South Carolina Academic Standards and Performance Indicators for Science 2014

Instructional Units Resource

Chemistry

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As support for implementing the *South Carolina Academic Standards and Performance Indicators for Science 2014*, the standards for Chemistry have been grouped into possible units. In the Overview of Units below, the titles for those possible units are listed in columns. Refer to the Overview document to note these unit titles and how Standards, Conceptual Understandings, Performance Indicators, Science and Engineering Practices, and Crosscutting Concepts align. Following the Overview of Units, an Instructional Unit document is provided that delivers guidance and possible resources in teaching our new *South Carolina Academic Standards and Performance Indicators for Science 2014*. The purpose of this document is to provide guidance as to how all the standards in this grade may be grouped into units and how those units might look. Since this document is merely guidance, districts should implement the standards in a manner that addresses the district curriculum and the needs of students. This document is a living document and instructional leaders from around the state will continuously update and expand these resource documents. These documents will be released throughout the 2016-2017 school year with the intentionality of staying ahead of instruction. Teachers should also note that links to the Standards document, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, the SEP Support Document, and the Support Document 2.0 are embedded throughout the Instructional Unit format for reference.

Acknowledgments

Jean Baptiste Massieu, famous deaf educator, made a statement that is now considered a French proverb. “Gratitude is the memory of the heart. Indeed, appreciation comes when you feel grateful from the depths of your heart. The head keeps an account of all the benefits you received and gave. But the heart records the feelings of appreciation, humility, and generosity that one feels when someone showers you with kindness.” It is with sincere appreciation that we humbly acknowledge the dedication, hard work and generosity of time provided by teachers and instructional leaders across the state that have made and are continuing to make the Instructional Unit Resources possible.

Chemistry Overview of Units

Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
ATOMIC STRUCTURE AND NUCLEAR PROCESSES	BONDING AND CHEMICAL FORMULAS	STATES OF MATTER	SOLUTIONS, ACIDS, AND BASES	CHEMICAL REACTIONS	THERMOCHEMISTRY AND CHEMICAL KINETICS
Standard	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
H.C.2	H.C.3	H.C.4	H.C.5	H.C.6	H.C.7
Conceptual Understanding	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**
H.C.2A H.C.2B	H.C.3A	H.C.4A	H.C.5A	H.C.6A	H.C.7A
Performance Indicators	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**
H.C.2A.1 H.C.2A.2 H.C.2A.3 H.C.2B.1 H.C.2B.2 H.C.2B.3 H.C.2B.4	H.C.3A.1 H.C.3A.2 H.C.3A.3 H.C.3A.4 H.C.3A.5 H.C.3A.6 H.C.3A.7	H.C.4A.1 H.C.4A.2 H.C.4A.3	H.C.5A.1 H.C.5A.2 H.C.5A.3 H.C.5A.4	H.C.6A.1 H.C.6A.2 H.C.6A.3 H.C.6A.4	H.C.7A.1 H.C.7A.2 H.C.7A.3 H.C.7A.4
***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**
S.1A.2 S.1A.6 S.1A.4 S.1A.8 S.1A.5	S.1A.2 S.1A.6 S.1A.3 S.1A.4	S.1A.2 S.1A.3 S.1A.4	S.1A.4 S.1A.5 S.1A.8	S.1A.2 S.1A.3 S.1A.5	S.1A.2 S.1A.5 S.1A.3 S.1A.4
***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**
1, 2, 3, 4, 5, 6, 7	1, 4, 6	2, 4, 5	2, 3, 6	1, 2, 3, 4, 7	2, 3, 4, 6, 7

**Teachers have the discretion to enhance the selected SEP's and CCC's.*

Unit Title
Solutions, Acids, and Bases
Standard http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf
H.C.5 The student will demonstrate an understanding of the nature and properties of various types of chemical solutions.

Conceptual Understanding

H.C.5A Solutions can exist in any of three physical states: gas, liquid, or solid. Solution concentrations can be expressed by specifying the relative amounts of solute and solvent. The nature of the solute, the solvent, the temperature, and the pressure can affect solubility. Solutes can affect such solvent properties as freezing point, boiling point, and vapor pressure. Acids, bases, and salts have characteristic properties. Several definitions of acids and bases are used in chemistry.

New Academic Vocabulary

Some students may need extra support with the following academic vocabulary in order to understand what they are being asked to understand and do. Teaching these terms in an instructional context is recommended rather than teaching the words in isolation. A great time to deliver explicit instruction for the terms would be during the modeling process. Ultimately, the student should be able to use the academic vocabulary in conversation with peers and teachers. These terms are pulled from the essential knowledge portion of the Support Doc 2.0 (http://ed.sc.gov/instruction/standards-learning/science/support-documents-and-resources/) and further inquiry into the terms can be found there.

Solution	Solute	Solvent	Solvation	Dissociation	Ionization
Dispersion	Solubility	Concentration	Molarity	Percent by Mass	Molality
Mole Fraction	Dilution	Percent by Volume	Acids	Bases	Arrhenius Acid
Arrhenius Base	Neutralization	Acid/Base Indicators	Bronsted-Lowry Acid	Bronsted-Lowry Base	Conjugate Acid
Conjugate Base	Colligative Properties	Vapor Pressure	Freezing Point	Boiling Point	Intermolecular Forces
Strong Electrolyte	Weak Electrolyte	Nonelectrolyte	Net Ionic Equation	pH	pOH
Hydronium Ion	Hydroxide Ion	Kw			

Performance Indicators

Text highlighted below in *orange* and *italicized/underlined* shows connections to SEP's.

H.C.5A.1 *Obtain and communicate information* to describe how a substance can dissolve in water by dissociation, dispersion, or ionization and how intermolecular forces affect solvation.

H.C.5A.2 *Analyze and interpret data* to explain the effects of temperature and pressure on the solubility of solutes in a given amount of solvent.

H.C.5A.3 *Use mathematical representations* to analyze the concentrations of unknown solutions in terms of molarity and percent by mass.

H.C.5A.4 *Analyze and interpret data* to describe the properties of acids, bases, and salts.

*Science and Engineering Practices

Support for the guidance, overviews of grade level progressions, and explicit details of each SEP can found in the Science and Engineering Support Doc (http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf). It is important that teachers realize that the nine science and engineering practices are not intended to be used in isolation. Even if a performance indicator for a given standard only lists one of the practices as a performance expectation, scientists and engineers do not use these practices in isolation, but rather as part of an overall sequence of practice. When educators design the learning for their students, it is important that they see how a given performance expectation fits into the broader context of the other science and engineering practices. This will allow teachers to provide comprehensive, authentic learning experiences through which students will develop and demonstrate a deep understanding of scientific concepts.

H.C.1A.4 Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning; (2) support or refute hypotheses, explanations, claims, or designs; or (3) evaluate the strength of conclusions.

H.C.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data.

H.C.1A.8 Obtain and evaluate scientific information to (1) answer questions; (2) explain or describe phenomena; (3) develop models; (4) evaluate hypotheses, explanations, claims, or designs; or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature or (2) reporting the results of student experimental investigations.

*Cross Cutting Concepts (http://www.nap.edu/read/13165/chapter/8)

The link above provides support from the Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012). The text in blue and *italicized/underlined* below provides a brief explanation of how the specific content ties to the CCC's.

2. Cause and effect: Mechanism and explanation: The National Research Council (2012) states that "events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts" (p. 84). *When the temperature of the system goes up, the solubility of solid of goes up. If the water is warmer, then the solute dissolves more easily.*

3. Scale, proportion, and quantity: The National Research Council (2012) states that "in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance" (p. 84). *If you evaporate some of the water in solution, molarity will increase.*

6. Structure and function: The National Research Council (2012) states that "the way in which an object or living thing is shaped and its substructure determine many of its properties and functions " (p. 84). *Acids donate H^+ ions; bases accept H^+ ions. Stronger acids ionize easily because they are so electronegative and have such a strong pull that the hydrogen is snapped from the compound.*

**Teachers have the discretion to enhance the selected SEP's and CCC's.*

Prior Knowledge

- 5.P.2B (Properties of Mixtures and Solutions)
- 7P.2B.3 (Physical and chemical properties of acids and bases)

Subsequent Knowledge

- N/A

Possible Instructional Strategies/Lessons

Strategies and lessons that will enable students to master the standard and/or indicator.

- H.C.5A.1
  - Sugar and Salt Solutions: In this simulation of solvation, students are able to model on a molecular level, the processes of dissolving, solvation, and dissociation in an electrolyte and a nonelectrolyte. Students can see the cause and effect of solvating an electrolyte. Interactive graphs and charts are also included in this simulation to enable students to visualize the concentration of solvated ions. This simulation also prompts discussion of types and strengths of intermolecular forces and their effects on solubility versus dissociation. This is a free resource; however, it does require you to create an account. There are several associated activities associated with this simulation. This simulation can be found at https://phet.colorado.edu/en/simulation/sugar-and-salt-solutions.

  - Why Does Water Dissolve Salt?: In this performance-based activity, students will construct models of solutes and solvents. They will use these models to predict how molecular or ionic structures will affect solute-solvent interaction during dissolution. The extension for this lesson is for students to complete a wet-lab where they predict and test the solubility of solutes in various solvents depending upon molecular structure and intermolecular forces of attraction. This lesson can be found at http://www.middleschoolchemistry.com/lessonplans/chapter5/lesson3.

- Solubility Rules and the Mystery Solutions: In this multi-day tiered lab, students will make predictions about the solubility of products formed by mixing reactant solutions. Using their data, students will derive solubility rules for compounds. At the conclusion of this lesson, students will apply their understanding of solubility rules to construct a solution for hazardous waste clean-up and disposal. This lab can be located using https://ims.ode.state.oh.us/ODE/IMS/Lessons/Content/CSC_LP_S06_BA_L11_I01_01.pdf.

- Dissociation, Ionization, Dispersion Modeling: Students will create models of water, molecules, ionic compounds, etc. out of construction paper, Styrofoam balls, foam board, etc. They will model and communicate the processes of dissociation, ionization, and dispersion.

- H.C.5A.2
  - Temperature Affects the Solubility of Gases: Students will alter the temperatures of club soda to generate data with which they will analyze and interpret the relationship between temperature and solubility of gases. An extension of this activity is to alter the pressure on the club soda to generate data to analyze and interpret the relationship between pressure and solubility of gases. Pressure sensors will be needed for the extension. This inquiry activity is located at http://www.inquiryinaction.org/classroomactivities/activity.php?id=19.

  - Solubility Curve of Sugar in Water: Students create different solutions of sugar water to expose to different temperatures. They will create a solubility curve from which to analyze and interpret data by answering questions. This lab can be found by https://www.siena.edu/assets/files/general/Solublity_of_Sugar.pdf.

  - How is the Solubility of a Compound Determined?: In this virtual lab simulation from Glencoe, students will predict how the temperature of a solvent affects the mass amount of solutes that can dissolve. Students will test five solutes and have a choice of four different temperatures at which to dissolve specified masses of each solute. This activity also includes interactive journal questions, tables for data collection, and solubility graphs that will enable students to analyze and interpret data. This virtual lab can be found at http://www.glencoe.com/sites/common_assets/science/virtual_labs/PS15/PS15.html.

- H.C.5A.3
    - Concentration: In this PhET simulation, students will predict how changes to a solution, solvent, or solute will affect the overall solution concentration. Students will also calculate the molarity of solutions using solute mass data and solution volume data. The intent of this activity is for students to use mathematical representations to calculate solution concentration. There are several lesson resources (including multiple choice questions, conceptual questions, and extended labs) that enable students to use mathematical models and representations of solution concentration. This activity is located at https://phet.colorado.edu/en/simulation/concentration.

    - Molarity Murder Mystery Lab: This is a two-part lab activity where students use their understanding of chemical reactions (precipitation reactions) to determine which chemical was used as a murder weapon. In the second part of the lab, students use reaction stoichiometry and their understanding of solution concentration to determine which suspect committed the crime. This lab requires students to use mathematical representations of solution concentration to solve the mystery. This inquiry based lab can be located at the following site: http://www.smusd.org/site/handlers/filedownload.ashx?moduleinstanceid=4199&dataid=8290&FileName=Molarity%20Murder%20Mystery%20Lab%202014.pdf.

    - Exploring Freezing Point Depression Using Freeze Pops: In this lab activity, student groups derive the correlation between freezing point depression and solution concentration using a freeze pop. Each group will prepare a specified solution concentration and monitor the temperature and the appearance of a freeze pop over a fifteen minute period. Student groups will have to develop a procedure to prepare their solution concentration. At the end of the activity, students will share their findings with the class and determine the relationship between solution concentration and freezing point depression. Students can use mathematical models to calculate molality and to calculate the theoretical freezing point depression of water. They can evaluate their experimental results compared to their calculations. As an extension this activity, students could use the same concentrations of different solutes to reiterate how intermolecular forces and bonding affect solute-solvent interactions. This activity can be located using http://serc.carleton.edu/sp/mnstep/activities/35396.html.

- H.C.5A.4
    - Measuring pH of Household Chemical: Students will be able to analyze and interpret qualitative and quantitative data in this lab. Students will test substances with pH paper and red cabbage juice. pH probes will be required for this lab. (Make sure to follow the

guidelines included with the lab probe to ensure safe operation of your probe.) This lab can be found at https://msu.edu/~helddomi/Science/BigChemistry.doc.

- Red Cabbage Lab-Acids and Bases: Students test household substances from vinegar to shampoo and conditioner to analyze and interpret the qualitative data produced by the red cabbage juice test. This lab can be found at http://web.stanford.edu/~ajspakow/downloads/outreach/ph-student-9-30-09.pdf.

- pH Scale PhET Simulation: Students are able to test the pH of different substances in order to analyze and interpret whether they are acidic or basic. This simulation can be found at https://phet.colorado.edu/en/simulation/ph-scale.

- Trick or Titrate: Students will titrate citric acid present in Skittles candy using sodium hydroxide. Students will use an indicator to monitor, analyze, and interpret how an indicator changes in the presence of acids and bases. Students will also use pH probes and interfaced software to build a titration curve. Using this curve, students will locate the equivalence point and use this information to calculate the concentration of citric acid in the candy. As an extension, students can design their own experiments to compare the concentration of citric acid in different colors of candy. This lab activity can be found using https://www.pasco.com/resources/blogs/chemistry/trick-or-titrate.cfm.

- Eggs to Dye For: In this lab activity, students analyze and interpret the relationship between the equilibrium constant of an acid (K_a) and the effect it has on the intensity a dye color in the process of dyeing eggs. This activity reviews the reaction/solubility of calcium carbonate with acids and provides several diagrams explaining why acids are used in dyeing eggs. Students research different acids in household substances (vinegar, aspirin, and orange juice) and then design an experiment to test the relationship between acid strength and dye color intensity. As an extension to this activity, students could add household bases to the mixture to analyze and interpret their activity on dye color intensity. This lesson can be found using http://www.sciencefriday.com/educational-resources/eggs-to-dye-for/.

Resources

- What Happens When Stuff Dissolves?: This short video provides a model for solvation of electrolytes vs. nonelectrolytes. The video enables students to visualize solvation, dissociation, and discuss intermolecular forces. This video can be found at https://www.youtube.com/watch?v=0cPFx0wFuVs.

- Ionization and Dissociation Tutorial: This short video differentiates the mechanisms by which molecular and ionic compounds dissolve in water. This resource is available at https://www.youtube.com/watch?v=EaGfeyGEaTQ.

- Solubility Rules - This resource defines the solubility rules that students need to be familiar with to predict if and how a substance will dissolve in water. This resource is available at http://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Equilibria/Solubilty/Solubility_Rules.

- What's the Difference Between Molarity and Molality?: This video demonstrates the conceptual and mathematical differences between molarity and molality. It also includes examples of solution preparation of a given concentration using drawings. This video can be found at https://www.youtube.com/watch?v=96oNrVnTk50.

- Solution Concentration: This resource provides sample practice problems and answers for solution concentrations including molarity, molality, mass percent, and dilutions. At the end of the tutorial, students can self-assess by completing independent practice problems. This resource can be found using http://www.ck12.org/section/Solution-Concentration-::of::-Solutions-::of::-CK-12-Chemistry-Intermediate/.

- Temperature and Pressure Effects on Solubility: This resource assists students by providing them with situational data to analyze and interpret. This resource is available at http://chemistry.elmhurst.edu/vchembook/174temppres.html.

- Temperature Effects on Solubility: This resource provides excellent examples of real-world application for how temperature affects solubility. This resource can be found at http://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Equilibria/Solubilty/Temperature_Effects_on_the_Solubility_of_Gases .

- Pressure Effects on the Solubility of Gases: This resource provides a real-world example of how pressure affects solubility of gases. This resource can be found at http://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Equilibria/Solubilty/Pressure_Effects_On_the_Solubility_of_Gases.

- Solubility Curve Worksheet: This worksheet provides a solubility curve with questions for students to answer. This worksheet can be found at https://allinonehighschool.files.wordpress.com/2015/03/day-131-unit-test-second-part-solubility-curve-worksheet.pdf.

- Chemistry12.1 What are acids and bases?: In this video, the Arrhenius theory of acids and bases is explained. Students will be able to view the chemical equation in which the H+ ion and OH- ion are released. This video can be found at https://www.youtube.com/watch?v=Vbh52HDorkc.

- The Arrhenius Definition: This website explains the Arrhenius theory of acids and bases. It also discusses the limitations of the theory. This website is https://www.boundless.com/chemistry/textbooks/boundless-chemistry-textbook/acids-and-bases-15/acids-and-bases-107/the-arrhenius-definition-449-10531/ .

- Acid-Base Titration: This flash animation allows students to simulate the technique of titration on both a macroscale level and a microscale level. In this simulation, students can monitor changes in the pH of a solution during titration; and they can visualize the changes in the concentrations of hydronium and hydroxide ions. This animation can be found at http://www.mhhe.com/physsci/chemistry/animations/chang_7e_esp/crm3s5_5.swf .

Sample Formative Assessment Tasks/Questions

Additional sample formative assessment tasks/questions for grade bands are located at the end of each of the SEP Support Doc.
(http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf)

- Dissociation vs. Ionization Gallery Walk: Student groups will be given a set of cards containing names of different chemicals. Students will first translate the name into a chemical formula. Groups will then predict solubility and the mechanism by which the chemical will dissolve (dissociation versus ionization). Students will support their claims by drawing a diagram or writing an equation to show the method of dissolving. Evidence should be communicated on large chart paper. At the conclusion of the activity, students will complete a gallery walk to observe evidence on the chart paper. Upon returning to their own chart paper, each group will write a summary statement differentiating between dissociation and ionization based on the evidence collected during the gallery walk.

- Dissociation, Ionization, and Dispersion Formative Assessment: This assessment will “piggyback” on the Dissociation, Ionization, and Dispersion Modeling activity. Students will communicate their knowledge of the differences between the processes by using a graphic organizer.

- Temperature and Pressure vs. Solubility Graphs: Using information from a solubility graph, students make statements as they analyze and interpret what is happening in the graph. They can make predictions as to what would happen if the temperature/pressure changes are not recorded on the graph.

- Preparation of a Solution Lab Practical: Each student will be given a slip of paper with a specified solution concentration and volume. Students will use mathematical representations to calculate the mass of solute required to prepare the solution; and they will physically prepare their solutions using appropriate lab equipment, such as pipets, burets, and volumetric flasks.

- Acids and Bases "Grab Bag": The teacher must prepare note cards having H^+, OH^- , and various metal cations on them. The teacher will separate the hydrogen/hydroxide ions in one bag and the metal cations in another bag. Students will blindly grab a card from each bag. Students will match cards and brainstorm about the properties of their compounds, i.e. taste, reaction to litmus paper/red cabbage juice, what it reacts with, solubility, percent ionization, and dissociation. They must create an advertisement or "Wanted" poster to communicate their findings.

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