Nuclear Astrophysics Content Expectations for Indiana

National Science Educational Standard: Unifying concepts and processes in science

Earth and Space Science

Principles of Earth and Space Science

The Universe

ES.1.3 Compare and contrast the differences in size, temperature, and age between our sun and other stars.

ES.1.5 Understand and explain the relationship between planetary systems, stars, multiple-star systems, star clusters, galaxies, and galactic groups in the universe.

ES.1.6 Discuss how manned and unmanned space vehicles can be used to increase our knowledge and understanding of the universe.

ES.1.8 Discuss the role of sophisticated technology, such as telescopes, computers, space probes, and particle accelerators, in making computer simulations and mathematical models in order to form a scientific account of the universe.

ES.1.9 Recognize and explain that the concept of conservation of energy is at the heart of advances in fields as diverse as the study of nuclear particles and the study of the origin of the universe

National Science Educational Standard: Physics

Physics

Principles of Physics

The Properties of Matter

P.1.1 Describe matter in terms of its fundamental constituents and be able to differentiate among those constituents.

The Relationships Between Motion and Force

The Nature of Energy

P.1.12 Use the law of conservation of energy to predict the outcome(s) of an energy transformation

The Nature of Atomic and Subatomic Physics

P.1.29 Describe the nuclear model of the atom in terms of mass and spatial relationships of the electrons, protons, and neutrons.

P.1.30 Explain that the nucleus, although it contains nearly all of the mass of the atom, occupies less than the proportion of the solar system occupied by the sun. Explain that the mass of a neutron or a proton is about 2,000 times greater than the mass of an electron.

P.1.31 Explain the role of the strong nuclear force in binding matter together.

P.1.32 Using the concept of binding energy per nucleon, explain why a massive nucleus that fissions into two medium-mass nuclei emits energy in the process.

P.1.33 Using the same concept, explain why two light nuclei that fuse into a more massive nucleus emit energy in the process.

P.1.34 Understand and explain the properties of radioactive materials, including half-life, types of emissions, and the relative penetrative powers of each type.

P.1.35 Describe sources and uses of radioactivity and nuclear energy.

Integrated Chemistry-Physics

Structure and Properties of Matter

CP.1.1 Understand and explain that atoms have a positive nucleus (consisting of relatively massive positive protons and neutral neutrons) surrounded by negative electrons of much smaller mass, some of which may be lost, gained, or shared when interacting with other atoms.

CP.1.2 Realize that and explain how a neutral atom's atomic number and mass number can be used to determine the number of protons, neutrons, and electrons that make up an atom.

CP.1.3 Understand, and give examples to show, that isotopes of the same element have the same numbers of protons and electrons but differ in the numbers of neutrons.

CP.1.4 Know and explain that physical properties can be used to differentiate among pure substances, solutions, and heterogeneous mixtures.

Changes in Matter

CP.1.8 Know and explain that the nucleus of a radioactive isotope is unstable and may spontaneously decay, emitting particles and/or electromagnetic radiation.

CP.1.9 Show how the predictability of the nuclei decay rate allows radioactivity to be used for estimating the age of materials that contain radioactive substances.

CP.1.11 Understand and give examples to show that an enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.

CP.1.13 Explain that the rate of reactions among atoms and molecules depends on how often they encounter one another, which is in turn affected by the concentrations, pressures, and temperatures of the reacting materials.

Energy Transformations

CP.1.19 Understand and explain that the energy released whenever heavy nuclei split or light nuclei combine is roughly a million times greater than the energy absorbed or released in a chemical reaction. ($E=mc^2$)

National Science Educational Standard: The History and Nature of Science

Physics

Historical Perspectives

P.2.10 Describe how later, Austrian and German scientists showed that when uranium is struck by neutrons, it splits into two nearly equal parts plus tow or three extra neutrons. Note that Lise Neitner, and Austrian physicist, was the first to point out that if these fragments added up to less mass than the original uranium nucleus, then Einstein's special relativity theory predicted that a large amount of energy would be released. Also note that Enrico Fermi, an Italian working with colleagues in the United States, showed that the extra neutrons trigger more fissions and so create a sustained chain reaction in which a prodigious amount of energy is given off.