01 Atomic Structure and Properties

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

Standards

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.
	Developing and Using Models
PS1.C	Nuclear Processes
	Energy and Matter
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.
	Engaging in Argument from Evidence
PS4.A	Wave Properties
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.
	Obtaining, Evaluating, and Communicating Information
PS4.B	Electromagnetic Radiation
	Cause and Effect
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.
ESS1.A	The Universe and Its Stars
HS-ESS1-2	Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
	Constructing Explanations and Designing Solutions
HS-ESS2-3	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
ESS2.B	Plate Tectonics and Large-Scale System Interactions

Enduring Understandings

1. Matter is defined by its atomic structure, where a central nucleus of protons and neutrons is surrounded by electrons, giving rise to periodic trends that predict elemental behavior and bulk properties based on electrical forces.

2. Stability in matter is achieved by minimizing energy, whether through chemical bonds or nuclear processes like fission, fusion, and radioactive decay, which alter nuclear binding energies while conserving the total number of nucleons.

3. These nuclear reactions, governed by strong and weak forces, power stars and create all heavy elements and provide energy that reaches Earth as radiation. Radiation also enables radiometric dating

via predictable exponential decay.

4. Electromagnetic radiation behaves as both waves and photon particles, traveling through a vacuum at the speed of light and interacting with matter by transferring thermal energy, causing cellular ionization, or revealing elemental identities through unique emission spectra.

Essential Questions

1. How do atomic structures, subatomic forces, and the conservation of energy explain the properties, transformations, and stability of matter?

2. How has our understanding of the invisible atom evolved over time through the interplay of scientific inquiry, evidence, and technology?

3. What forces govern the stability of an atomic nucleus, and how do they mediate nuclear processes like fission, fusion, and radioactive decay?

4. How does the lifecycle of stars and the behavior of the sun drive the production of elements and the continuous flow of energy to Earth?

5. How is visible light and other forms of electromagnetic radiation created by electrons in an atom?

6. What is electromagnetic radiation, and how do its dual wave-particle behaviors explain the varied effects and forms of light?

7. What are the effects of different types of electromagnetic radiation and what are its applications in medicine and technology?

8. How is nuclear energy harnessed and what are the benefits and drawbacks of using it?

Knowledge and Skills

Knowledge

1. Students will evaluate how structural differences in electron configurations dictate specific macroscopic properties, such as magnetic behaviors or visible light emission during electron excitation. (DCI PS4.B Electromagnetic Radiation)

2. Students will analyze nuclear processes (fission, fusion, and radioactive decay) as transformations where elemental identity is altered, mass is converted to energy via binding energy changes, yet the total nucleon count (protons + neutrons) remains strictly conserved. (DCI PS1.C Nuclear Processes)

3. Students will analyze how Earth's internal structure (crust, mantle, liquid outer core, solid inner core) is sustained by thermal convection currents driven primarily by the ongoing heat generation of radioactive decay. (DCI ESS2.B Plate Tectonics and Large Scale System Interactions)

4. Students will analyze the lifecycle of stars, explaining how core nuclear fusion sequentially creates

elements up to iron before energy limitations cause normal stars to collapse or explode. (DCI: ESS1.A The Universe and Its Stars)

5. Students will evaluate the sun's lifespan as a dynamic, finite system (approx. 10 billion years) sustained by hydrogen-to-helium fusion that converts mass into solar radiation. (DCI: ESS1.A The Universe and Its Stars)

6. Students will critique the dual nature of electromagnetic radiation, determining when the wave model (e.g., speed, frequency, medium interactions) or the particle model (e.g., photon absorption, photoelectric effect) is required to explain a phenomenon. (DCI PS4.A Wave Properties)

7. Students will analyze the relationship between EM radiation wavelengths and matter, identifying how longer waves convert to thermal energy while shorter wavelengths possess the ionization energy required to disrupt DNA or excite electrons to cause structural shifts. (DCI PS4.B Electromagnetic Radiation)

Skills

1. Construct and defend a mathematical model using the wave equation to determine the identity of unknown elements from their unique stellar absorption or emission spectra.

2. Formulate an evidence-based argument to justify the medical efficacy and safety constraints of using short-lived metastable isotopes like Technetium-99m in diagnostic imaging.

3. Develop a dynamic simulation or physical model that illustrates how the outward flow of energy from radioactive decay in the mantle drives plate tectonics through thermal convection and matter cycling.

4. Formulate and calculate complete nuclear equations for fission, fusion, and alpha/beta/gamma decays, proving the conservation of mass number and atomic number across the reaction.

5. Appraise and debate the long-term reliability and environmental impact of nuclear energy compared to fossil fuels, utilizing a cost-benefit analysis framework focused on waste half-lives and carbon emissions.

6. Construct a graphical timeline and model of the sun's core processes, calculating the net energy yield of hydrogen fusion with binding energy graphs, and diagramming how that energy radiates to Earth.

7. Design and conduct an investigation of electron transitions that occur to create color using observing spectral light tubes and diffraction gratings to model the electron transitions required to create different colors.

8. Evaluate the validity and reliability of conflicting media claims regarding the health risks of daily exposure to various ambient EM frequencies (e.g., 5G cellular networks, microwaves, ultraviolet sunlight).

9. Generate an engineering design solution utilizing photovoltaic principles to optimize solar energy capture, accounting for constraints like light frequency, material efficiency, and environmental degradation.

Resources

Core Resources:

CK-12 Chemistry Intermediate

Supplemental Resources:

- Chemistry in the Community 4th Edition

- Density Lab
- Spectroscopy Webquest
- Halloweenium Lab
- http://www.teachchemistry.org/periodic-trends

- Edpuzzles: Eyes of Nye,

- Pivot Interactives

- University of Texas Gas Behavior Simulator

- Barometer Reading

- Teach Chemistry Periodic Trends Simulator

- Bill Nye Nuclear Energy Video

- Gigaphysics Geiger-Muller Tube Simulator

- X-Rays Reading

Assessments

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

Modifications

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