

Chemistry in Water

Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS)

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[NGSS Performance Expectations\(s\)](#)

[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.

[HS-ESS2-5](#). Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

[HS-ESS3-1](#). Construct an explanation based on evidence for how the availability of water resources, natural hazards and changes in climate have influence human activity.

[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.

Background Information

The following lessons have been developed by a committee of STEM teachers at GUHSD with funding from a NSF grant awarded to the Center for Water Studies at Cuyamaca College. Other lessons for Space & Earth Sciences and Physics have also been developed. More resources are available at cws.careers.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions 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.	PS1.A: Structure and Properties of Matter The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. PS1.B: Chemical Reactions The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to	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. Structure and Function The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular

<p>Planning and Carrying Out Investigations 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.</p> <p>Asking Questions and Defining Problems Analyze complex real-world problems by specifying criteria and constraints for successful solutions.</p>	<p>describe and predict chemical reactions.</p> <p>ESS2.C: The Roles of Water in Earth's Surface Processes: The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.</p> <p>ESS3.A: Natural Resources - Resource availability has guided the development of human society</p> <p>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. 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.</p> <p>ETS1.B: 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.</p>	<p>substructures of its various materials.</p> <p>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.</p>
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CCSS Connections to Support Reading, Writing, Speaking, Listening and Mathematics

Students construct an explanation that includes: i. Specific cause and effect relationships between environmental factors (natural hazards, changes in climate, and the availability of natural resources) and features of human societies including population size and migration patterns.

Instructional Sequence 1

Performance Expectation(s)	<p>PS 1-2 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.</p> <p>ETS 1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</p> <p>ESS 2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.</p> <p>ESS 3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.</p>
Concepts from: ➤ <i>Evidence Statements</i> ➤ <i>Clarification Statements</i>	<ul style="list-style-type: none"> • Carbon based reactions, and solubility rules can be studied & used to help create a filter system or analyze what minerals are in samples of polluted water. • Identify the problems associated with finding and providing safe drinking water from the chemical perspective.
3 Dimensions of Focus	<p>SEP: Asking Questions and Defining Problems</p> <p>CCC: Influence of Science, Engineering, & Technology on Society and the Natural World</p> <p>DCI: PS1A & ESS 2C</p>
Guiding Question(s)	How can we change wastewater into clean drinkable water?
Guiding Phenomenon	Is natural water ready to drink?

5E Stage (4 weeks)	Driving Question(s)	What the Teacher Does	What the Student Does
Engage Materials:	Why is having clean water so important for societies?	Show Video on Need for Clean Water Elicit questions about the video and the availability of clean water in our neighborhoods and around the world. Chart students answers with stickies or use a digital app like padlet,	Ask questions concerning the video and brainstorm what they can do to help solve a world problem of this scale by doing something in their own neighborhood (other than buying a challise). Have students write

<p>*Chart paper *Stickies *Whiteboards *Chromebooks *journals</p>		<p>PearDeck to archive student responses</p> <p>Introduce the new PURE WATER program being installed by San Diego City. Discuss the issues surrounding this project including students questions and concerns. Optional: schedule a field trip to PURE via</p>	<p>questions on stickies. Save stickies on a large poster paper for future use.</p> <p>Suggest questions, concerns and comments surrounding the issues of getting clean water to their own homes, the Pure Water Project and then also to people around the world.</p>
		<p>Optional additional engage piece: "Which Water is Which"</p>	<p>Students match the the letters of the jars with the list of types of water that they believe is in each jar. <i>More instructions on gDoc.</i></p>
<p>Explore</p>	<p>What are some various methods in which water is cleaned and made safe for drinking?</p>	<p>Lead a discussion of how our local community makes water safe to drink.</p> <p>Introduce Modeling Wastewater Treatment where students test the different methods and determine which one produces the best water quality. Debrief lab success/failure</p>	<p>Students conduct Modeling Wastewater Treatment activity</p> <p>Students generate a poster of the Pros/Cons of their filtration for sharing with other groups. Conduct a walk-around with one expert to explain the results for their group during the walk-around</p>
<p>Explore Materials: Ice cubes Index cards</p>		<p>Teacher sets up lab stations and leads a discussion in order to access students prior knowledge of any special properties of water. Student answers will vary and many students may have little to no background knowledge concerning water's properties. The teacher will want to make some decisions as to how much knowledge of water he/she wants the students to learn.</p>	<p>• Properties of water lab or • Properties of water lab 2 from Monte Vista</p> <p>Students will generate some kind of statements of understanding, CER writing, or evidence statements.</p>
<p>Explore</p>	<p>What are some important vocabulary words associated with water properties?</p>	<p>Hand out Speed Dating Worksheet. Or Water Cooler Talk</p>	<p>• Water Cooler Talk or • Water Vocabulary Speed Dating Activity</p>
<p>Explore</p>		<p>Optional engineering activity JPL/NASA Water Filtration project</p>	<p>Students do JPL/NASA Water Filtration project for an engineering component</p>
<p>Explain</p>		<p>Tic Tac Toe Water Properties push out assignment over google classroom</p>	<p>Students will choose 3 of the squares to complete and link their work in each square.</p>

Explore	OPTIONAL UNIT ON MERCURY	Analysing Mercury content Teacher's intro page	Mercury Project Data - Google Sheet
Explore Materials: Depends on lab chosen	Optional Unit on Water Quality What does term "water quality" refer to? How can you learn more about water quality?	OPTIONAL Water Standard Academy Unit Or OPTIONAL Water Quality removing contaminants	
Explore Materials:	What is the engineering design process?	Teacher leads a discussion about how developing nations might purify their water. List student suggestions. Pass out student worksheet and have the students answer questions 1 and 2. Show PBS Learning Media: Simple Solutions: The Engineering Design Process Teachers have to create a free PBS sign-in account to access this video which covers engineering a solution for a water need.	Students answer questions 1 and 2 of the Design Process Worksheet before individually watching the Simple Solutions: The Engineering Design Process clip. Students then complete the Design Process Worksheet .
Explore	What is wastewater and how can it be reused/recycled?	Show students How Wastewater Goes from Polluted to Pure and explain how their waste treatment from the previous activity did or did not cover all the methods used in the process shown in this video for actual water treatment . As needed the teacher can review High level slides on Ozone's use in water purification with students.	Students read and take notes on Obscure Chemical Taints Water Supply article Students choose one of the 4 methods for filtering contaminants out of water and argue from evidence as to which is the best method. Household Water Treatments
Explain	Optional additional activities Does San Diego County currently have any ways in which it recycles wastewater?	Engage: Students read article on the issues with outdoor defecation . Field trip to Pure Water Facility	Students then conduct The Poop on Poop activities including a wastewater treatment plant virtual tour Students choose to read and collect evidence from one of these 3 articles: How Ozone helps purify water or An Overview of Ozone in water, wastewater treatment or Ozone in Drinking Water Treatment ? Then students argue from evidence as to whether or not an ozone treatment step is essential to water purification.
Explore Careers in Water		Explore Careers for Clean water Potable Water Activism	Career based activities (Currently only shared with GUHSD)

Elaborate			Inquiry-based Water Quality Lab
Evaluate		There are several ways to evaluate/assess this unit.	

[Other LINKS and/or general ideas not yet explored or vetted that could be used by any of the Water Teams](#)

Instructional Sequence 2

Performance Expectation(s)	
Concepts from: ➤ <i>Evidence Statements</i> ➤ <i>Clarification Statements</i>	•
3 Dimensions of Focus	SEP: CCC: DCI:
Guiding Question(s)	What properties of water give it unique qualities?
Guiding Phenomenon	

5E Stage (Time Frame)	Guiding Question(s)	What the Teacher Does	What the Student Does
Engage			
Explore			

Explain			
Elaborate			
Evaluate			