San Mateo Union High School District
Course of Study

Approved by:
BOARD OF TRUSTEES
3/9/17

Chemistry in the Earth System
FINAL DRAFT

I. **Course Description**

A. **UC/CSU "a-g" Subject Area:** D

B. **Rationale for Course:** The course is based on the Next Generation Science Standards and the California Frameworks for the 3-Course Model of Chemistry in the Earth System.
The content for the course Chemistry in the Earth System, in grades 9 through 12, will generally be drawn from the Science Content Standards for California Public Schools, the Next Generation Science Standards, the NGSS-based California Frameworks for the 3-Course Model of Chemistry in the Earth System, and the Common Core State Standards for Literacy in History/Social Studies, Science and Technical Subjects.

C. **Grade Level:** 10-12

D. **Credits:** 10 Credits per year, (5 per semester)

E. **Prerequisites:** Algebra I as a prerequisite or co-requisite.

F. **Brief Course Description:** Students will investigate the formation of the first elements and their transformation to heavier elements in the context of stars as nuclear element factories. They will use this knowledge to explore the structure of an atom and patterns in the periodic table. Students will investigate the forces that hold matter together and how society uses its understanding of elements and molecules to develop useful materials. Students will explore the interactions of atoms and molecules as illustrated by chemical reactions. Students will investigate Earth's atmosphere and climate system. Students will explore the factors that drive chemical and physical changes based on their understanding of elements and materials science. They will examine connections between matter and energy into and out of chemical systems, extending the concept to the movement of energy through Earth's systems and ways humans may control these moments. Students will investigate these concepts in the context of greenhouse gases, their effect on the atmosphere, and the stability and changes of the chemistry of the ocean and other bodies of water on Earth.

II. **Course Purpose: Goals and Student Outcomes**

Students will explore physical science concepts that build comprehension around matter, its properties, and its interactions with other matter and energy in the context of the earth system. The instructional segments within this scope and sequence are presented thematically to provide a context for student learning of Chemistry's place in the Earth System. Students will explore science and engineering practices, crosscutting concepts and disciplinary core ideas, demonstrating their understanding through NGSS-aligned Performance Expectations.

III. **Chemistry Course Outline**

Module (Order is not prescribed)	**Combustion (unifying concept)**	**Heat and Energy in the Earth System**	**Structure of Matter: From Stars to Atoms**	**Earth Material Science: From Atoms to Compounds**	**Chemical Reactions**	**Earth's Atmosphere**	**Water**
Essential Questions (Lens)	● *What is energy, how is it measured, and how does it flow within a system?* ● *How do the products of combustion affect global systems?*	● *How is energy stored, transferred, and conferred?* ● *How are plate techtonics and energy transfer related?* ● *How are heat changes measured, calculated, and predicted?*	● *What is a star's role in the formation of atoms?* ● *In what ways are all atoms similar? How do differences in atoms give rise to periodicity?*	● *Why do materials have different properties and how do we use different materials in society?* ● *How are compounds formed from atoms or ions?* ● *What forces hold various types of matter together?*	● *How does the structure of molecules influence chemical reactions?* ● *What are the relationships between materials and energy in a chemical reaction?*	● *What effects are humans having on the climate?* ● *How do natural and unnatural chemical reactions affect Earth's temperature and weather patterns?*	● *How have humans impacted the equilibrium of the hydrosphere?* ● *How does the changing chemistry of Earth's water systems affect global climate?*
Unit Description	Short Unit: Making macro-level observations of changes, Kinetic Molecular Theory, and the nature of matter. Students	Chemical energy will be explored as it relates to climate change and the energy balance on Earth. Students will develop models of energy conservation within systems	This module takes students from the formation of atoms to our understanding of their structure and resulting properties, wherein students will	In this unit students will explore and model bond formation, valence shell electron pair repulsion (VSEPR), electronegativity and how it	Students will explore conservation of energy and bond energies in preparation to apply knowledge of chemistry concepts in the context of climate change.	Emissions from energy source combustion reactions effect on atmospheric equilibrium. Study of the structures of molecules can explain how different	Study the global hydrosphere in relation to properties of solutions, concentration, rates of reactions, equilibrium, and acid/base chemistry.

	observe material properties at the bulk scale that they will later explain on the atomic scale. Combustion and CO_2 tie together several Modules**.**	and the mechanisms of heat flow, relate macroscopic heat transport to atomic scale interactions of particles, and use evidence from Earth's surface to infer the heat transport processes at work in the planet's interior and plate tectonics.	develop models for changes in nuclear composition and energy release during fission, fusion and radioactive decay. These nuclear processes build on the explanation for plate tectonics.	determines molecular polarity, intermolecular forces, and formation and properties of compounds.	To this end, conservation of matter, interactions between molecules, the concept of the mole, dimensional analysis and stoichiometry, and the factors that influence reaction rates will be addressed.	molecules trap heat in the atmosphere while gas relationships enable exploring the effects of the trapped heat in Earth's climate and related systems. Students also may evaluate chemical engineering solutions to reduce impacts of climate change.	These concepts relate to the chemistry of, and interactions between, the atmosphere and the hydrosphere (i.e., ocean acidification/ acid rain), pollutants affect on water systems, and possible human interventions.
NGSS Performance Expectations	HS-PS3-4	HS-PS3-1 HS-PS3-2 HS-PS3-4 HS-ESS2-3 HS-PS1-7 HS-PS1-4 HS-PS3-4	HS-PS1-1 HS-PS1-3 HS-PS1-8 HS-ESS1-3	HS-PS1-1 HS-PS1-2 HS-PS1-3 HS-ESS3-1	HS-PS1-4 HS-PS1-7 HS-PS3-5 HS-PS1-5	HS-PS1-5 HS-ESS2-2 HS-ESS2-4 HS-ESS2-6 HS-ESS3-4 HS-ESS3-5	HS-PS1-5 HS-ESS2-5 HS-PS1-6 HS-ESS3-5 HS-ESS3-4 HS-ESS3-6
Disciplinary Core Ideas	• PS1.A: Structure and Properties of Matter • PS1.B: Chemical Reactions • PS3.D: Energy and	• PS3.A: Definitions of Energy • PS3.B: Conservation of Energy and Energy Transfer	• PS1.A: Structure and Properties of matter • PS2.B: Electrical atraction and repulsion • ESS1.C:	• PS1.A: Structure and Properties of Matter • PS1.B: Chemical Reactions • PS2.B: Types of Interactions	• PS1.B: Chemical reactions • ESS1.C: History of Planet Earth • PS3.D: Energy in Chemical	• PS3.B: Conservation of Energy and Energy Transfer • PS3.D: Energy in Chemical Reactions • ESS1.B:	• PS1.B: Chemical Reactions • ESS2.C: The Roles of Water in Earth's Surface Processes • ESS2.D:

	Chemical processes in Everyday Life	• ESS2.B: Plate Tectonics and Large-Scale System Interactions	History of Planet Earth	• ESS2.A: Earth Materials and Systems	Processes • PS3.B: Conservation of Energy and Energy Transfer	Earth and the Solar System • ESS2.D: Weather and Climate • ESS3.C: Human Impacts on Earth's Systems • ESS3.D: Global Climate Change	Weather and Climate • ESS3.D: Global Climate Change • ETS1.C: Optimizing the Design Solution
Science and Engineering Practices	• Asking Questions, • Planning and Carrying Out Investigations, • Developing and Using Models, • Using Mathematics	• Developing and Using Models • Using Mathematics and Computational Thinking • Analyzing and Interpreting Data	• Developing and Using Models • Constructing Explanations • Engaging in Argument from Evidence • Planning and Carrying Out Investigations	• Developing and Using Models • Constructing Explanations • Engaging in Argument from Evidence • Planning and Carrying Out Investigations	• Constructing Explanations and Developing Solutions • Developing and Using Models • Using Mathematics and Computational Thinking	• Developing and Using Models • Constructing Explanations and Developing Solutions • Analyzing and Interpreting Data • Planning and Carrying Out Investigations	• Constructing Explanations and Developing Solutions • Analyzing and Interpreting Data • Planning and Carrying Out Investigations • Using Mathematics and Computational Thinking
Crosscutting Concepts	• Systems and System Models	• Energy and Matter • Scale,	• Cause and Effect • Patterns	• Cause and Effect • Patterns	• Patterns • Energy and Matter	• Patterns • Systems and System	• Stability and Change • Systems and

	• Cause and Effect • Energy and Matter	Proportion, and Quantity	• Structure and Function • Systems and System Models	• Structure and Function	• Stability and Change • Cause and Effect	Models • Stability and Change • Cause and Effect • Energy and Matter	System Models • Patterns • Cause and Effect

IV. **Key Assignments**: Chemistry students will be able to experience a variety of labs and projects that integrate concepts of chemistry with earth science. Some examples include: Flame Test Lab Write Up, Reactions Unit Assessment, Acid Rain Micro-Environment Chamber Analysis, and Atomic Modeling Project.

V. **Instructional Methods and/or Strategies including Instructional Technology**: Guided Inquiry, Direct Instruction, Collaborative Group Work, Independent Research, Instructional Technology (PhET on-line simulations; Concord Consortium simulations; Modeling Curriculum (AMTA), Annenberg Learner, POGILs)

VI. **Assessment Methods and/or Tools**: Teachers will use a variety of formative and summative assessments. This laboratory-based class integrates laboratory experiences, projects, and assessments with reading, research, and experiential learning. Assessment methods include standard-based grading, rubrics-based presentations, and pencil-paper tests.

VII. **Textbook(s) and Supplemental Instructional Materials**: Zumdahl **World of Chemistry**, Key Curriculum Press **Living By Chemistry,** Glencoe **Chemistry Matter and Change, ChemMatters Magazine, POGIL**

VIII. **Appendix - NGSS Standards**

Performance Expectations For Chemistry in the Earth System: Links provide details on disciplinary core ideas, science and engineering practices and crosscutting concepts encapsulated by the designated performance expectation. Some performance expectations, particularly the Earth and Space Science (ESS) standards, are covered partially in this course of study, and the remaining components are covered either in the Living Earth or Physics in the Universe.

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.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms,

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

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.

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.

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

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

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.

HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

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).

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction

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.

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.

HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.