Florida Interim Assessment Item Bank and Test Platform

Item Specifications

Science
Chemistry
Grades 9–12

FLORIDA DEPARTMENT OF EDUCATION
www.fldoe.org

TABLE OF CONTENTS

I. Introduction

The U.S. Department of Education awarded a Race to the Top grant to Florida in August 2010. An important component of this grant focused on the development of high-quality assessment items and balanced assessments for use by districts, schools, and teachers. The assessment items will be stored in the Florida Interim Assessment Item Bank and Test Platform (IBTP), a statewide secure system which allows Florida educators to search the item bank, export test items, and generate customized high-quality assessments for computer-based delivery or paper-and-pencil delivery. The IBTP allows Florida educators to determine what students know and are able to do relative to instruction on Florida's Next Generation Sunshine State Standards and the Common Core State Standards (CCSS).

A. Purpose of the Item Specifications

The *Item Specifications* define the expectations for content, standards alignment, and format of assessment items for the Item Bank and Test Platform. The *Item Specifications* are intended for use by item writers and reviewers in the development of high-quality assessment items.

B. Scope

The *Item Specifications* provide general and grade-specific guidelines for the development of all Grades 9–12 Chemistry assessment items available in the Florida Interim Assessment Item Bank.

C. Standards Alignment

Items developed for the Florida Interim Assessment Item Bank and Test Platform will align to the Next Generation Sunshine State Standards for Science and, where appropriate and applicable, the Common Core State Standards for Mathematics and Literacy in Science and Technical Subjects.

1. Next Generation Sunshine State Standards

Florida's Next Generation Sunshine State Standards (NGSSS) for Science provide the basis for science teaching and learning in Florida's public schools. For Grades 9–12 Chemistry, the NGSSS are divided into benchmarks that identify what a student should know and be able to do in each course. The NGSSS are available at *http://www.floridastandards.org/homepage/index.aspx*.

2. Common Core State Standards

Selected standards from the Common Core State Standards for Mathematics and Literacy in Science and Technical Subjects have been embedded in Florida's course descriptions for Grades 6–12 science courses to provide support for science literacy and mathematics skills. Appendix B of this document provides a list of the CCSS Mathematics and Literacy Standards associated with the Grades 9–12 Chemistry courses. Assessment items for Chemistry should be aligned to one or more of the associated CCSS, whenever appropriate, in addition to the targeted chemistry benchmark.

II. Criteria for Item Development

Science item writers for the Florida Interim Assessment Item Bank must have a comprehensive knowledge of science curriculum based on the Next Generation Sunshine State Standards and an understanding of the range of cognitive abilities of the target student population. Item writers should understand and consistently apply the guidelines established in this document. Item writers are expected to use their best judgment in writing items that measure the science benchmarks of the NGSSS and the CCSS, where appropriate, without introducing extraneous elements that reflect bias for or against a group of students.

A. Overall Considerations for Item Development

These guidelines are provided to ensure the development of high-quality assessment items for the Florida Interim Assessment Item Bank.

1. Each item should be written to measure primarily one NGSSS benchmark; however, other benchmarks may also be addressed for some item types.
2. Whenever possible, each item will also be aligned to a secondary CCSS Mathematics and/or Literacy standard applicable to a particular grade.
3. Items should be appropriate for students in terms of grade-level instruction, experience and difficulty, cognitive development, and reading level. The reading level of the test items should be on grade level. (Refer to the glossaries in CPALMS for each course.)
4. Of the assessment items associated with a given benchmark, 50% or more should meet or exceed the cognitive level (DOK) of the benchmark.
5. Each item should be written clearly and unambiguously to elicit the desired response.
6. Items should not disadvantage or exhibit disrespect to anyone in regard to age, gender, race, ethnicity, language, religion, socioeconomic status, disability, occupation, or geographic region.

B. Item Contexts

The context in which an item is presented is called the item context or scenario. These guidelines are provided to assist item writers with development of items within an appropriate context.

1. The item context should be designed to interest students at the targeted level. Scenarios should be appropriate for students in terms of grade-level experience and difficulty, cognitive development, and reading level.
2. The context should be directly related to the question asked. The context should lead the student cognitively to the question. Every effort should be made to keep items as concise as possible without losing cognitive flow or missing the overall idea or concept.
3. Information and/or data in items must be accurate and verifiable using reliable sources. Source documentation should accompany items as needed.

4. All item scenarios, graphics, diagrams, and illustrations must be age-, grade-, and experience-appropriate.
5. Item contexts and illustrations depicting individuals conducting laboratory investigations should include proper safety equipment and model safe laboratory procedures.
6. Scenarios describing scientific investigations should model current science methodology and adhere to the Intel International Science and Engineering Fair Rules and Guidelines unless otherwise noted in the benchmark clarification statements. These rules and guidelines can be found using the Document Library link at: *http://www.societyforscience.org/ISEF*.
7. Items or illustrations may include, but are not limited to, the following common laboratory tools: dissection equipment, electronic balance, flask, hot plate, meter stick, petri dish, pH sensor, pipette, probe, prism, pulley, test strips, triple-beam balance, battery, beaker, compass, eyedropper, flashlight, graduated cylinder, light bulb, magnet, metric measuring tape, metric ruler, microscope, microscope slide, model, safety goggles, spring scales, stopwatch, telescope, test tube, thermometer, and topographic map.
8. The item content should be timely but not likely to become dated.

C. Use of Media

Media can be used to provide either necessary or supplemental information—that is, some media contain information that is necessary for answering the question, while other media support the context of the question. Items may include diagrams, illustrations, charts, tables, audio files, or video files unless otherwise noted in the Individual Benchmark Specifications.

1. Items should not begin with media. Media in items is always preceded by text.
2. All visual media (tables, charts, graphs, photographs, etc.) should be titled. Titles should be in all caps, boldfaced, and centered, and may be placed above or below the visual media.

D. Item Style and Format

This section presents stylistic guidelines and formatting directions that should be followed while developing items.

1. Items should be clear and concise and should use vocabulary and sentence structure appropriate for the assessed grade level. Writers should refer to the resources provided during item writer training and to the glossaries in CPALMS.
2. The words *most likely* or *best* should be used only when appropriate to the question.
3. At Grades 9–12, temperatures should be given in degrees Celsius unless otherwise noted in the Individual Benchmark Specifications.

4. Metric units of measure should be used in scenarios addressing mass, length, weight, and/or volume. International System of Units (SI) should be used unless otherwise noted in the Individual Benchmark Specifications.
5. The first occurrence of units of measure should be written out in the item stem, e.g., kilograms (kg). In graphics, an abbreviation may be used (e.g., g or cm). To avoid confusion between the preposition *in* and the abbreviation for inches, only units of measure in graphics should be presented, e.g., height (cm) NOT height (in cm).
6. In titles of tables and charts and in labels for axes, the unit of measure should be included, preferably in lowercase and in parentheses, e.g., height (m).
7. Items requiring art should be to scale whenever possible. If not possible, a not-to-scale text box should be included at the bottom left of the art.
8. Graphics in items should be clearly labeled and contain all necessary information.
9. Items referring to new developments or discoveries should include phrases similar to *according to current knowledge* or *based on current knowledge*.
10. Items using the word *not* should emphasize the word *not* using all uppercase letters (e.g., Which of the following is NOT an example of . . .). The word *not* should be used sparingly.
11. As appropriate, boldface type should be used to emphasize key words in the item (e.g., **least**, **most**, **greatest**, **percent**, **best**).
12. Masculine pronouns should NOT be used to refer to both sexes. Name(s) should be used whenever possible to avoid gender-specific pronouns (e.g., instead of "The student will make changes so that he . . .", use "John and Maria will make changes so that they . . .").
13. Grades 9–12 items may express values using scientific notation
14. Decimal numbers between –1 and 1 should have a leading zero.
15. SI units should be expressed in a single type of unit when possible (e.g., 1.4 kilograms instead of 1 kilogram 400 grams).
16. Commas should be used in numbers greater than or equal to 1,000 except for numbers having an SI unit. In this case, numbers with four digits should be presented without a comma or a space (e.g., 9960 meters). Numbers with more than four digits should be presented with a thin space inserted in place of a comma (e.g., 10 123 kilograms).
17. In most cases, scenarios involving elements, chemical formulas, or chemical symbols and/or equations should be written out followed by the abbreviation, e.g., carbon dioxide (CO_2).
18. In the item stem, values needed to compute answers should be presented as numerals.

E. Item Types

This section presents guidelines for development of the following types of items:

- Selected Response (SR)—1 point
- Gridded Response (GR)—1 point
- Short Response (SHR)—1 point
- Constructed Response (CR)—2 points
- Extended Response (ER)—4 points
- Essay Response (ESR)—6 points
- Performance Task (PT)—1–10 points

1. Selected Response (SR) Items (1 point)

Selected response items require students to choose an answer from the choices given. Each item consists of a stem and either three or four answer options, depending on the grade level (see #3 below). One of the answer options is the correct answer, and the remaining options are called distractors. Selected response items may also include a stimulus and/or passage.

1. SR items should take approximately one minute per item to answer.
2. SR items are worth one point each.
3. SR items for grades K, 1, and 2 should have three answer options (A, B, and C). SR items for all other grades and courses should have four answer options (A, B, C, and D).
4. SR items must have only one correct answer option.
5. During item development and review, the correct response should be indicated.
6. During item development and review, the rationale for distractors (incorrect answer choices) should be indicated. The rationale should include information explaining why a student would select that distractor.
7. Distractor rationales should represent computational or conceptual errors or misconceptions commonly made by students who have not mastered the assessed concepts.
8. Each distractor should be a believable answer (i.e., plausible, but incorrect).
9. All answer options should be written in a style appropriate to the question asked. For example, a "how" question should have answer options that explain how.
10. Options should have parallel structure whenever possible. Test item options should not have an outlier (e.g., an answer option that is significantly longer than or different from the other options).
11. Items should not be clued or answered by information in the stem or other options.

12. Options such as *none of the above*, *all of the above*, *not here*, *not enough information*, or *cannot be determined* should not be used as answer options.
13. If an option is a single word or a phrase, the option should start with a lowercase letter. If an option is a sentence, the sentence should be conventionally capitalized and punctuated. Options that are imperatives should be treated as sentences.
14. Answer options that are single words should be arranged in alphabetical or reverse alphabetical order.
15. Answer options that are phrases or sentences should be arranged from shortest to longest or longest to shortest.
16. Numerical answer options should be arranged in ascending or descending order.
17. Numerical answer options that represent relative magnitude or size should be arranged as they are shown in the stem or in some other logical order.
18. When the item requires the identification of a choice from the item stem, table, chart, or illustration, the options should be arranged as they are presented in the item stem, table, chart, or illustration.
19. If the answer options for an item are neither strictly numerical nor denominate numbers, the options should be arranged by the logic presented in the item, by alphabetical order, or by length.

2. **Gridded Response (GR) Items (1 point)**

   Gridded response questions are worth 1 point each. The questions require students to solve problems and mark their answers by filling in the appropriate bubbles for the numbers on answer grids. Students must accurately complete the grid to receive credit for their answers.

3. **Short Response (SHR) Items (1 point)**

   Short response items usually include a scenario and instructions on how to respond. The recommended time allotment for a student to respond is 3 minutes. A complete answer is worth 1 point. There are no partial points for this item type.

4. **Constructed Response (CR) Items (2 points)**

   Constructed response items usually include a scenario and instructions on how to respond. The recommended time allotment for a student to respond is 5 minutes. A complete answer is worth 2 points and a partial answer is worth

1 point. The constructed response holistic rubric and exemplar specific to each item are used for scoring as follows:

SCORING RUBRIC	
2	A score of two indicates that the student has demonstrated a thorough understanding of the scientific concepts and/or procedures embodied in the task. The student has completed the task correctly, in a scientifically sound manner. When required, student explanations and/or interpretations are clear and complete. The response may contain minor flaws that do not detract from the demonstration of a thorough understanding.
1	A score of one indicates that the student has provided a response that is only partially correct. For example, the student may arrive at an acceptable conclusion or provide an adequate interpretation, but may demonstrate some misunderstanding of the underlying scientific concepts and/or procedures. Conversely, a student may arrive at an unacceptable conclusion or provide a faulty interpretation, but could have applied appropriate and scientifically sound concepts and/or procedures.
0	A score of zero indicates that the student has not provided a response or has provided a response that does not demonstrate an understanding of the scientific concepts and/or procedures embodied in the task. The student's explanation may be uninterpretable, lack sufficient information to determine the student's understanding, contain clear misunderstandings of the underlying scientific concepts and/or procedures, or may be incorrect.

Exemplars: A specific exemplar should be developed for each constructed response item. Exemplars will be used as scoring guides and should be specific to the item, but not so specific as to discount multiple correct answers. Exemplars should include a clear and defensible description of the top score point, and contain straightforward language that is accurate, complete, and easy to interpret.

5. **Extended Response (ER) Items (4 points)**

Extended response items include a scenario and instructions on how to respond and are worth 4 score points. However, ER items are usually more complex than SHR items and 2-point CR items. The recommended time allotment for a student to respond is 10–15 minutes. The extended response holistic rubric and exemplar specific to each item are used for scoring as follows:

SCORING RUBRIC	
4	A score of four indicates that the student has demonstrated a thorough understanding of the scientific concepts and/or procedures embodied in the task. The student has completed the task correctly, used scientifically sound procedures, and provided clear and complete explanations and interpretations. The response may contain minor flaws that do not detract from a demonstration of a thorough understanding.
3	A score of three indicates that the student has demonstrated an understanding of the scientific concepts and/or procedures embodied in the task. The student's response to the task is essentially correct, but the scientific procedures, explanations, and/or interpretations provided are not thorough. The response may contain minor flaws that reflect inattentiveness or indicate some misunderstanding of the underlying scientific concepts and/or procedures.
2	A score of two indicates that the student has demonstrated only a partial understanding of the scientific concepts and/or procedures embodied in the task. Although the student may have arrived at an acceptable conclusion or provided an adequate interpretation of the task, the student's work lacks an essential understanding of the underlying scientific concepts and/or procedures. The response may contain errors related to misunderstanding important aspects of the task, misuse of scientific procedures/processes, or faulty interpretations of results.
1	A score of one indicates that the student has demonstrated a very limited understanding of the scientific concepts and/or procedures embodied in the task. The student's response is incomplete and exhibits many flaws. Although the student's response has addressed some of the conditions of the task, the student has reached an inadequate conclusion and/or provided reasoning that is faulty or incomplete. The response exhibits many flaws or may be incomplete.
0	A score of zero indicates that the student has not provided a response or has provided a response that does not demonstrate an understanding of the scientific concepts and/or procedures embodied in the task. The student's explanation may be uninterpretable, lack sufficient information to determine the student's understanding, contain clear misunderstandings of the underlying scientific concepts and/or procedures, or may be incorrect.

Exemplars: A specific exemplar should be developed for each extended response item. Exemplars will be used as scoring guides and should be specific to the item, but not so specific as to discount multiple correct answers. Exemplars should include a clear and defensible description of the top score point, and contain straightforward language that is accurate, complete, and easy to interpret.

6. **Essay Response (ESR) Items (6 points)**

   Essay response items consist of asking a general question or providing a stimulus (such as an article or research paper on a relevant topic), and asking the students to express their thoughts or provide facts about the topic using logic and reason. Essay response items encompass a higher level of thinking and a broader range of skills that includes CCSS literacy standards, both of which are critical to future success in higher education and the workforce.

   In most cases, essay responses will go beyond a single paragraph in length, with a distinct introduction, body, and conclusion. An essay response will be worth a total of 6 points, with a rubric structure similar to that of the 4-point extended response. Students should be given about 20 to 30 minutes to complete each item.

   Exemplars: A specific exemplar should be developed for each essay response item. Exemplars will be used as scoring guides and should be specific to the item, but not so specific as to discount multiple correct answers. Exemplars should include a clear and defensible description of the top score point, and contain straightforward language that is accurate, complete, and easy to interpret.

7. **Performance Task (PT) Items (1–10 points)**

   Performance tasks are used to measure students' ability to *demonstrate* knowledge and skills from one or more benchmarks of the NGSSS and the CCSS. Specifically, performance tasks may require students to create a product, demonstrate a process, or perform an activity that demonstrates proficiency in science. They are evaluated using customized scoring rubrics, and each task may be worth 1–10 points. Performance tasks may have the following characteristics:

   1. Performance tasks may cover a short time period or may cover an extended period of time.
   2. Performance tasks must contain clear and explicit directions for understanding and completing the required component tasks and producing the objective output.
   3. All tasks, skills, and/or behaviors required by the performance tasks must be objective, observable, and measurable.
   4. All necessary equipment, materials, and resources should be referenced within the text of the performance task.
   5. Performance tasks should elicit a range of score points.
   6. Performance tasks generally require students to organize, apply, analyze, synthesize, and/or evaluate concepts.

7. Performance tasks may measure performance in authentic situations and outside the classroom, where appropriate and practical.
8. Typical response formats include demonstrations, laboratory performance, oral presentations, exhibits, or other products.
9. Every performance task requires a companion rubric to be used for scoring purposes. Rubrics should meet the following criteria:
    a. The rubrics and performance tasks should be developed in tandem to ensure compatibility.
    b. Rubrics must be specific to the individual requirements of each performance task; generic rubrics are not acceptable.
    c. The rubric must allow for efficient and consistent scoring.
    d. The customized rubric will also serve as an exemplar and should include a clear and defensible description of the top score point, and contain straightforward language that is accurate, complete, and easy to interpret.
    e. The highest score descriptor should allow for all foreseeable methods of correctly and thoroughly completing all requirements of the performance task.

A performance task may address one or more benchmarks or standards and may be composed of multiple items. The expectation is the performance tasks will include a demonstration of the student's mastery of the benchmark or standard. Items are expected to have rubrics.

F. Complex Stimuli and Reading Passages

The cross-curricular focus on aligning Florida IBTP items with the Common Core State Standards for mathematics and literacy make complex reading passages important components of the item bank. A passage is a segment of written work, followed by a series of questions that assess the student's comprehension of reading and the content presented. Some science items will be associated with a reading passage, while others will be standalone items.

G. Readability

Items must be written with readability in mind. In addition, vocabulary must be appropriate for the grade level being tested. The following sources provide information about the reading level of individual words:

Taylor, Stanford E. *EDL Core Vocabularies: Reading, Mathematics, Science, and Social Studies*. Austin, TX: Steck-Vaughn-EDL, 1989.

Mogilner, Alijandra. *Children's Writer's Word Book*. Cincinnati, OH: Writer's Digest Books, 1992.

H. Cognitive Complexity

1. Overview

Florida's adoption of the Common Core State Standards (CCSS) for Mathematics and English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects presents Florida with an opportunity to revise its current Depth of Knowledge (DOK) Model of Cognitive Complexity. More information about Florida's Depth of Knowledge levels is available online at http://www.cpalms.org/cpalms/dok.aspx.

2. **Levels of Depth of Knowledge for Science**

Interpreting and assigning Depth of Knowledge levels to objectives within science standards and assessment items is an essential requirement of alignment analysis. Please note that, in science, "knowledge" can refer to content knowledge, knowledge of science processes, and nature of science.

Level 1 (Recall) is the recall of information such as a fact, definition, or term, as well as performing a simple science process or procedure. Level 1 only requires students to demonstrate a rote response; use a well-known formula; follow a set, well-defined procedure (like a recipe); or perform a clearly defined series of steps. Standards that lend themselves to simple word problems that can be directly translated into and solved by a formula are considered Level 1. Some examples that represent but do not constitute all of Level 1 performance are:

- Recall or recognize a fact, term, or property.
- Represent in words or diagrams a scientific concept or relationship.
- Provide or recognize a standard scientific representation for simple phenomena.
- Perform a routine procedure, such as measuring length.
- Identify familiar forces (e.g., pushes, pulls, gravitation, friction, etc.)
- Identify objects and materials as solids, liquids, or gases.

Level 2 (Basic Application of Concepts & Skills) includes the engagement of some mental processing beyond recalling or reproducing a response. The content knowledge or process involved is more complex than in Level 1. Level 2 requires that students make some decisions as to how to approach the question or problem. Level 2 activities include making observations and collecting data; classifying, organizing, and comparing data; and representing and displaying data in tables, graphs, and charts.

Some action verbs, such as "explain," "describe," or "interpret," may be classified at different DOK levels, depending on the complexity of the action. For example, interpreting information from a simple graph, which requires reading information from the graph, is at Level 2. An activity that requires interpretation from a complex graph, such as making decisions regarding features of the graph that should be considered and how information from the graph can be aggregated, is at Level 3. Some examples that represent but do not constitute all of Level 2 performance are:

- Specify and explain the relationships among facts, terms, properties, and variables.
- Identify variables, including controls, in simple experiments.
- Distinguish between experiments and systematic observations.

- Describe and explain examples and non-examples of science concepts.
- Select a procedure according to specified criteria and perform it.
- Formulate a routine problem given data and conditions.
- Organize and represent data.

Level 3 (Strategic Thinking & Complex Reasoning) requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. The cognitive demands at Level 3 are complex and abstract. The complexity results not only from the fact that there could be multiple answers, a possibility for both Levels 1 and 2, but also because the multi-step task requires more demanding reasoning. In most instances, requiring students to explain their thinking is at Level 3; requiring a very simple explanation or a word or two should be at Level 2. An activity that has more than one possible answer and requires students to justify the response they give would most likely be at Level 3.

Experimental designs in Level 3 typically involve more than one dependent variable. Other Level 3 activities include drawing conclusions from observations; citing evidence and developing a logical argument for concepts; explaining phenomena in terms of concepts; and using concepts to solve non-routine problems. Some examples that represent but do not constitute all of Level 3 performance are:

- Identify research questions and design investigations for a scientific problem.
- Design and execute an experiment or systematic observation to test a hypothesis or research question.
- Develop a scientific model for a complex situation.
- Form conclusions from experimental data.
- Cite evidence that living systems follow the laws of conservation of mass and energy.
- Explain how political, social, and economic concerns can affect science, and vice versa.
- Create a conceptual or mathematical model to explain the key elements of a scientific theory or concept.
- Explain the physical properties of the Sun and its dynamic nature and connect them to conditions and events on Earth.
- Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.

Level 4 (Extended Thinking & Complex Reasoning) standards and assessment items have the same high cognitive demands as Level 3 with the additional requirement that students work over an extended period of time or with extended effort. Students are required to make several connections—relating ideas within the content area or among content areas—and have to select or devise one approach among many alternatives for how the situation or problem can be solved. Standards, goals, and objectives can be stated in such a way as to expect students to perform extended thinking. Many, but not all, performance assessments and open-ended assessment activities requiring significant thought will be at Level 4.

Level 4 requires complex reasoning and an extended period of time either for a science investigation relevant to a standard or for carrying out the complex analysis and synthesis required of an assessment item. For example, a standard or performance task that calls for the student to use evidence from multiple fields of scientific inquiry in supporting a scientific claim might be classified at Level 4, depending upon the complexity of the analysis. In any event, an activity or performance task associated with a Level 4 standard will require an extended period of time for a student to accomplish.

It is important to reiterate that the extended time period is not a distinguishing factor if the required work is only repetitive and does not require the application of significant conceptual understanding and higher-order thinking. For example, an activity that calls upon a student to measure the water temperature from a river each day for a month before constructing a graph would be classified as at Level 2. On the other hand, an activity that calls upon a student to conduct a complex river study that requires taking into consideration a number of variables would be at Level 4. Some examples that represent but do not constitute all of a Level 4 performance are:

- Based on provided data from a complex experiment that is novel to the student, deduce the fundamental relationships among several variables.
- Conduct an investigation, from specifying a problem to designing and carrying out an experiment and analyzing data and forming conclusions.
- Explain how a particular scientific theory (e.g., evolution, plate tectonics, atomic theory, etc.) is supported by evidence from multiple lines of inquiry.
- Produce a detailed report of a scientific experiment or systematic observation, and infer conclusions based upon evidence obtained.
- Write a detailed history of the development of an important scientific concept (e.g., atomic theory, gravitation) and explain how current conceptions developed from prior ones.

I. Item Difficulty

Item writers will not be expected to make a prediction of difficulty for each item created. However, item writers should develop items that reflect a range of difficulty levels.

J. Universal Design

The application of universal design principles helps develop assessments that are usable to the greatest number of students, including students with disabilities and nonnative speakers of English. To support the goal of providing access to all students, the items in the Florida Interim Assessment Item Bank maximize readability, legibility, and compatibility with accommodations, and item development includes a review for potential bias and sensitivity issues.

Items must allow for the widest possible range of student participation. Item writers must attend to the best practices suggested by universal design, including, but not limited to,

- reduction in wordiness;
- avoidance of ambiguity;
- selection of reader-friendly construction and terminology; and
- consistently applied concept names and graphic conventions.

Universal design principles also inform decisions about item layout and design, including, but not limited to, type size, line length, spacing, and graphics.

K. Sample Items

Appendix A of this document contains a selection of sample items. The sample items represent a range of cognitive complexities and item types.

III. Review Procedures for Florida Interim Assessment Item Bank Items

Prior to being included in the Florida Interim Assessment Item Bank, items must pass several levels of review as part of the item development process.

A. Review for Item Quality

Assessment items developed for the Florida Interim Assessment Item Bank are reviewed by Florida educators, the FDOE, and the Item Bank contractors to ensure the quality of the items, including grade-level appropriateness, standards alignment, accuracy, and other criteria for overall item quality.

B. Review for Bias and Sensitivity

Items are reviewed by groups of Florida educators generally representative of Florida's geographic regions and culturally diverse population. Items are reviewed for the following kinds of bias: gender, racial, ethnic, linguistic, religious, geographic, and socioeconomic. Item reviews also include consideration of issues related to individuals with disabilities.

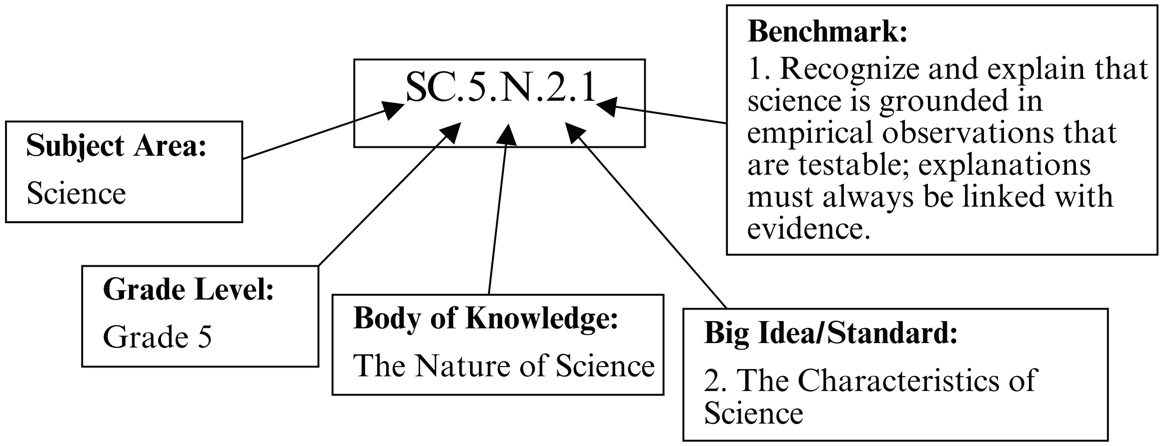
This review is to ensure that the primary purpose of assessing student achievement is not undermined by inadvertently including in the item bank any material that students, parents, or other stakeholders may deem inappropriate. Reviewers are asked to consider the variety of cultural, regional, philosophical, political, and religious backgrounds throughout Florida and to determine whether the subject matter will be acceptable to Florida students, their parents, and other members of Florida communities.

IV. Guide to the Individual Benchmark Specifications

A. Benchmark Classification System

Each benchmark in the NGSSS is labeled with a system of numbers and letters.

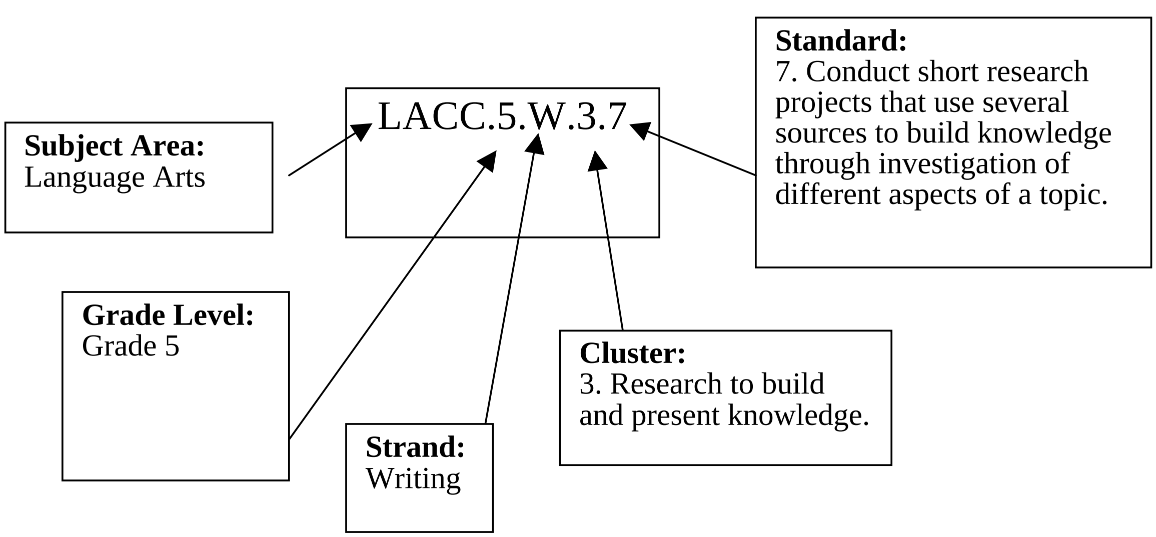
- The two letters in the *first position* of the code identify the **Subject Area**.
- The number(s) in the *second position* represent the **Grade Level**.
- The letter in the *third position* represents the **Body of Knowledge**.
- The number in the *fourth position* represents the **Big Idea/Standard**.
- The number in the *last position* identifies the specific **Benchmark**.



B. Common Core State Standard Classification System

Each standard in the CCSS is also labeled with a system of numbers and letters.

- The four letters in the *first position* of the code identify the **Subject Area**.
- The number(s) in the *second position* represent the **Grade Level**.
- The letter in the *third position* represents the **Strand**.
- The number in the *fourth position* represents the **Cluster**.
- The number in the *last position* identifies the specific **Standard**.



V. Definitions of Benchmark Specifications

The *Item Specifications* identify how the benchmarks in Florida's NGSSS and the CCSS are assessed by items in the Florida Interim Assessment Item Bank. For each assessed benchmark, the following information is provided in the Individual Benchmark Specifications section.

Body of Knowledge/ Strand	refers to the general category of science knowledge (Earth/Space Science, Life Science, Physical Science, and Nature of Science).
Standard/Big Idea	refers to a main idea or description statement of general expectations regarding knowledge and skill development.
Benchmark	refers to specific statements of expected student achievement.
Common Core State Standard Connections	refers to the Common Core Literacy and Mathematics Standards that are closely related to the benchmark. (See Appendix B for a list of CCSS standards associated with this course/grade band.)
Benchmark Clarifications	explain how achievement of the benchmark will be demonstrated by students. The clarification statements explain what students are expected to do when responding to the question.
Content Limits	define the range of content knowledge and degree of difficulty that should be assessed in the items for the benchmark. Content limits may be used to identify content beyond the scope of the targeted benchmark if the content is more appropriately assessed by another benchmark. These statements help to provide validity by ensuring the test items are clearly aligned to the targeted benchmark.

VI. Individual Benchmark Specifications

This section of the *Item Specifications* provides benchmark-specific guidance for assessment item development based on the NGSSS science benchmarks for grades 9–12.

A. Grades 9–12 Chemistry Item Specifications

Course Number: 2003340

Benchmark SC.912.L.18.12	
Body of Knowledge/ Strand	**Life Science**
Standard	**18: Matter and Energy Transformations**
Benchmark	**SC.912.L.18.12: Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe the properties of water at a conceptual and molecular level; for example, specific heat, polarity, and cohesive behavior; and • explain how these properties make water essential for life on Earth.
Content Limits	Items for this benchmark referring to the properties of water should focus on: • hydrogen bonding • polarity • cohesive behavior • ability to moderate temperature • expansion upon freezing • versatility as a solvent

Benchmark SC.912.P.8.1	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.1: Differentiate among the four states of matter.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will distinguish the four states of matter, i.e., solid, liquid, gas, and plasma, for a substance.
Content Limits	Items for this benchmark assessing • the definition of the four states of matter (solid, liquid, gas, and plasma) will include shape, volume, and motion of the particles; and • phase changes among the three common states of matter (solids, liquids, gases) will describe all the possible phase changes including behavior of particles before, during, and after a phase change. Items for this benchmark referring to plasma are limited to: • identification as the fourth state of matter • the form it occurs on Earth, such as lightning bolts • the most common form of matter in space, including material for stars

Benchmark SC.912.P.8.2	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.2: Differentiate between physical and chemical properties and physical and chemical changes of matter.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	N/A
Content Limits	N/A

Benchmark SC.912.P.8.3	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.3: Explore the scientific theory of atoms (also known as atomic theory) by describing changes in the atomic model over time and why those changes were necessitated by experimental evidence.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • analyze and differentiate among the theories and associated scientists that led to the modern atomic theory; • discuss the importance of certain experiments; for example, cathode ray tube and gold foil that led to the discovery of the particles that make up the atom; • explain how certain experiments led to the creation of the historical and modern atom models: for example, the plum pudding atom and the nuclear atom.
Content Limits	Items for this benchmark referring to development of the modern atomic theory will assess the significance of certain atomic models leading to the creation of the modern atomic model.

Benchmark SC.912.P.8.4	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.4: Explore the scientific theory of atoms (also known as atomic theory) by describing the structure of atoms in terms of protons, neutrons, and electrons, and differentiate among these particles in terms of their mass, electrical charges, and locations within the atom.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will describe the structure of atoms and differentiate among identification, description, location, mass, and electrical charge of subatomic particles.
Content Limits	Items for this benchmark assessing atom structure will include, but are not limited to, the identification of the number of atomic orbitals, electrons, neutrons, protons, and the location of each subatomic particle for a given atom; for example, helium has two electrons, two protons, two neutrons, one atomic orbital, the protons and neutrons are in the nucleus, and the electrons are in the atomic orbital.

Benchmark SC.912.P.8.5	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.5: Relate properties of atoms and their position in the periodic table to the arrangement of their electrons.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe how the periodic table is organized; • relate the position of the atom on the periodic table to its properties and to its arrangement of electrons; and • predict properties of atoms based on position in the periodic table.
Content Limits	Items for this benchmark assessing the organization of the modern periodic table may include • descriptions of the historical development of the modern periodic table, with the scientist and associated property used for organization; for example, Henry Moseley arranged elements in the periodic table based on atomic number; and • identifying the parts of the modern periodic table; for example, groups, periods, element classification, and group name, and how the elements are arranged.

Benchmark SC.912.P.8.6	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.6: Distinguish between bonding forces holding compounds together and other attractive forces, including hydrogen bonding and van der Waals forces.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	N/A
Content Limits	N/A

Benchmark SC.912.P.8.7	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.7: Interpret formula representations of molecules and compounds in terms of composition and structure.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will classify and describe the structures of molecules and compounds based on formula representation.
Content Limits	Items for this benchmark may require students to apply various models, such as Lewis structures and molecular models, for classifying and describing various molecule and compound structures.

Benchmark SC.912.P.8.8	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.8: Characterize types of chemical reactions; for example, redox, acid-base, synthesis, and single- and double-replacement reactions.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • classify and distinguish among the different types of chemical reactions; and • predict products for certain types of chemical reaction based on the activity series for metals and halogens.
Content Limits	Items for this benchmark may require students to • include identification and description of the different types of chemical reactions, for example, describing the reactants and products of acid-base reactions; and • employ use of reaction classification and the activity series for metals and halogens to predict if the reaction will transpire and what products form if the reaction does occur.

Benchmark SC.912.P.8.9	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.9: Apply the mole concept and the law of conservation of mass to calculate quantities of chemicals participating in reactions.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • balance chemical equations in order to calculate quantities of chemicals in reactions; and • calculate and convert mass to moles to particles or a combination for compounds and molecules.
Content Limits	N/A

Benchmark SC.912.P.8.11	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.11: Relate acidity and basicity to hydronium and hydroxide ion concentration and pH.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • measure pH using various tools; for example, litmus paper pH indicators and pH probe; and • use the hydronium and/or hydroxide ion concentration in solution to calculate pH.
Content Limits	Items for this benchmark • assessing acidity and basicity will include identification and descriptions of properties of acids and bases and acid-base models, for example, the Arrhenius model; • assessing acid and base concentration will calculate pH and pOH using hydronium and/or hydroxide ion concentration, respectively, in solution and use the calculations to determine acid/base strength as weak or strong; • calculating acidity and basicity are limited to solving for pH and pOH using basic logarithmic math and K_a for a given pH.

Benchmark SC.912.P.10.1	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.1: Differentiate among the various forms of energy and recognize that they can be transformed from one form to others.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • analyze and distinguish among energy transformations (for example, chemical to thermal) in classroom laboratories and real world scenarios; and • explain how energy transformations follow the Law of Conservation of Energy.
Content Limits	Items for this benchmark may require students to • analyze classroom laboratory scenarios and/or real world scenarios for identification and differentiation among energy transformations (for example, mechanical to electrical in a hydrothermal dam or chemical to thermal in a hot pack); and • relate energy transformation to the Law of Conservation of Energy.

Benchmark SC.912.P.10.5	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.5: Relate temperature to the average molecular kinetic energy.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will use the kinetic-molecular theory to describe the behavior and kinetic energy of a molecule and compound during changes in temperature.
Content Limits	Items for this benchmark assessing temperature and kinetic energy will include a conceptual prediction of the behavior of a molecule and compound during changes in temperature.

Benchmark SC.912.P.10.6	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.6: Create and interpret potential energy diagrams: for example, chemical reactions, orbits around a central body, motion of a pendulum.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	N/A
Content Limits	Items for this benchmark may require students to • create and identify the parts of a potential energy diagram of a chemical reaction from provided information, such as the energy of reactants, activation energy, and the absorbing or releasing of heat; and • analyze and explain the potential energy diagram of a chemical reaction in terms of energy (reactants and products), activation energy, and the absorption or release of heat.

Benchmark SC.912.P.10.7	
Body of Knowledge/ Strand	Physical Science
Standard	**10: Energy**
Benchmark	**SC.912.P.10.7: Distinguish between endothermic and exothermic chemical processes.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • justify a chemical process as either endothermic or exothermic from a potential energy diagram; and • relate endothermic and exothermic to enthalpy.
Content Limits	Items for this benchmark may require students to • identify and differentiate a chemical reaction/process as endothermic and exothermic through empirical evidence and thermochemical equations. • use the potential energy diagram to classify chemical reactions as endothermic and exothermic; and • conceptually relate enthalpy to endothermic and exothermic reactions through thermochemical equations and potential energy diagrams.

Benchmark SC.912.P.10.9	
Body of Knowledge/ Strand	Physical Science
Standard	**10: Energy**
Benchmark	**SC.912.P.10.9: Describe the quantization of energy at the atomic level.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • explain the relationship between energy and frequency; and • predict the behavior of and/or calculate quantum and photon energy from frequency.
Content Limits	N/A

Benchmark SC.912.P.10.12	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.12: Differentiate between chemical and nuclear reactions.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • identify the characteristics of chemical and nuclear reactions; and • describe how chemical reactions differ from nuclear reactions in terms of the changes to the nucleus of an atom.
Content Limits	Items for this benchmark may require students to describe differences between a chemical and nuclear reaction in terms of energy, nuclear changes, and real world application.

Benchmark SC.912.P.10.18	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.18: Explore the theory of electromagnetism by comparing and contrasting the different parts of the electromagnetic spectrum in terms of wavelength, frequency, and energy and relate them to phenomena and applications.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • explain how the quantization of energy of an atom relates to the electromagnetic (EM) spectrum; • identify and describe the different aspects and electromagnetic radiation of the EM spectrum; and • use the EM spectrum to calculate wavelength, frequency, and/or energy.
Content Limits	Items for this benchmark may require students to • use a simple definition of the theory of electromagnetism to relate the quantization of energy to electromagnetic radiation and the EM spectrum; and • explain how electromagnetic radiation relates/comprises the EM spectrum.

Benchmark SC.912.P.12.10	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.10: Interpret the behavior of ideal gases in terms of kinetic molecular theory.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • explain the behavior of an ideal gas using the molecular theory with regard to compression, expansion, diffusion, effusion, and partial pressures of gases; and • apply the kinetic-molecular theory to predict and calculate the behavior of an ideal gas with regard to changes in volume, pressure, and temperature.
Content Limits	Items for this benchmark may require students to • conceptually apply the kinetic-molecular theory and various gas laws; and • predict and calculate the behavior of ideal gases by using different gas laws that limit math to simple manipulations of gas law equations.

Benchmark SC.912.P.12.11	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.11: Describe phase transitions in terms of kinetic molecular theory.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe solids, liquids, and gases in terms of compressibility, structure, shape, and volume; and • explain and predict the transition of solids, liquids, and gases based on kinetic-molecular theory.
Content Limits	Items for this benchmark may require students to • identify graphical representations of solids, liquids, and gases based on structure, shape, and volume; • use the kinetic-molecular theory to describe phase changes of solids, liquids, and gases; and • use phase diagrams of a substance to predict the phase of that substance with regard to changes in temperature, pressure, and energy.

Benchmark SC.912.P.12.12	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.12: Explain how various factors, such as concentration, temperature, and presence of a catalyst, affect the rate of a chemical reaction.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe rates of chemical reactions with respect to collisions between reacting particles and factors including, but not limited to, concentration, catalyst, and how temperature affects those collisions; and • explain how the presence of a catalyst lowers the activation energy of a chemical reaction.
Content Limits	Items for this benchmark may require students to describe the influence of activation energy on a chemical reaction.

Benchmark SC.912.P.12.13	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.13: Explain the concept of dynamic equilibrium in terms of reversible processes occurring at the same rates.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • identify equilibrium reactions; • explain how reactions can occur at equal rates in terms of the concentration of reactants and products remaining constant; and • identify reversible reactions in terms of energy changes.
Content Limits	N/A

Benchmark SC.912.N.1.1	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.1: Define a problem based on a specific body of knowledge, for example, biology, chemistry, physics, and earth/ space science, and do the following:** **1. pose questions about the natural world,** **2. conduct systematic observations,** **3. examine books and other sources of information to see what is already known,** **4. review what is known in light of empirical evidence,** **5. plan investigations,** **6. use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems and also the generation and interpretation of graphical representations of data, including data tables and graphs),** **7. pose answers, explanations, or descriptions of events,** **8. generate explanations that explicate or describe natural phenomena (inferences),** **9. use appropriate evidence and reasoning to justify these explanations to others,** **10. communicate results of scientific investigations, and** **11. evaluate the merits of the explanations produced by others.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	N/A
Content Limits	Items for this benchmark defining a scientific problem will assess only within the concepts of chemistry.

Benchmark SC.912.N.1.2	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.2: Describe and explain what characterizes science and its methods.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe the steps of the scientific method and explain why experiments do not always correspond exactly; • apply the definition of science and its methodology to real world scenarios.
Content Limits	Items for this benchmark may require students to • describe steps defined in the scientific method and explain that these steps do not follow a definite sequence in a chemistry experiment; • apply the definition of chemistry and methods used in chemistry to real world scenarios, such as gamma rays used in cancer treatment.

Benchmark SC.912.N.1.4	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.4: Identify sources of information and assess their reliability according to the strict standards of scientific investigation.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • identify what constitutes an informational source acceptable in a scientific investigation; and • recognize a reliable informational source that does not meet the strict standards of specific scientific investigation.
Content Limits	Items for this benchmark assessing sources of information are limited in scope to topics relating to chemistry.

Benchmark SC.912.N.1.5	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.5: Describe and provide examples of how similar investigations conducted in many parts of the world result in the same outcome.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will discuss, using examples, how similar experiments/ investigations conducted in separate locations/parts of the world may either strengthen or weaken a scientific finding.
Content Limits	Items for this benchmark assessing similar but separate scientific investigations are limited in scope to topics relating to chemistry.

Benchmark SC.912.N.1.6	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.6: Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	N/A
Content Limits	Items for this benchmark assessing scientific inferences are limited in scope to topics relating to chemistry.

Benchmark SC.912.N.1.7	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.7: Recognize the role of creativity in constructing scientific questions, methods, and explanations.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • recognize that constructing scientific questions, methods, and explanations includes but is not limited to strict linear thinking; and • acknowledge that creative thinking is an integral part of science and scientific investigations.
Content Limits	Items for this benchmark assessing creation of scientific questions, methods, and explanations are limited in scope to topics relating to chemistry.

Benchmark SC.912.N.2.2	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**2: The Characteristics of Scientific Knowledge**
Benchmark	**SC.912.N.2.2: Identify which questions can be answered through science and which questions are outside the boundaries of scientific investigation, such as questions addressed by other ways of knowing, such as art, philosophy, and religion.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	N/A
Content Limits	Items for this benchmark assessing questions are limited in scope to topics relating to chemistry.

Benchmark SC.912.N.2.4	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**2: The Characteristics of Scientific Knowledge**
Benchmark	**SC.912.N.2.4: Explain that scientific knowledge is both durable and robust and open to change. Scientific knowledge can change because it is often examined and re-examined by new investigations and scientific argumentation. Because of these frequent examinations, scientific knowledge becomes stronger, leading to its durability.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	N/A
Content Limits	Items for this benchmark assessing characteristics of scientific knowledge are limited in scope to topics relating to chemistry.

Benchmark SC.912.N.2.5	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**2: The Characteristics of Scientific Knowledge**
Benchmark	**SC.912.N.2.5: Describe instances in which scientists' varied backgrounds, talents, interests, and goals influence the inferences and thus the explanations that they make about observations of natural phenomena and describe that competing interpretations (explanations) of scientists are a strength of science as they are a source of new, testable ideas that have the potential to add new evidence to support one or another of the explanations.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will describe • using examples, how methods and technology are cross-curricular for various science fields, such as a nuclear particle accelerator used in both chemistry and physics; • how the use of competing interpretations from scientists creates new, testable ideas and possibly new evidence supporting other scientists' explanations; and • how competition of ideas and explanations leads to advances across the various fields of science.
Content Limits	N/A

Benchmark SC.912.N.3.2	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**3: The Role of Theories, Laws, Hypotheses, and Models**
Benchmark	**SC.912.N.3.2: Describe the role consensus plays in the historical development of a theory in any one of the disciplines of science.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will explain that a scientific theory is not established until similar conclusions are yielded by a multitude of experiments conducted by various scientists.
Content Limits	Items for this benchmark may require students to describe how a concept becomes a scientific theory in chemistry.

Benchmark SC.912.N.3.3	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**3: The Role of Theories, Laws, Hypotheses, and Models**
Benchmark	**SC.912.N.3.3: Explain that scientific laws are descriptions of specific relationships under given conditions in nature, but do not offer explanations for those relationships.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • define a scientific law; and • identify how observations become a law.
Content Limits	Items for this benchmark may require students to differentiate between a scientific theory, hypothesis, and law.

Benchmark SC.912.N.3.5	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**3: The Role of Theories, Laws, Hypotheses, and Models**
Benchmark	**SC.912.N.3.5: Describe the function of models in science and identify the wide range of models used in science.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • define and explain the function of models in science; and • identify a wide range of models used in chemistry (for example: Bohr models and molecular models).
Content Limits	N/A

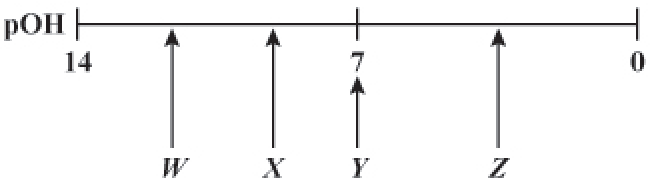
Benchmark SC.912.N.4.1	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**4: Science and Society**
Benchmark	**SC.912.N.4.1: Explain how scientific knowledge and reasoning provide an empirically based perspective to inform society's decision making.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will distinguish between pure and applied research and explain how knowledge gained is used to better inform society's decision makers regarding problem solving.
Content Limits	N/A

Appendix A: Sample Items

Sample Item 1

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
912/ Chemistry	SR	2	SC.912.P.8.11: Relate acidity and basicity to hydronium and hydroxyl ion concentration and pH.	N/A	1

The scale below shows the pOH values for solutions *W*, *X*, *Y*, and *Z*.



Which solution has an equal concentration of hydronium ions and hydroxyl ions?

A. *W*

B. *X*

C. *Y**

D. *Z*

Correct Answer: C

Rationales:

A	Incorrect. Some students may not recognize that a pOH value of 7 indicates equal concentrations of hydronium and hydroxyl ions. Concentration of hydroxyl ions would be greater than concentration of hydronium ions at a pOH greater than 7.
B	Incorrect. Some students may not recognize that a pOH value of 7 indicates equal concentrations of hydronium and hydroxyl ions. Concentration of hydroxyl ions would be greater than concentration of hydronium ions at a pOH greater than 7.
C	Correct.
D	Incorrect. Some students may not recognize that a pOH value of 7 indicates equal concentrations of hydronium and hydroxyl ions. Concentration of hydronium ions would be greater than concentration of hydroxyl ions at a pOH less than 7.

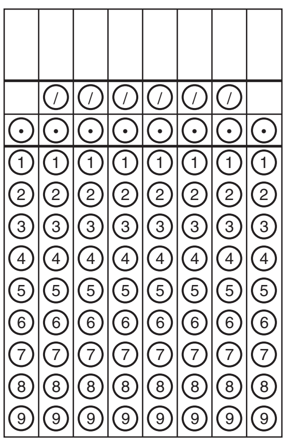
Sample Item 2

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
912/ Chemistry	GR	2	SC.912.P.8.9: Apply the mole concept and the law of conservation of mass to calculate quantities of chemicals participating in reactions.	MACC.912.N-Q.1.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.	1

Use the following chemical equation to answer the question:

$2CH_4(g) + S_8(s) \rightarrow 2CS_2(l) + 4H_2S(g)$

Calculate the mass of CS_2 when 10.0 g of CH_4 react with 80.0 g of S_8 to produce 47.5 g of H_2S.



Correct Answer: 47.5

Correct Answer	The student first determined the limiting reagent and then used it to calculate the amount of $CS_{2.}$ 10.0g CH_4 (1 mol CH_4/16.0 g CH_4)(2 mol CS_2/2 mol CH_4)(76.0 g CS_2/1 mol CS_2) = 47.5 g

Sample Item 3

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
912/ Chemistry	CR	1	SC.912.P.10.5: Relate temperature to the average molecular kinetic energy.	LACC.910.WHST.1.2: Write informative/ explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	2

A scientist is conducting an experiment to observe the effects of temperature changes on the behavior of helium gas stored in a closed container.

Part 1: Describe how gas particles in a sealed container behave as temperature decreases.

Part 2: Explain the relationship between kinetic energy and temperature.

Scoring Rubric and Exemplar

Rubric	
2	A score of two indicates that the student has demonstrated a thorough understanding of the scientific concepts and/or procedures embodied in the task. The student has completed the task correctly in a scientifically sound manner. When required, student explanations and/or interpretations are clear and complete. The response may contain minor flaws that do not detract from the demonstration of a thorough understanding.
1	A score of one indicates that the student has provided a response that is only partially correct. For example, the student may arrive at an acceptable conclusion or provide an adequate interpretation but may demonstrate some misunderstanding of the underlying scientific concepts and/or procedures. Conversely, a student may arrive at an unacceptable conclusion or provide a faulty interpretation but could have applied appropriate and scientifically sound concepts and/or procedures.
0	A score of zero indicates that the student has not provided a response or has provided a response that does not demonstrate an understanding of the scientific concepts and/or procedures embodied in the task. The student's explanation may be uninterpretable, lack sufficient information to determine the student's understanding, contain clear misunderstanding of the underlying scientific concepts and/or procedures, or may be incorrect.

Exemplar	
2	(Part 1) When temperature is lowered, the motion of the particles will slow down and continue to slow down until the freezing point is reached or the temperature is increased. (Part 2) Kinetic energy and temperature have a direct relationship.

Sample Item 4

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
912/ Chemistry	ER	2	SC.912.P.12.12: Explain how various factors, such as concentration, temperature, and presence of a catalyst affect the rate of a chemical reaction.	LACC.910.WHST.1.2: Write informative/ explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	4

A teacher demonstrates a reaction between a solid and a solution to a group of students.

Explain two ways the forward rate of reaction can be decreased. In your answer, be sure to describe how the molecules behave in relation to the change in reaction rate.

Scoring Rubric and Exemplar

Rubric	
4	A score of four indicates that the student has demonstrated a thorough understanding of the scientific concepts and/or procedures embodied in the task. The student has completed the task correctly, used scientifically sound procedures, and provided clear and complete explanations and interpretations. The response may contain minor flaws that do not detract from a demonstration of a thorough understanding.
3	A score of three indicates that the student has demonstrated an understanding of the scientific concepts and/or procedures embodied in the task. The student's response to the task is essentially correct, but the scientific procedures, explanations, and/or interpretations provided are not thorough. The response may contain minor flaws that reflect inattentiveness or indicate some misunderstanding of the underlying scientific concepts and/or procedures.

2	A score of two indicates that the student has demonstrated only a partial understanding of the scientific concepts and/or procedures embodied in the task. Although the student may have arrived at an acceptable conclusion or provided an adequate interpretation of the task, the student's work lacks an essential understanding of the underlying scientific concepts and/or procedures. The response may contain errors related to misunderstanding important aspects of the task, misuse of scientific procedures/processes, or faulty interpretations of results.
1	A score of one indicates that the student has demonstrated a very limited understanding of the scientific concepts and/or procedures embodied in the task. The student's response is incomplete and exhibits many flaws. Although the student's response has addressed some of the conditions of the task, the student has reached an inadequate conclusion and/or provided reasoning that is faulty or incomplete. The response exhibits many flaws or may be incomplete.
0	A score of zero indicates that the student has not provided a response or has provided a response that does not demonstrate an understanding of the scientific concepts and/or procedures embodied in the task. The student's explanation may be uninterpretable, lack sufficient information to determine the student's understanding, contain clear misunderstanding of the underlying scientific concepts and/or procedures, or may be incorrect.

Exemplar	
4	Decrease the concentration of either reactant. There will be fewer molecules to collide which will therefore slow the rate of reaction. Decrease the temperature of the solution. This will lower the kinetic energy of the molecules and therefore slow the rate of reaction.

Sample Item 5

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
912/ Chemistry	ESR	3	SC.912.P.8.8: Characterize types of chemical reactions, for example: redox, acid-base, synthesis, and single and double replacement reactions.	LACC.910.WHST.1.2: Write informative/ explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	6

Many reactions are used in the classroom to demonstrate the various classifications of chemical reactions.

Write a balanced equation for a chemical reaction between H_2SO_4 and KOH. Identify the reactants, products, and type of chemical reaction occurring, including the chemical formula and chemical name. Then explain how conservation of mass is expressed by the balanced equation.

Scoring Rubric and Exemplar

Rubric	
6	Complete and correct response is made to all parts of the prompt. Appropriate scientific terminology is used. There are no major conceptual errors, though there may be non-detracting minor errors. In-depth understanding of the scientific concepts applicable to the prompt is demonstrated. Thorough understanding of the connection between the scientific concepts and the real-life application is demonstrated.
5	Complete and correct response is made to all parts of the prompt. Appropriate scientific terminology is used correctly. There are no major conceptual errors, though there may be minor conceptual errors. Understanding of the scientific concepts applicable to the prompt is demonstrated. Connections are made between the scientific concepts and real life application.
4	Complete and correct response is made to all parts of the prompt. There are minor errors in the use of scientific terminology. There are minor conceptual errors or omissions. The response may attempt connections between the scientific concepts and the real life application.
3	Response to two or more parts of the prompt is attempted. There is limited use of scientific terminology. Response contains some major conceptual errors or omissions. Response shows limited understanding.
2	Response to one or more parts of the prompt is attempted. The use of scientific terminology may be missing. Response contains many major conceptual errors and omissions. Shows minimal understanding.
1	Little attempt to answer the prompt is evident. Scientific terminology is missing. Response contains many major conceptual errors or omissions. Explanation shows no understanding.
0	Response addresses an entirely different response or is completely unintelligible.

Exemplar	
6	The student writes a balanced equation for the reaction, for example: H_2SO_4 + 2KOH → K_2SO_4 + $2H_2O$ <u>or</u> H_2SO_4 + 2KOH → K_2SO_4 + 2HOH; identifies the reactants H_2SO_4 (sulfuric acid; acid) and KOH (potassium hydroxide; base); identifies the products (H_2O or HOH) and a salt, K_2SO_4 (potassium sulfate); and identifies the type of reaction as an acid-base chemical reaction. Then the student explains how the Law of Conservation of Mass is expressed in this reaction; the number of elements in the product equals the number of elements in the reactant. Mass is conserved because the amount of products equals the amount of reactants except in a different phase (e.g., liquid to solid).

Sample Item 6

Performance Task 2–6 points

PT Item 1: The first item requires students to predict the correct products for the reaction and then perform the reaction.

PT Item 2: The second item is a constructed response item and requires students to balance the reaction. It is worth two points.

PT Item 3: The third item is a constructed response item and requires students to explain, with supporting evidence in a response, which reactant is the limiting reactant. This is worth two points.

Student Instructions:

This performance task asks you to identify with supporting evidence the limiting reactant for the chemical reaction of magnesium and oxygen. You will need safety clothing, magnesium, a pen or pencil, paper, and a calculator.

PT Item 1

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
912/ Chemistry	PT	2	SC.912.P.8.8: Characterize types of chemical reactions, for example: redox, acid-base, synthesis, and single and double replacement reactions.	LACC.910.WHST.1.2: Write informative/ explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	2

For this task, you will react magnesium strips with oxygen in the air through the process of combustion (under the supervision of the teacher).

Part 1: Predict and write the unbalanced chemical equation for this reaction.

Part 2: Perform the reaction, following proper laboratory safety precautions.

Scoring Rubric and Exemplar

Exemplar	
2	The student makes a logical prediction of the reaction: $Mg(s) + O_2(g) \rightarrow MgO(s)$ The student properly performs the reaction using proper safety precautions.

PT Item 2

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
912/ Chemistry	CR	2	SC.912.P.8.8: Characterize types of chemical reactions, for example: redox, acid-base, synthesis, and single and double replacement reactions.	N/A	2

Identify the type of reaction that occurs in PT Item 1, and balance the equation.

Scoring Rubric and Exemplar

Teacher Instructions:

The first item is the performance task itself, and it is mandatory while the other items are supplemental.

Exemplar	
2	A complete 2-point response includes 1 point for identifying this reaction as a synthesis reaction, and 1 point for correctly balancing the chemical equation: $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

PT Item 3

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
912/ Chemistry	CR	2	SC.912.P.8.9: Apply the mole concept and the law of conservation of mass to calculate quantities of chemicals participating in reactions.	LACC.910.WHST.1.2: Write informative/ explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	2

Now, use your balanced equation to identify the limiting reactant if 10 g of magnesium were reacted with 30 g of oxygen. Support your answer by showing your math and explaining your answer.

Scoring Rubric and Exemplar

Exemplar	
2	The student identifies the limiting reactant and supports the answer with the correct calculations. Balanced equation from PT Item 2: 2Mg(*s*) + O_2(g) → 2MgO(s) A) 10 g Mg (1 mol Mg/24. g Mg)(1 mol O_2/2 mols Mg)(32 g O_2/1 mol O_2) = 6.58 g O_2 AND/OR 30 g O_2 (1 mol O_2/32 g O_2)(2 mols Mg/1 mol O_2)(24.3 g Mg/1 mol O_2) = 45.56 g Mg B) Therefore, Mg is the limiting reactant.

Appendix B: Common Core State Standard Connections

A. Reading Standards for Literacy in Science and Technical Subjects—Chemistry

LACC.910.RST.1.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
LACC.1112.RST.1.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
LACC.910.RST.1.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
LACC.1112.RST.1.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LACC.910.RST.2.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.
LACC.1112.RST.2.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.
LACC.910.RST.2.5	Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
LACC.910.RST.3.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
LACC.1112.RST.3.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
LACC.910.RST.4.10	By the end of grade 10, read and comprehend science/ technical texts in the grades 9–10 text complexity band independently and proficiently.
LACC.1112.RST.4.10	By the end of grade 12, read and comprehend science/ technical texts in the grades 11–12 text complexity band independently and proficiently.

B. Writing Standards for Literacy in Science and Technical Subjects—Chemistry

LACC.910.WHST.1.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

LACC.1112.WHST.1.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
LACC.910.WHST.3.9	Draw evidence from informational texts to support analysis, reflection, and research.
LACC.1112.WHST.3.9	Draw evidence from informational texts to support analysis, reflection, and research.

C. Mathematics Standards in Science and Technical Subjects—Chemistry

MACC.912.N-Q.1.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MACC.912.N-Q.1.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

MACC.912.F-IF.3.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.