Chemistry in the Earth System AB 361413/14

Title: Chemistry in the Earth System AB
Length of course: Full Year
Subject area: Laboratory Science (D) / Chemistry
UC honors designation? No
Prerequisites: Algebra (Required)
Co-requisites: Algebra (Recommended)
Integrated (Academics / CTE)? No
Grade levels: 10th, 11th, 12th

Course Description

Course overview:
“Chemistry in The Earth System” is a laboratory-based college-preparatory course. As part of the three course model, and originating from “A Framework for K-12 Science Education” and “Next Generation Science Standards (NGSS)” (see Background Information below), there is integration of some topics traditionally taught as Earth Science and Physics. This course explains how chemical processes help drive the Earth system. The course is sequenced based on a specific storyline about climate change. As such, the course will focus on both physical science and earth science disciplinary core ideas (DCI). The course also emphasizes the continued development of the Science and Engineering Practices (SEP) and Cross Cutting Concepts (CCC). Each of the six instructional segments (IS) includes a bundle of NGSS performance expectations (PE) from these two disciplinary core ideas. Each of the instructional segments is centered on questions about observations of a specific phenomenon. Upon completion of the course students will have explored the fundamentals of chemistry and essential roles that these processes play in Earth’s solid geosphere, its liquid hydrosphere, and its gaseous atmosphere.

This course meets the LAUSD graduation requirement of one year of physical science, and meets one year of the University of California ‘d’ entrance requirement for laboratory science.

Course content:

Combustion

In this brief introductory unit, students investigate the amount of stored chemical potential energy in food. They make observations of material properties at the bulk scale that they will later explain in the atomic scale. The themes of combustion and CO2 tie together several of the Instructional Segments.

Unit Assignment(s):

Students ask questions about what different food items mean and why they are included on the nutrition label. Students are commonly familiar with the idea of Calories, but may ask “What are Calories?” and “how do they measure them?” These questions drive an investigation using a standard calorimetry experiment to measure the energy output of different foods.

Unit Lab Activities:

The calorimetry experiment can be done with a soda can. Students light a nut or other high Calorie snack food on fire below a metal can containing a measured amount of water. The burning food transfers energy to the water in the can. By measuring the temperature increase in the water, students calculate the amount of energy transferred, which can be measured in the familiar unit of Calories (HS-PS3-1). Students analyze the data then represent the system with a pictorial model by drawing a diagram of the components and interactions.

Heat and Energy in the Earth System

Students develop models of energy conservation within systems and the mechanisms of heat flow. They relate macroscopic heat transport to atomic scale interactions of particles, which they will apply in later units to construct models of interactions between atoms. They use evidence from Earth's surface to infer the heat transport processes at work in the planet's interior.

Unit Assignment(s):

Students develop a of density driven flow in rock to help understand heat transfer and explain how these flows give rise to plate tectonics and their movement. Students gather many pieces of evidence that this motion is occurring. They research that scientists can directly observe these motions using modern day Global Positioning System (GPS) measurements . One revealed in such measurements is that large sections of the Earth all move together in the same direction at the same time (what we call plates). They also research age of the seafloor. There are long stripes down the middle of many oceans with very young seafloor and then a clear where the ages are symmetrically older in both directions away from the stripe of youngest rocks. Students should be able to use seafloor ages and surface motion rates as evidence that convection occurs in Earth's interior. Students their with a pictorial of Earth's interior that has annotations to indicate how heat transfer drives movement within the Earth.

Unit Lab Activities:

Students measure the temperature of two bodies of water before and after mixing, or the temperatures of metal blocks and water prior to, and following immersion. By repeating these investigations with differing quantities of materials, students can apply the concept of scale, proportion, and quantity to predict temperature changes, equilibrium conditions, and magnitudes of energy transferred (HS-PS3-1). Students relate the processes of conduction, convection, and radiation to the motion of individual particles (HS-PS3-2).

Atoms, Elements, and Molecules

Students recognize patterns in the properties and behavior of elements, as illustrated on the periodic table. They use these patterns to develop a model of the interior structure of atoms and to predict how different atoms will interact based on their electron configurations. They use chemical equations to represent these interactions and begin to make simple stoichiometric calculations.

Unit Assignment(s):

Students interpret the trends on the periodic table in light of their underlying model for atomic structure. They relate the overall order of the periodic table to the number of protons and electrons in the atom's outermost energy level. Students develop a simple model of interactions between atoms based on their electron configuration. They should be able to use the periodic patterns of electron configuration in the periodic table to predict properties such as the overall reactivity of metals and the number of bonds an atom can form (HS-PS1-1), as well as being able to predict the outcome of simple chemical reactions (HS-PS1-2).

Unit Lab Activities:

Students observe an incandescent light bulb and individual wavelengths of emitted light from an elemental gas discharge tube using a spectroscope. They record their observations using colored pencils drawing a full spectrum for the light bulb and discrete lines for the discharge tubes onto a lab worksheet and analyze and compare the differences in emitted light between the two. In the flame tests lab, the student burns different salt solutions containing metal ions which excites the atom's electrons to a higher energy level and then they fall back down to a lower energy (resting) state and emit light with a specific wavelength. The students complete a lab worksheet indicating the color of light observed and learn that different salt solutions containing the same metal ion will emit the same wavelength of light, therefore being a method of identifying an element.

Chemical Reactions

Students refine their models of chemical bonds and chemical reactions. They compare the strength of different types of bonds and attractions and develop models of how energy is stored and released in chemical reactions.

Unit Assignment(s):

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They use this evidence to support a of different types of chemical bonds and attractions. When considering ionic bonds, this model includes attractions between charged particles related to Coulomb's Law.

Students will learn how the nucleus of one atom has enough attractive force to pull one, two, or three electrons away from nuclei that does not have the same attractive force on its own electrons. By applying the principles of electrostatic attraction, students should be able to predict that the resulting cations and anions will be attracted to each other and form ionic bonds. However, if either ion feels a stronger attraction to a different particle, then the existing bond is easily broken. Knowing that when salt dissolves in water, its bonds are broken, students can make inferences about the charge of water molecules.

Unit Lab Activities:

Students plan and conduct investigations using probes and computer probeware to continuously monitor the temperature change in several chemical reactions.

Students take screen captures of the temperature plots, classify each reaction as endothermic or exothermic, and represent it using two or more established model-types or an additional model type that they develop on their own. When writing their lab reports, students apply scientific principles and evidence to construct explanations for the thermal changes that they have observed in each reaction.

Chemistry of Climate Change

Students develop models of energy flow in Earth's climate. They revisit combustion reactions from Unit One to focus on emissions from fossil fuel energy sources. They apply models of the structures of molecules to explain how different molecules trap heat in the atmosphere. Students evaluate different chemical engineering solutions that can reduce the impacts of climate change.

Unit Assignment(s):

Students work in small groups to create a single year graph of CO_2 emissions in order to identify trends and patterns. Students associate the changes with the seasons since they repeat once a year. The pattern of fluctuating CO_2 relates to the growth of vegetation; since there is more vegetated land area in the northern hemisphere, the consumption of CO_2 by plants varies as seasons shift from the productive summer months in the northern hemisphere to summer in the southern hemisphere. The class tapes their graphs side-by-side to the wall in sequence so that they create one long time series graph, reaching up to 35 years of data. Students use the past data and draw a graph predicting the next five years, extrapolating both the long-term trend of increasing CO_2 and the annual variation, then calculate the year in which atmospheric CO_2 will reach 540 ppm (approximately double the pre-industrial CO_2 levels), assuming that current trends continue.

Unit Lab Activities:

Students in small groups have two jars with thermometers that can be inserted through a lid and affixed using putty, so they are sealed and the thermometer stays in one place. Two ring stands with 150 watt light bulbs are horizontally placed equidistant from each jar. One jar contains a votive candle which is lit and then extinguished (this jar represents the CO2 enhanced atmosphere). The other jar has just air. The students let the jars come to thermal equilibrium and then turn on the lights and begin recording each jar's temperature every minute onto a data table for 15 minutes. The data is then plotted onto a graph of time vs. temperature for both jars. Students learn in this lab that a CO2 enriched environment (representative of the earth) will warm up to a higher temperature and retain the heat compared a non CO2 enriched environment. At the end of the lab, a class discussion of how humans are affecting our global climate due to burning of fossil fuels is discussed and students attach a quick write about that topic to their graph.

Dynamics of Chemical Reactions and Ocean Acidification

Students investigate the effects of fossil fuel combustion on ocean chemistry. They develop models of equilibrium in chemical reactions and design systems that can shift the equilibrium. Students conduct original research on the interaction between ocean water and shell-building organisms.

Unit Assignment(s):

Students analyze news articles to obtain information that documents systems-level interactions between CO2 emissions,ocean chemistry, organisms within the ocean, and human prosperity. Students conduct a simple engaging activity to visualize the relationship between atmospheric CO2 and ocean chemistry. Students in small groups investigate different interactions within the bio-geo-chemical system. They formulate their own research questions and design their own experiment.

Unit Lab Activities:

Students design an investigation to measure the effect of changing CO_2 concentration on the pH of water. To do this, students are instructed that all CO2 should enter the water through contact with air. Teachers that do not have access to probeware can instead utilize universal indicator solution along with flasks, tubing and other supplies. This allows students to better understand how increased CO_2 levels in the atmosphere affect CO_2 levels in the ocean.

Course Materials

Websites

Title	Author(s)/Editor(s)/Compiler(s)	Affiliated Institution or Organization	URL
CK12	[empty]	CK12 Foundation	www.ck12.org
Phet Simulation	[empty]	University of Boulder Colorado	https://phet.colorado