction proceeds? ● How is the stability of a gaseous system affected by changes in the system? ● How is energy transferred within and between systems? ● How do energy and matter cycle in Earth's systems in relationship to global climate change?
	Acquisition	
	Students will know… ● PS3.A: Definitions of Energy ● PS3.B: Conservation of Energy and Energy Transfer ● PS3.D: Energy in Chemical Processes	*Students will be skilled at…* ● Using Mathematics and Computational Thinking ● Developing and Using Models ● Planning and Carrying Out Investigations ● Scientific Knowledge is Based on Empirical Evidence

Summary of Key Learning: The kinetic molecular theory is developed to use as a model for predicting and explaining the outcome of changes to physical and chemical systems. These changes could include pressure, temperature, volume, concentration as well as energy input. It is important to take into account both the motion of particles and the relative positions of particles. Energy changes are extremely relevant to climate changes that are of significant concern in today's society. The KMT will be applied to explaining the changes that are being seen in sea level rise and warming of the atmosphere.

Stage 2 - Evidence

<table>
<tr>
<td rowspan="2">Learning Goals Measured:
can be referenced by number
• PS1-5
• PS3-2
• ESS2-4
• ETS1-4</td>
<td>Success Criteria
• Students construct an explanation that includes the idea that as the kinetic energy of colliding particles increases and the number of collisions increases, the reaction rate increases.
• Students use and describe the following chain of reasoning that integrates evidence, facts, and scientific principles to construct an explanation for chemical and physical changes based on the KMT.
• Students develop models in which they identify and describe the relevant components, including: i. All the components of the system and surroundings, as well as energy flows between the system and the surroundings; ii. Clearly depicting both a macroscopic and a molecular/atomic-level representation of the system;
• Students describe the relationships between components in their models of Intermolecular Forces.
• Students use their models to show that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is transferred into or out of the system.
• Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
• Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
Unit 5 Assessment outcomes</td>
</tr>
<tr>
<td>Sample Assessment (e.g. Performance tasks, anchor of student work, common assessment etc.
Students evaluate competing proposals (provided by teachers) for actions that might be taken to mitigate the effects of climate change through altering the carbon cycle in light of social, economic, and moral considerations. They respectfully provide critiques of the proposals. Reference</td>
</tr>
<tr>
<th colspan="2">Stage 3 – Learning Plan</th>
</tr>
</table>

Learning Goals Addressed: **can be referenced by number* • PS1-5 • PS3-2 • ESS2-4 • ETS1-4	**Sample Assignment:** A brief summary of one assignment that explains what a student produces, how the student completes the assignment, and what the student learns. Make connections to unit learning goals (2-4 sentences). Students will explore a Phet Simulation called Greenhouse Effect Simulation. This simulation makes visible how different greenhouse gases react to different types of photons - UV and Visible. It also allows students to explore different atmospheric compositions to model how that would affect the temperature of the atmosphere.
	Sample Lab: Provide an example of a teacher-supervised, hands on laboratory activity that involve inquiry, observation, analysis and write-up. Briefly describe the activity and how it directly relates to and supports the students learning outcomes of this unit (2-4 sentences) In Developing a Kinetic Molecular Theory for Gases Lab, or KMT Stations Lab will investigate many phenomena to think about how gaseous molecules interact under conditions of changing pressure, temperature and volume. Students have not yet had direct instruction about gas laws or the KMT model. When all investigations are complete, small groups of students present their CERs for one of the investigations so that all investigations are in the ned, discussed by the whole class. .

	Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended).
	
	• Consistent use of assessments: pre-assessments to know student prior knowledge, formative assessments to check in where students are in their learning and summative assessments to determine if they got it.
	• Language Development:(access HMH online ELL resources)
	    ○ Spanish Periodic Table
	    ○ Glossary of new vocabulary given to students, various strategies can be used such as:
	        ■ 5 box chart or a frayer model to define terms, give an example, draw an image, identify a similar term, and write a phrase.

	■ 2 column charts-comparing terms by adding phrases from readings/texts to identify meanings of terms. ■ Word Quests- students find new terms in readings, write the terms in the first column, write the sentence that the terms is found in the second column and in the last column, write their own sentence using the term ■ Use the emerge, expand, bridge approach to new terms (see HMH online tools) ● Sentence starters to get students using appropriate language to communicate understanding of content. ● Strategic student grouping: ○ grouping students for labs and other in-class projects based on skill level (whether that's similar or mixed groupings) helps students have needs met either through cooperation with peers or by allowing the teacher to provide more targeted guidance ● Cornell notes with sentence starters and fill in the blanks: ○ Helps students with more effective note taking technique. Encourages students to go back and review their notes. ● Graphic organizers: ○ Helps students organize the information that they collect in lab, practice worksheets or during in-class projects. ● Spiraled lessons: ○ Students encounter the same information in multiple contexts to help reinforce learning and encourage application. ● Math scaffolds: ○ Use of data tables to organize mathematical information from word problems and experiments ○ Use of graph choice chart to guide students in graphing. Post on classroom walls, use for assessments. ○ Equation templates aid students in applying units and substituting in appropriate experimental values with example problems completed ○ Inclusion of challenge problems and extension options for accelerated students.

	● Visual supports for students in order to manipulate algebraic equations and other most utilized problem solving skills in calculations. Make laminated copies for the classroom. .

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td colspan="3">Unit 6: The Dynamics of Chemical Reactions and Ocean Acidificiation</td></tr>
<tr><td rowspan="5">ESTABLISHED LEARNING GOALS (e.g. standards at the local, state and/or national level)
*can be referenced by number

● PS1-6
● PS1-7
● ESS2-2
● ESS2-6
● ESS3-5</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…

Explain how increased CO_2 in the atmosphere is impacting the earth's oceans using the concepts of hydrolysis, pH and equilibrium. Discuss possible solutions to minimize the negative impacts.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that…
(click on the PEs listed under the Established learning goals for more details)
● Patterns
● Stability and Change
● Energy and Matter
● Scientific Knowledge Assumes an Order and Consistency in Natural Systems
● Influence of Engineering, Technology, and Science on Society and the Natural World</td><td>ESSENTIAL QUESTIONS

● Why are the oceans becoming more acidic?
● How is this change related to the burning of fossil fuels?
● What cause-and-effect mechanisms explain how a reaction proceeds?
● What scale is used to rate the strengths of acids and bases?
● What predictable patterns happen when chemical equilibrium is disturbed?
● How can matter cycles and energy flows in chemical equilibrium processes be used to address ecological and economic concerns?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
</table>

<table>
<tr><td></td><td>Students will know…
(click on the PEs listed under the Established learning goals for more details)

● PS1.B: Chemical Reactions
● ETS1.C: Optimizing the Design Solution
● ESS2.A: Earth Materials and Systems
● ESS2.D: Weather and Climate
● ESS3.D: Global Climate Change</td><td>Students will be skilled at…
(click on the PEs listed under the Established learning goals for more details)

● Constructing Explanations and Designing Solutions
● Using Mathematics and Computational Thinking
● Analyzing and Interpreting Data
● Scientific Investigations Use a Variety of Methods
● Scientific Knowledge is Based on Empirical Evidence</td></tr>
<tr><td colspan="3">Summary of Key Learning: In this unit, students will use the phenomena of ocean acidification as context for understanding pH, equilibrium and carbon cycling. In the entry event, students will begin by watching an animation that depicts the change in CO_2 in the atmosphere over time and a video that describes how ocean acidification impacts local oceans. Students will create an initial model that shows their current understanding of how CO_2 impacts earth's oceans. Students will then learn about pH and acid base indicators and perform an experiment that simulates increased CO_2 concentration in the atmosphere above a body of water. Following this experiment, students will revise their initial model of ocean acidification. Next, students will perform an equilibrium experiment where they look at how changing factors like concentration, temperature, etc. shift equilibriums. That will be followed by looking specifically at the equilibrium of CO_2, carbonic acid and carbonate that exist in earth's oceans through the use of guided notes and a second iteration of their initial lab, which now introduces calcium carbonate into the simulated ocean. Students will conclude by preparing a final revision of their ocean acidification model. Students will also complete a written assessment.</td></tr>
<tr><th colspan="3">Stage 2 - Evidence</th></tr>
<tr><td>Learning Goals Measured:
*can be referenced by number
● PS1-5
● PS1-6
● PS1-7
● ESS2-2
● ESS2-6
● ESS3-5
● ESS3-6</td><td colspan="2">Success Criteria (e.g.. Learning progression, rubric, proficiency scale, etc.)
● Students will be able to define the terms acid, base and neutral
● Students will be able to determine the pH of a solution using an indicator
● Students know that pH is measured on a logarithmic scale
● Students will be able to do simple pH calculations
● Students will be able to define equilibrium
● Students will be able to use LeChatelier's principle to predict how changes in concentration, temperature and pressure alter equilibrium concentrations</td></tr>
</table>

	• Students will be able to explain how CO_2 moves from the earth's atmosphere into the hydrosphere • Students will be able to describe how increased levels of CO_2 in earth's oceans increase their acidity • Students will be able to describe how increased acidity in earth's oceans impact the biosphere. • Students will be able to identify how human activity has altered the amount of CO_2 in earth's atmosphere and oceans Unit 6 Assessment outcomes
	Sample Assessment (e.g. Performance tasks, anchor of student work, common assessment etc.) Ocean Acidification Modeling Worksheet: This worksheet contains all the models created by the student from initial to final.
Stage 3 – Learning Plan	
Learning Goals Addressed: **can be referenced by number* Ocean Acidification Notes • PS1-5 • PS1-6 • ESS2-2 • ESS2-6 • ESS3-5 • ESS3-6 Ocean Acidification Lab • PS1-5 • PS1-6 • PS1-7 • ESS2-2 • ESS2-6 • ESS3-5 • ESS3-6	**Sample Assignment:** A brief summary of one assignment that explains what a student produces, how the student completes the assignment, and what the student learns. Make connections to unit learning goals (2-4 sentences). Ocean Acidification Notes: In this assignment, students will take notes as they navigate through a series of slides that demonstrate many of the aspects of ocean acidification. This assignment will help students understand how changing atmospheric conditions alter the equilibrium responsible for ocean pH. Students work on the assignment in groups of two, but each student completes their own set of notes. These notes will be revisited using Cornell Note procedures. **Sample Lab:** Provide an example of a teacher-supervised, hands on laboratory activity that involve inquiry, observation, analysis and write-up. Briefly describe the activity and how it directly relates to and supports the students learning outcomes of this unit (2-4 sentences) Ocean Acidification Lab (Part 1, Part 2, HMH Lab): This lab uses a model ocean in a cup to simulate how increased CO_2 levels in the atmosphere increase pH in the ocean (Part 1) and how increased pH levels in the ocean cause carbonate ion concentration to decrease, impacting organisms with shells. Students will use their observations and conclusions from this lab to support the construction of their model of ocean acidification.

	Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended).
	
	● Consistent use of assessments: pre-assessments to know student prior knowledge, formative assessments to check in where students are in their learning and summative assessments to determine if they got it.
	● Language Development:(access HMH online ELL resources)
	    ○ Spanish Periodic Table
	    ○ Glossary of new vocabulary given to students, various strategies can be used such as:
	        ■ 5 box chart or a frayer model to define terms, give an example, draw an image, identify a similar term, and write a phrase.
	        ■ 2 column charts-comparing terms by adding phrases from readings/texts to identify meanings of terms.
	        ■ Word Quests- students find new terms in readings, write the terms in the first column, write the sentence that the terms is found in the second column and in the last column, write their own sentence using the term
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	● Sentence starters to get students using appropriate language to communicate understanding of content.
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Instructional Materials:

Suggested textbook(s), materials, equipment and resources ● Include: title, author, publisher, edition, website if applicable, note primary or supplementary material ● Please indicate if the books and materials have been previously approved by the board ● If the books and materials have not been board approved, please complete a book approval form as well and submit to the board with the new Course of Study. ● *English courses must have any suggested books approved by the department prior to sending the CoS to the board for approval	**Piloting HMH *Chemistry in the Earth* materials, will adopt for 1 year, 2020-2021, digital materials and workbook sets.** **Phet Simulations from Colorado University will be utilized frequently. Phet.colorado.edu**