Introduction to Indiana's Academic Standards for Science – 2010

Indiana's Academic Standards for Science were last revised in 2000. This new document, Indiana's Academic Standards for Science – 2010, reflects the ever-changing science content and the underlying premise that science education should be an inquiry-based, hands-on experience. These standards were adopted by the Indiana State Board of Education in April, 2010, and will be implemented in the 2011-12 school year.

Indiana's Academic Standards for Science – 2010 reflect a few significant changes that are worth noting. Primarily, there are fewer standards and each grade level focuses on the big ideas for each of these sub-disciplines: physical science; earth science; life science; and science, technology and engineering. The overarching organization of the standards has also changed; they are divided into two sections: Process Standards and Content Standards, which are described in greater detail below.

Process Standards

The Process Standards are the processes and skills that students are expected to learn and be able to do within the context of the science content. The separation of the Process Standards from the Content Standards is intentional; in doing so we want to make explicit the idea that what students are doing while they are learning science is extremely important. The Process Standards reflect the way in which students are learning and doing science and are designed to work in tandem with the science content, resulting in robust instructional practice.

The Process Standards are organized in the following grade bands: K-2, 3-5, 6-8. Within each grade band, the Process Standards address a particular topic or topics. Kindergarten introduces The Nature of Science, while grades 1 through 5, reflect two parts: The Nature of Science and The Design Process. In grades 6 through 8, Reading for Literacy in Science and Writing for Literacy in Science have been added to emphasize these processes in science. For high school, the Process Standards include Reading and Writing for Literacy in Science as well as The Nature of Science.

As noted in the previous paragraph, grades 6 through 8 and high school content courses will include Reading and Writing for Literacy in Science. It is important to note that these Process Standards emerged with the adoption of the Common Core State Standards in the area of Reading and Writing for Literacy in Science. The Literacy Standards establish that instruction in reading, writing, speaking, listening, and language is a shared responsibility. The Literacy Standards are predicated on teachers in the content areas using their unique disciplinary expertise to help students meet the particular challenges of reading, writing, speaking, listening, and language in their respective fields. It is important to note that the literacy standards are meant to complement rather than supplant content standards in the disciplines.

Part of the motivation behind the disciplinary approach to literacy promulgated by the Literacy Standards is extensive research establishing the need for college- and career-ready students to be proficient in reading complex informational text independently in a variety of content areas. Most of the required reading in college and workforce training programs is informational

in structure and challenging in content. Postsecondary education programs typically provide students with both a higher volume of such reading than is generally required in K-12 schools and comparatively little scaffolding.

The Literacy Standards make clear that significant reading of informational texts should also take place outside ELA classrooms in order for students to be ready for college and careers. Future assessments will apply the sum of all the reading students do in a grade, not just their reading in the ELA context. The Literacy Standards demand that a great deal of reading should occur in all disciplines.

The Literacy Standards also cultivate the development of three mutually reinforcing writing capacities: writing to persuade, to explain, and to convey real or imagined experience. College and career readiness requires that writing focus significantly on writing to argue and to inform or explain.

The Literacy Standards use grade level bands to present the standards. Teachers teaching at the beginning of the grade band may need to provide scaffolding for students to be successful, where teachers teaching at the end of the grade band should expect students to demonstrate the standards independently.

Content Standards

In grades 1 through 8, the Content Standards are organized in four distinct areas: 1) physical science; 2) earth science; 3) life science; and 4) science, technology and engineering. Kindergarten has only the first three areas: physical, earth and life science. In each of these areas there is at least one core standard, which serves as the big idea at that grade level for that content area. For the high school science courses, the content standards are organized around the core ideas in each particular course, which are represented by the core standard. The core standard is not meant to stand alone or be used as an individual standard, but instead is meant to help teachers organize their instruction around the “big ideas” in that content area and for grades K-8, at that particular grade level. Beneath each core standard are indicators which serve as the more detailed expectations within each of the content areas.

Finally, in the development of these revised science standards, careful attention was paid to how ideas are articulated across the grade levels so that content and skills that students will need to succeed in a particular sub-discipline are introduced in an appropriate manner in the early elementary grades and then progressed as students move towards high school.

Chemistry I

Process Standards

The Nature of Science

Scientific knowledge is scientists' best explanations for the data from many investigations. Ideas about objects in the microscopic world that we cannot directly sense are often understood in terms of concepts developed to understand objects in the macroscopic world that we can see and touch. Student work should align with this process of science and should be guided by those principles. Students should also understand that scientific knowledge is gained from observation of natural phenomena and experimentation by designing and conducting investigations guided by theory and by evaluating and communicating the results of those investigations according to accepted procedures. These concepts should be woven throughout daily work.

- Develop explanations based on reproducible data and observations gathered during laboratory investigations.
- Recognize that their explanations must be based both on their data and other known information from investigations of others.
- Clearly communicate their ideas and results of investigations verbally and in written form using tables, graphs, diagrams and photographs.
- Regularly evaluate the work of their peers and in turn have their work evaluated by their peers.
- Apply standard techniques in laboratory investigations to measure physical quantities in appropriate units and convert quantities to other units as necessary.
- Use analogies and models (mathematical and physical) to simplify and represent systems that are difficult to understand or directly experience due to their size, time scale or complexity. Recognize the limitations of analogies and models.
- Focus on the development of explanatory models based on their observations during laboratory investigations.
- Explain that the body of scientific knowledge is organized into major theories, which are derived from and supported by the results of many experiments and allow us to make testable predictions.
- Recognize that new scientific discoveries often lead to a re-evaluation of previously accepted scientific knowledge and of commonly held ideas.
- Describe how scientific discoveries lead to the development of new technologies and conversely how technological advances can lead to scientific discoveries through new experimental methods and equipment.
- Explain how scientific knowledge can be used to guide decisions on environmental and social issues.

Reading Standards for Literacy in Science

Key Ideas and Details

11-12.RS.1 Cite specific textual evidence to support analysis of science, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

11-12.RS.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

11-12.RS.3 Follow precisely a complex multistep procedure when carrying out experiments or taking measurements; analyze the specific results based on explanations in the text.

Craft and Structure

11-12.RS.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific context relevant to *grades 11-12 texts and topics*.

11-12.RS.5 Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

11-12.RS.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas

11-12.RS.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.

11-12.RS.8 Evaluate the hypotheses, data, analysis, and conclusions in a science text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

11-12.RS.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Range of Reading and Level of Text Complexity

11-12.RS.10 By the end of grade 12 read and comprehend science texts in the grades 11-CCR text complexity band independently and proficiently.

Writing Standards for Literacy in Science

Text Types and Purposes

11-12.WS.1 Write arguments focused on *discipline-specific content*.

a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.
c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
e. Provide a concluding statement or section that follows from or supports the argument presented.

11-12.WS.2 Write informative/explanatory texts, including scientific procedures/ experiments.

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).

11-12.WS.3 *Note: Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In science, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations that others can replicate them and (possibly) reach the same results.*

Production and Distribution of Writing

11-12.WS.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

11-12.WS.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

11-12.WS.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge

11-12.WS.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

11-12.WS.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectivity to maintain the flow of ideas, avoiding plagiarism and overreliance on any once source and following a standard format for citation.

11-12.WS.9 Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing

11-12.WS.10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Content Standards

Standard 1: Properties and States of Matter

Core Standard
Describe the nature of physical and chemical properties and changes of matter. (C.1.1, C.1.2, C.1.3, C.1.4)

Core Standard
Compare and contrast states of matter at the molecular level. (C.1.5, C.1.6, C.1.7)

C.1.1 Based on physical properties, differentiate between pure substances and mixtures.

C.1.2 Observe and describe chemical and physical properties of different types of matter and designate them as either extensive or intensive.

C.1.3 Recognize observable indicators of chemical changes.

C.1.4 Describe physical and chemical changes at the molecular level.

C.1.5 Describe the characteristics of solids, liquids and gases and changes in state at the molecular level.

C.1.6 Explain and apply the law of conservation of mass as it applies to chemical processes.

C.1.7 Define density and distinguish among materials based on densities. Perform calculations involving density.

Standard 2: Atomic Structure and the Periodic Table

Core Standard
Describe how the properties and arrangements of the subatomic particles contribute to the structures of atoms. (C.2.1, C.2.2, C.2.7, C.2.8, C.2.9)

Core Standard
Describe how the structure of the periodic table reflects the numbers of electrons and protons and the configuration of electrons in an atom. (C.2.3, C.2.4, C.2.5, C.2.6)

C.2.1 Describe how models of atomic structure changed over time based on available experimental evidence and understand the current model of atomic structure.

C.2.2 Describe how the subatomic particles (i.e., protons, neutrons and electrons) contribute to the structure of an atom and recognize that the particles within the nucleus are held together against the electrical repulsion of the protons.

C.2.3 Determine the number of protons, neutrons, and electrons in isotopes and in those isotopes that comprise a specific element. Relate these numbers to atomic number and mass number.

C.2.4 Calculate the average atomic mass of an element from isotopic abundance data.

C.2.5 Write the electron configuration of an element and relate this to its position on the periodic table.

C.2.6 Use the periodic table and electron configuration to determine an element's number of valence electrons and its chemical and physical properties.

C.2.7 Compare and contrast nuclear reactions with chemical reactions.

C.2.8. Describe how fusion and fission processes transform elements present before the reaction into elements present after the reaction.

C.2.9 Understand that the radioactive decay process is random for any given atom but that this property leads to a predictable and measurable exponential decay of a sample of radioactive material. Know how to calculate the initial amount, the fraction remaining or the half-life of a radioactive isotope when given two of the other three variables.

Standard 3: Bonding and Molecular Structure

Core Standard

Describe how the configuration of electrons within an atom determines its interactions with other atoms. (C.3.1, C.3.2, C.3.3, C.3.4)

Core Standard

Describe the attractive forces among molecules and their effect on chemical and physical properties. (C.3.5)

C.3.1 Describe, compare and contrast the characteristics of the interactions between atoms in ionic and covalent compounds.

C.3.2 Compare and contrast how ionic and covalent compounds form.

C.3.3 Draw structural formulas for and name simple molecules.

C.3.4 Write chemical formulas for ionic compounds given their names and vice versa.

C.3.5 Compare and contrast ionic, covalent network, metallic and polar and non-polar molecular crystals with respect to constituent particles, strength of bonds, melting and boiling points and conductivity; provide examples of each type.

Standard 4: Reactions and Stoichiometry

Core Standard

Use balanced chemical equations and the mole concept to determine the quantities of reactants and products.

C.4.1 Predict products of simple reactions such as synthesis, decomposition, single replacement and double replacement.

C.4.2 Balance chemical equations using the law of conservation of mass and use them to describe chemical reactions.

C.4.3 Given mass of the sample, use the mole concept to determine the number of moles and number of atoms or molecules in samples of elements and compounds.

C.4.4 Using a balanced chemical equation, calculate the quantities of reactants needed and products made in a chemical reaction that goes to completion.

C.4.5 Describe, classify and give examples of various kids of reactions-synthesis (i.e., combination), decomposition, single displacement, double displacement and combustion.

C.4.6 Determine oxidation states and identify the substances gaining and losing electrons in redox reactions.

C.4.7 Perform calculations to determine the composition of a compound or mixture when given the formula.

Standard 5: Behavior of Gases

Core Standard

Using the kinetic molecular theory, describe and explain the behavior of ideal gases. (C.5.1)

Core Standard

Using the ideal gas equation of state $PV = nRT$, examine the relationship among the number of moles, volume, pressure and temperature for ideal gases. (C.5.2, C.5.3)

C.5.1 Use kinetic molecular theory to explain changes in gas volumes, pressure, moles and temperature.

C.5.2 Using the ideal gas equation of state $PV = nRT$, calculate the change in one variable when another variable is changed and the others are held constant.

C.5.3 Given the equation for a chemical reaction involving one or more gases as reactants, products or both, calculate the volumes of gas when assuming the reaction goes to completion and the ideal gas law holds.

Standard 6: Thermochemistry

Core Standard

Recognize that chemical reactions result in either the release or absorption of energy. (C.6.1, C.6.2, C.6.3)

Core Standard

Apply the law of conservation of energy. (C.6.4)

C.6.1 Explain that atoms and molecules are in constant motion and that this motion increases as thermal energy increases.

C.6.2 Distinguish between the concepts of temperature and heat flow in macroscopic and microscopic terms.

C.6.3 Classify chemical reactions and phase changes as exothermic or endothermic.

C.6.4 Solve problems involving heat flow and temperature changes by using known values of specific heat, phase change constants (i.e., latent heat values) or both.

Standard 7: Solutions

Core Standard

Describe the composition and characteristics of solutions. (C.7.1, C.7.2, C.7.3, C.7.4)

Core Standard

Identify the factors that qualitatively affect solubility, reaction rates and dynamic equilibrium. (C.7.5, C.7.6)

C.7.1 Describe the composition and properties of types of solutions.

C.7.2 Explain how temperature, pressure and polarity of the solvent affect the solubility of a solute.

C.7.3 Describe the concentration of solutes in a solution in terms of molarity. Perform calculations using molarity, mass and volume.

C.7.4 Prepare a specific volume of a solution of a given molarity when provided with a known solute.

C.7.5 Explain how the rate of a reaction is qualitatively affected by changes in concentration, temperature, surface area and the use of a catalyst.

C.7.6 Write equilibrium expressions for reversible reactions.

Standard 8: Acids and Bases

Core Standard

Use acid-base definitions to identify acids and bases when given their formulas and reactions. (C.8.1, C.8.2, C.8.3)

Core Standard

For any aqueous solution, explain the meaning of the value indicated by the pH scale in terms of the hydrogen ion concentration. (C.8.4, C.8.5)

C.8.1 Use Arrhenius and Brønsted-Lowry definitions to classify substances as acids or bases.

C.8.2 Describe the characteristic properties of acids and bases.

C.8.3 Compare and contrast the dissociation and strength of acids and bases in solutions.

C.8.4 Given the hydronium (H_3O^+) ion concentration in a solution, calculate the pH and vice versa. Explain the meaning of these values.

C.8.5 From acid-base titration data, calculate the concentration of an unknown solution.

Standard 9: Organic Chemistry and Biochemistry

Core Standard

Describe the unique nature of carbon atoms' ability to bond to one another and other elements, which forms countless carbon-based substances and macromolecules.

C.9.1 Use structural formulas to illustrate carbon atoms' ability to bond covalently to one another to form many different substances.

C.9.2 Illustrate the variety of molecular types formed by the covalent bonding of carbon atoms and describe the typical properties of these molecular types.