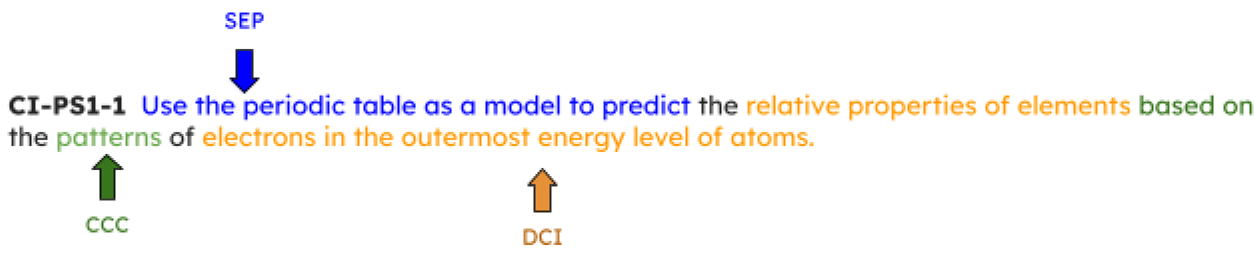
ARKANSAS
K-12 SCIENCE STANDARDS
EDUCATION FOR A NEW GENERATION

Fundamental Science Content
Chemistry Integrated

2023

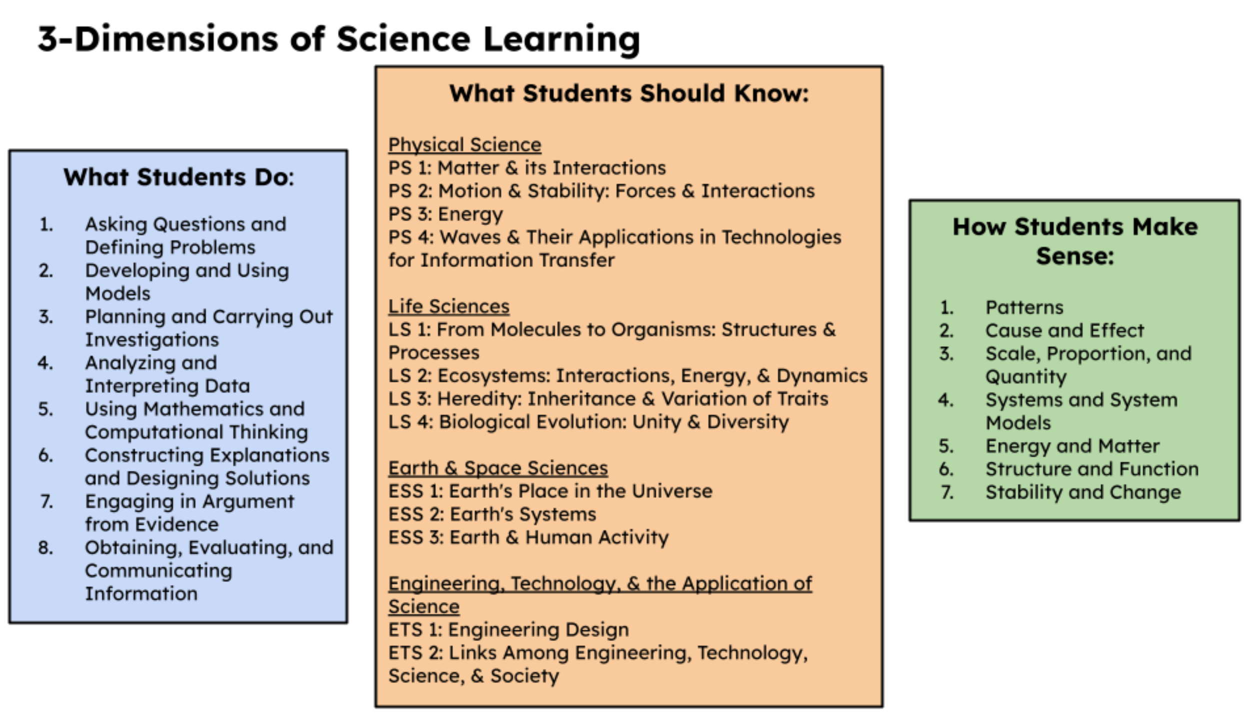
The Arkansas K-12 Science Standards are available [here](). The standards are three-dimensional, consisting of a Science and Engineering Practice (SEP), a Disciplinary Core Idea (DCI), and a Cross Cutting Concept (CCC). By the end of the grade level, students should be able to demonstrate the full scope of the standard. Example:



The focus of this document is specifically on the science core ideas in Chemistry- Integrated. In Arkansas K-12 Science Standards, science content is found in the DCI portion of each standard. Three-dimensional learning and assessment best prepare students for success so that students have the opportunity to demonstrate both what they know *and* can do in science. Refer to the full standards document to find the corresponding science and engineering practice and cross-cutting concept for each standard. The core ideas are organized into the following domains of science:

- Physical Science
- Life Science
- Earth & Space Science
- Engineering Technology & Applications of Science

Each domain contains core ideas organized into component ideas. By the end of Chemistry Integrated, students are expected to know the bulleted information under each component idea. Standards that address the bulleted information are included in parentheses and those with an asterisk include an engineering component.



Physical Science

*Asterisks indicate best opportunities to integrate ETS performance expectations into content.

† Indicates PE's partially addressed in PS-I and fully addressed in Chemistry- Integrated.

Matter
Structure and properties of matter
• Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (CI-PS1-1†)
• The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (CI-PS1-1†, CI-PS1-2†)
• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (CI-PS1-3†)
• A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (CI-PS1-4†)
Chemical Reactions
• In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (CI-PS1-6)
• The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (CI-PS1-2†, CI-PS1-7†)
• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (CI-PS1-4†, CI-PS1-5)
Nuclear Processes
• Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (CI-ESS1-6)
• Nuclear processes, including fusion, fission, and radioactive decay of unstable nuclei, involve the release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (CI-PS1-8)
Motion and Stability
Forces & Motion
• Newton's second law accurately predicts changes in the motion of macroscopic objects. (CI-PS2-1†)
• Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (CI-PS2-2)
• If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (CI-PS2-2)

Types of Interactions
• Attraction and repulsion between electric charges at the atomic scale (i.e., Coulomb's Law) explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (CI-PS1-1†,CI-PS1-3†)
• Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (CI-PS2-4)
• Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (CI-PS2-4)
Energy
Definitions of Energy
• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (CI-PS3-1†)
Conservation & Transfer of Energy
• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (CI-PS3-1†)
• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (CI-PS3-1†)
• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (CI-PS3-1)
• The availability of energy limits what can occur in any system. (CI-PS3-1)
Energy & Forces
• When two objects interacting through a field change relative position, the energy stored in the field is changed. (CI-PS3-5)
Energy in Everyday Life
• Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (CI-ESS1-1)
• Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (CI-PS4-5)
Waves
Wave Properties

• The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (CI-PS4-1†)
• Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (CI-PS4-5)
• [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., the relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (CI-PS4-3)
Electromagnetic Radiation
• Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow the identification of the presence of an element, even in microscopic quantities. (CI-ESS1-2)
• Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (CI-PS4-3)
• When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (CI-PS4-4)
• Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (CI-PS4-5)
Waves in Information Technology
• Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, and scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (CI-PS4-5)

Earth & Space Science

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Earth's Place in the Universe
The Universe and Its Stars
• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (CI-ESS1-1)
• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (CI-ESS1-3)
• Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (CI-ESS1-3)

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• The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gasses, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (CI-ESS1-2)
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Earth and the Solar System
• Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (CI-ESS1-4)
The History of Planet Earth
• Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (CI-ESS1-6)
Earth's Systems
Earth's Materials
• Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior. (CI -ESS2-3)
Plate Tectonics
• The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (CI -ESS2-3)
Roles of Water on Earth's Processes
• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (CI-ESS2-5)
Earth and Human Activity
Human Impacts on Earth Systems

- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (CI -ESS3-4)

Engineering, Technology, and Applications of Science

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Engineering Design
Defining Engineering Problems
• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (CI2-ETS1-1, CI3-ETS1-1)
• Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (CI2-ETS1-1, CI3-ETS1-1)
Developing Possible Solutions
• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (CI2-ETS1-3)
• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (CI2-ETS1-4)
Optimizing the Design Solution
• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (CI-PS1-6, CI1-ETS1-2, CI2-ETS1-2. CI5-ETS1-2)
• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (CI-ESS3-4)
• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (CI4-ETS1-4)