Chemistry, Quarter 2, Unit 2.1

Big Bang Theory and Star Cycle

Overview

Number of instructional days: 7 (1 day = 53 minutes)

Content to be learned

- Relate the process of star formation to the size of a star.
- Recognize interactions between the force of gravity, fusion, and energy release in the development of a star.
- Identify and describe the characteristics common to most stars in the universe.
- Cite evidence for the Big Bang theory and explain how the theory has developed over time.
- Apply the properties of waves/particles to explain the movement, location, and composition of the stars and other bodies in the universe.

Processes to be used

- Use written and other media sources to explain how scientific knowledge about the universe has changed over time.
- Analyze data and cite evidence.
- Apply scientific knowledge to explain principles.
- Identify patterns of change within systems.

Essential questions

- How would you relate a star's composition to the process of its formation and its age?
- Historically, what evidence has been used to support the Big Bang theory?
- How are the properties of waves used to determine the relative location of celestial bodies?
- What is the relationship between the size of a star and the processes involved in the formation of the star?

Written Curriculum

Grade Span Expectations

ESS3 - The origin and evolution of galaxies and the universe demonstrate fundamental principles of physical science across vast distances and time

ESS3 (9-11) POC+SAE – 8

Explain the relationships between or among the energy produced from nuclear reactions, the origin of elements, and the life cycle of stars.

ESS3 (9-11)–8 Students demonstrate an understanding of the life cycle of stars by …

8a relating the process of star formation to the size of the star and including the interaction of the force of gravity, fusion, and energy release in the development of the star identifying and describing the characteristics common to most stars in the universe.

ESS3 (9-11) NOS–6

Provide scientific evidence that supports or refutes the "Big Bang" theory of how the universe was formed

ESS3 (9-11)–6 Students demonstrate an understanding of the formation of the universe by…

6a using data (diagrams, charts, narratives, etc.) to explain how the "Big Bang" theory has developed over time citing evidence to support its occurrence (Doppler Effect/red shift).

ESS3 (9-11) SAE -7

Based on the nature of electromagnetic waves, explain the movement and location of objects in the universe or their composition (e.g., red shift, blue shift, line spectra)

ESS3 (9-11)–7 Students demonstrate an understanding of processes and change over time within the system of the universe (Scale, Distances, Star Formation, Theories, Instrumentation) by...

7a applying the properties of waves/particles to explain the movement, location, and composition of the stars and other bodies in the universe.

Clarifying the Standards

Prior Learning

In grades K–4, students observed the enormous number of stars in the sky and learned that people have identified star patterns called constellations. In grades 5–6, students learned to describe the apparent motion and position of the objects in the sky and identified the sun as a star on the edge of our galaxy. In grades 7–8, students described the universe as containing billions of galaxies and recognized each galaxy as containing billions of stars.

Current Learning

This is reinforcement and development. Students in grade 9 looked at the process of star formation from the perspective of gravitational forces. Students use written and other media sources to explain how scientific knowledge about the universe has changed as technology has brought new evidence forward. Students also explain how the Big Bang theory has developed over time. The movement, location, and composition of stars and other bodies in the universe are analyzed using wave and particle properties. They study the lifecycle of stars, from the process of star formation and development—including the interaction of gravity, fusion, and energy release—to star destruction. Students learn that, for at least a portion of its life, a star shines due to thermonuclear fusion of hydrogen in its core, releasing energy that traverses the star's interior and then radiates into outer space. Almost all naturally occurring elements heavier than helium were created by stars, either via stellar nucleosynthesis during their lifetimes or by supernova nucleosynthesis when stars explode. Astronomers can determine the mass, age, chemical composition, and many other properties of a star by observing its spectrum, luminosity, and motion through space.

The concept of red and blue shift can be illustrated using balloons and felt-tip markers. Students place reference marks on a partially inflated balloon and draw waves between the marks with the markers. They measure the wavelengths and distances between points, then further inflate the balloon and measure again, comparing results. This is a good way for students to see the expanding system and red shift phenomenon.

Future Learning

Students who take advanced science classes may engage in further research, with topics including spectroscopy, examining the fusion reactions in stars and nuclear phenomena resulting from supernovae.

Additional Research Findings

According to the *Atlas of Science Literacy*, students need to understand how telescopes have been used to gather data about the universe. They should learn that light from the nearest star takes a few years to arrive to earth, but traveling to that star by rocket would take thousands of years. Students also need to understand that gravity depends on the masses of objects and the distances between them (p. 47).

Atlas also states that students need to understand the relationship between the speed of electromagnetic radiation and its relationship to frequency and wavelength. Additionally, they should recognize that observed wavelength depends on the relative motion of the source. If the objects are moving towards each other, the wavelength is shorter; if they are moving away, the wavelength is longer (red shift) (p. 49).

Notes About Resources and Materials

Chemistry, Quarter 2, Unit 2.2

Electron Configuration

Overview

Number of instructional days: 10 (1 day = 53 minutes)

Content to be learned

- Describe or diagram how energy changes occur.
- Compare and contrast electromagnetic waves to mechanical waves.
- Provide evidence of the relationship between the frequency and wavelength of any wave.
- * Write an electron configuration including *s*, *p*, *d*, and *f* orbitals and relate them to atomic interactions.

* *Advanced classes*

Processes to be used

- Observe how the energy changes in atoms.
- Create and use models of the atom.
- Examine changes in a system.

Essential questions

- How are electromagnetic waves similar to and different from mechanical waves?
- What is the relationship between the frequency, wavelength, and energy of any wave?
- How can mathematical evidence be used to prove that there is a relationship between the frequency and wavelength of a wave?
- How can modeling electrons in an atom be used to represent energy changes?

Written Curriculum

Grade Span Expectations

PS 2 - Energy is necessary for change to occur in matter. Energy can be stored, transferred, and transformed, but cannot be destroyed.

PS2 (9-11) POC+SAE -5

Demonstrate how transformations of energy produce some energy in the form of heat and therefore the efficiency of the system is reduced (chemical, biological, and physical systems).

PS2 (9-11)-5 Students demonstrate an understanding of energy by…

5a describing or diagraming the changes in energy (transformation) that occur in ~~different~~ systems ~~(eg. chemical = exo and endo thermic reactions, biological = food webs, physical = phase changes).~~

PS 3 - The motion of an object is affected by forces.

PS3 (9-11) SAE –10

Explain the effects on wavelength and frequency as electromagnetic waves interact with matter (e.g., light diffraction, blue sky).

PS3 (9-11)–10 Students demonstrate an understanding of waves by …

10b comparing and contrasting electromagnetic waves to mechanical waves.

10c qualifying the relationship between frequency and wavelength of any wave.

PS1 - All living and nonliving things are composed of matter having characteristic properties that distinguish one substance from another (independent of size or amount of substance)

PS1 (9-11) MAS+ FAF – 4

Model and explain the structure of an atom or explain how an atom's electron configuration, particularly the outermost electron(s), determines how that atom can interact with other atoms.

PS1 (9-11)– 4 Students demonstrate an understanding of the structure of matter by …

4aa writing an electron configuration to include *s, p, d*, and *f* orbitals and relating to atomic interactions.

Clarifying the Standards

Prior Learning

In grades K–4, the concept of mechanical waves was introduced, and students learned that mechanical waves can be produced many ways. They also learned that the sun is a source of energy.

In grades 5–6, students differentiated among properties of various waves and constructed models to explain energy transformations.

In grades 7–8, students learned to differentiate kinetic and potential energy and explain the transformation among the various energy forms. The Law of Conservation of Energy was also introduced.

Current Learning

Instructional level is developmental. This material is being introduced for the first time. Students in middle school have learned the Bohr Atomic model and should be aware that the different energy levels of atoms contain different number of electrons.

Students describe energy changes that occur in the atom. They learn that atoms have discreet energy levels; that a set amount of electrons can be found in each level; and that these electrons are located in atomic orbitals. They learn that the number of orbitals increases further from the nucleus and that as electrons move from one orbital to another, energy is either absorbed or released in energy packets called *quanta*.

Students will observe the emission spectra of selected elements. The students compare and contrast electromagnetic waves to mechanical waves and use mathematical relationships to show evidence of a relationship between the wavelength and frequency of any wave.

Students will learn the placement of electrons in the orbitals of the quantum model (*s*, *p*, *d*, *f*) and the rules that govern electron configuration.

Future Learning

Students will learn how energy changes occur when atoms from chemical bonds. Students will learn to determine which atoms will bond to each other and resulting energy changes.

Additional Research Findings

According to *Making Sense of Secondary Science,* the concept of energy transformations and conservation of energy is difficult for students. Research indicates that in order to promote learning about energy, more time should be devoted to qualitative questions and students should be advised to explain the physical phenomena in their own words (p. 147).

Benchmarks for Science Literacy states it may not be clear to students that some forms of energy such as light, sound, and chemical energy can be used to make things happen (p. 338).

According to the *Atlas of Science Literacy,* Volume 1, students need to understand that human eyes respond to a narrow range of wavelength and that accelerating electric charges produces electromagnetic waves.

Volume 2 of the *Atlas of Science Literacy* states that students rarely think energy is measurable and quantifiable. Students' alternative conceptualizations of energy influence their interpretations of textbook representations of energy (p. 24).

Notes About Resources and Materials

Chemistry, Quarter 2, Unit 2.3
Periodic Trends

Overview

Number of instructional days: 10 (1 day = 53 minutes)

Content to be learned

- Identify the basis for the arrangement of elements on the periodic table.
- Explain the basis for the arrangement of elements on the periodic table.
- Predict the relative physical and chemical properties of an element based on its location on the periodic table.

Processes to be used

- Compare and contrast the properties of metals, nonmetals, and metalloids.
- Observe the periodic trends of select groups of elements.
- Predict the identity/location of an element based on its periodic properties.

Essential questions

- What is the basis of the arrangement of atoms on the modern periodic table?
- How has the arrangement of elements on the periodic table changed over time?
- How do the properties of metals, nonmetals, and metalloids compare?
- How could you predict the physical and chemical properties of an element based on its location on the periodic table?

Written Curriculum

Grade Span Expectations

PS1 - All living and nonliving things are composed of matter having characteristic properties that distinguish one substance from another (independent of size or amount of substance).

PS1 (9-11) POC –3

Explain how properties of elements and the location of elements on the periodic table are related.

PS1 (9-11)-3 Students demonstrate an understanding of characteristic properties of matter by …

3a identifying and explaining the basis for the arrangement of the elements within the periodic table (e.g. trends, valence electrons, reactivity, electronegativity, ionization).

3b predicting the relative physical and chemical properties of an element based on its location within the Periodic Table.

Clarifying the Standards

Prior Learning

In grades K–2, students used simple tools to explore the properties of weight. In grades 3–4, they weighed objects and observed that the weight of an object remains the same despite a change in its shape.

In grades 5–6, students observed that the mass of the whole object is always the same as the sum of the masses of its parts. And, in grades 7–8, students cited evidence to conclude that the amount of matter before and after a physical or chemical change in a closed system remains the same.

Current Learning

This material is being introduced for the first time. Students identify and explain the basis for the arrangement of elements on the periodic table. The historical development of the periodic table is discussed within the context of the development of atomic theory. Students learn how an element's atomic number determines its position on the periodic table and they discuss its relationship to its electron configuration.

Students predict the relative physical and chemical properties of an element based on its location on the periodic table. The periodic trends of the atomic radius, ionization energy/electron affinity, and electronegativity are addressed. Teachers should do an investigation that demonstrates the periodic trends, such as properties of the alkaline earth metals.

Students create an annotated periodic table that identifies its basic organization. Students have previously learned that the periodic table is an organized list of the known elements. This unit provides the depth and added detail of the modern periodic table.

Future Learning

Students will learn to write an electron configuration to include *s*, *p*, *d*, and *f* orbitals. They will learn how to use the periodic table to predict oxidation states of the elements and therefore be able to form chemical compounds. They will also learn how to write balanced chemical equations and how to predict products of chemical reactions.

Students in biology will learn how electron configuration relates to carbon compounds such as carbohydrates, proteins, lipids, and nucleic acids.

Additional Research Findings

According to *Making Sense of Secondary Science*, students will have difficulty understanding polymorphic and polyatomic forms of elements due to varying conceptions of elements as the simplest type of substance (p. 76).

Additionally, the *Atlas of Science Literacy* states that students need to understand that all matter is composed of the approximately 100+ identified elements and that these elements are grouped by similar properties (p. 61).

Notes About Resources and Materials

Chemistry, Quarter 2, Unit 2.4

Chemical Bonds

Overview

Number of instructional days: 10 (1 day = 53 minutes)

Content to be learned

- Model and explain the structure of an atom.
- Explain how an atom's electron configuration—particularly with regard to the outermost electron(s)—determines how that atom can interact with other atoms.
- Model how atoms' electron configurations govern how they interact with one another.

Processes to be used

- Use and analyze models.
- Evaluate the strength and weakness of models.
- Compare and contrast.
- Make connections between form and function.

Essential questions

- How does the electron configuration determine an atom's interaction with other atoms?
- How does electron configuration determine the type of bond atoms will form?
- What types of information should be included in a model that shows how the electrons of atoms interact with each other?

Written Curriculum

Grade Span Expectations

PS1 - All living and nonliving things are composed of matter having characteristic properties that distinguish one substance from another (independent of size or amount of substance)

PS1 (9-11) MAS+ FAF – 4

Model and explain the structure of an atom or explain how an atom's electron configuration, particularly the outermost electron(s), determines how that atom can interact with other atoms.

PS1 (9-11)– 4 Students demonstrate an understanding of the structure of matter by …

4c explaining or modeling how the electron configuration of atoms governs how atoms interact with one another (e.g. covalent, hydrogen and ionic bonding).

Clarifying the Standards

Prior Learning

The concept of the atom was first introduced in grades 7 and 8. Students used diagrams and models to show the difference between atoms and molecules. In unit 1.2, students cited evidence for the development of the historical models of the atom, starting with Dalton's atomic theory and continuing through the experiments of J.J. Thompson and Ernest Rutherford. The various modifications of the atomic model through the late 19th and 20th centuries were diagrammed. Students compared the location of the three major subatomic particles of atoms (protons, electrons, and neutrons) and their location within an atom, their relative mass, and their charges.

Current Learning

For the first time, students learn that the electron arrangement in atoms determines the behavior of the element. Students will need to understand the function of the nucleus in chemical bonding; the concept of electronegativity also needs to be introduced. It is important that students understand that ionic and covalent compounds have different properties due to the nature of the chemical bonds formed between the ions or atoms. Metallic bonding and inter-molecular forces should also be discussed. How bonding impacts the unique physical properties of water should also be addressed. Students will use molecular model kits to examine the geometry of molecules. Also students can investigate the properties of covalent and ionic compounds through melting points, conductivity, and solubility testing.

Future Learning

Students in advanced classes will learn to predict geometry using valence shell electron pair repulsion theory (VSPER Theory). In chemistry 2, students will investigate intermolecular forces and applications in biological systems.

Additional Research Findings

According to the *Atlas of Science Literacy*, Volume 1, in order to understand how atoms form bonds with other atoms, students need to recognize that the elements on the periodic table are grouped by similar properties (p. 55).

Atlas of Science Literacy, Volume 2, states that students must be aware that structures at the nanoscale, and materials made up of these structures, have different properties at the macroscopic scale (p. 55).

According to the *Benchmarks for Science Literacy*, students lack an appreciation for the small size of particles and believe that there must be something in the space between them (p. 337). The book also states that students have problems understanding the forces between particles.

According to *Making Sense of Secondary Science*, students find it difficult to adequately conceptualize chemical combinations of elements until they can interpret this at the molecular level (p. 86).

Notes About Resources and Materials