01 Atomic Structure and Properties

Content Area: **Science**
Course(s): **Chemistry CP**
Time Period: **Semester 1**
Length: **10 weeks**
Status: **Published**

Standards

SCI.HS.PS1.C	Nuclear Processes
SCI.HS.PS3.D	Energy in Chemical Processes
SCI.HS.PS4.A	Wave Properties
SCI.HS.PS4.B	Electromagnetic Radiation
SCI.HS.ESS1.A	The Universe and Its Stars
SCI.HS.ESS2.A	Earth Materials and Systems
SCI.HS.ESS2.B	Plate Tectonics and Large-Scale System Interactions
SCI.HS-ESS1-1	Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
SCI.HS-ESS2-3	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
SCI.HS-PS4-3	Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
SCI.HS-PS1-8	Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
SCI.HS-PS4-4	Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
	Developing and Using Models
	Engaging in Argument from Evidence
	Scale, Proportion, and Quantity
	Energy and Matter
	Systems and System Models
	Cause and Effect
	Obtaining, Evaluating, and Communicating Information

Enduring Understandings

1. Physical, chemical, and nuclear changes are explained using the location and properties of subatomic particles.

2. The periodic table organizes all known elements and provides useful information for making predictions in chemistry.

3. Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons,

surrounded by electrons.

4. 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.

5. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy, by an amount known as the binding energy, than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

6. Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve changes in nuclear binding energies.

7. The total number of neutrons plus protons does not change in any nuclear process.

8. Strong and weak nuclear interactions determine nuclear stability and processes.

9. Spontaneous radioactive decays follow a characteristic exponential decay law.

10. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials from the isotope ratios present.

11. Normal stars cease producing light after having converted all of the material in their cores to carbon or, for more massive stars, to iron. Elements more massive than iron are formed by fusion processes but only in the extreme conditions of supernova explosions, which explains why they are relatively rare.

12. Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.

13. The main way in which that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.

14. Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy.

15. Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons.

16. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. Quantum theory relates the two models. (Boundary: Quantum theory is not explained further at this grade level.)

17. 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. (Because a wave is not much disturbed by objects that are small compared with its wavelength, visible light cannot be used to see such objects as individual atoms.

18. All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any other given medium depends on its wavelength and the properties of that medium.

19. 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.

20. Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. Atoms of each element emit and absorb characteristic frequencies of light, and nuclear transitions have distinctive gamma ray wavelengths. These characteristics allow identification of the presence of an element, even in microscopic quantities.

Essential Questions

1. How can one explain the structure, properties, and interactions of matter?
2. How do particles combine to form the variety of matter one observes?
3. What forces hold nuclei together and mediate nuclear processes?
4. How has human understanding of the atom changed over time?
5. What is the connection between science and technology related to the atom?
6. How do we know what we know about the atom if we cannot see them?
7. How do charges affect the force between objects on an atomic scale?
8. How does the force between electric charges at the atomic scale explain the structure, property and transformation of matter?
9. How do stars produce elements?
10. What causes the production of energy in the sun?
11. How do we know that the sun will provide energy tomorrow?
12. How do food and fuel provide energy?
13. If energy is conserved, why do people say it is produced or used?
14. What is light?
15. How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there?

Knowledge and Skills

Knowledge

1. Students will know that nuclear processes, including fusion, fission, and radioactive decays of unstable

nuclei, involve release or absorption of energy. (DCI PS1.C Nuclear Processes)

2. Students will know that in nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. The total number of neutrons plus protons is the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after. (DCI PS1.C Nuclear Processes)

3. Students will know that the star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (DCI: ESS1.A The Universe and Its Stars)

4. Students will know that nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (DCI: PS3.D Energy in Chemical Processes and Everyday Life)

5. Students will know that 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. (DCI ESS2.A: Earth Materials and Systems)

6. Students will know that motion 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 gravitational movement of denser material toward the interior. (DCI ESS2.A: Earth Materials and Systems)

7. Students will know that 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. (DCI ESS2.B Plate Tectonics and Large Scale System Interactions)

8. 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. (DCI PS4.A Wave Properties)

9. 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. (DCI PS4.B Electromagnetic Radiation)

10. 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. (DCI PS4.B Electromagnetic Radiation)

11. Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (DCI PS4.B Electromagnetic Radiation)

Skills

1. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the process of fission, fusion, and radioactive decay.

2. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

3. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

4. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.

5. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing