Fairfield Public Schools
Science Curriculum

Chemistry

Course

Course: Description

Students in high school continue to develop their understanding of physical science, specifically chemistry. The high school performance expectations in Chemistry build on the middle school ideas and skills and allow high school students to explain more in-depth phenomena. There are three disciplinary core ideas in high school chemistry: 1) Structure and Property of Matter 2) Energy 3) Chemical Reactions. These performance expectations blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain ideas across the science disciplines. In the chemistry performance expectations at the high school level, there is a focus on several scientific practices. These include developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations; students will use these practices to demonstrate understanding of the core ideas. Students are also expected to demonstrate understanding of several engineering practices, including design and evaluation.

Standards for this course are taken from the *Next Generation Science Standards* and are of three types:

Disciplinary Core Ideas: Shown as content objectives, these standards define what students should know about the most essential ideas in the major science disciplines. The focus is on a limited number of core ideas in science and engineering both within and across the disciplines to avoid the shallow coverage of a large number of topics and to allow more time for teachers and students to explore each idea in greater depth. Reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented.

Science and Engineering Practices: These standards enable students to apply the content in the DCI's and the skills of practicing scientists and engineers to explain phenomena and solve real world problems. Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science.

Cross-cutting Concepts: These standards provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas. These broad concepts tie together the influence of engineering, technology, and science on society and the natural world.

http://www.nextgenscience.org/next-generation-science-standards

CROSS CUTTING CONCEPTS

Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Chemistry: Overview

Course Essential Questions
• How can one explain the structure, properties, and interactions of matter? • How is energy transferred and conserved?

Course: Year-at-a Glance

Unit	Title	Unit Essential Questions
1	Structure and Properties of Matter	• HS-PS 1-3: How can investigations be planned and conducted to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles? • HS-PS 1-6: Why is the molecular-level structure important in the functioning of designed materials from a scientific and technical standpoint? • HS-PS 1-8: How can models be used 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?
2	Periodicity and Bonding	• HS-PS 1-1: How can the periodic table be used as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms? • HS-PS 1-3: How can investigations be planned and conducted to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles? • HS-PS 1-6: Why is the molecular-level structure important in the functioning of designed materials from a scientific and technical standpoint?
3	Energy	• HS-PS 3-4: How does evidence needed to show that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system?
4	Chemical Reactions:	• HS-PS 1-2: How can the outcome of simple chemical reactions be explained based on the outermost electron states of atoms, trends in

	Conceptual	the periodic table, and knowledge of the patterns of chemical properties? ● HS-PS 1-5: How can scientific principles be applied to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs? ● HS-PS 1-6: How can a chemical system be refined by specifying a change in conditions that would produce increased amount of products at equilibrium?
5	Chemical Reactions: Quantitative	● HS-PS 1-7: How can mathematical representations be used to support the claim that atoms, and therefore mass, are conserved during a chemical reaction? ● HS-PS 1-4: How can models be used to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy?

1. Structure and Properties of Matter

Overview

In structure and properties of matter, students are expected to develop understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to their properties.
- Understand why the molecular-level structure is important in the functioning of designed materials from a scientific and technical standpoint.
- 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.

Unit Essential Questions

- How can one explain the structure, properties, and interactions of matter?

Crosscutting Concepts

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

PS1.A: 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. (HS-PS1-1)
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),(secondary to HS-PS2-6)

- 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. (HS-PS1-4)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Corresponding CT Core Standards:

ELA/Literacy -

RST.9-10.7, RST.11-12.1, WHST.9-12.2, WHST.9-12.7, WHST.11-12.8, WHST.9-12.9 , MP.4, HSN-Q.A.1, HSN-Q.A.2 , HS-PS1-8,HS-PS2-6, HSN-Q.A.3

2. Periodicity and Bonding

Overview

Students are able to use the periodic table as a tool to explain and predict the properties of elements. Phenomena involving nuclei are also important to understand, as they explain the formation and abundance of the elements, radioactivity, the release of energy.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atom.
- Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
- Understand why the molecular-level structure is important in the functioning of designed materials from a scientific and technical standpoint.

Unit Essential Questions

- How can one explain the structure, properties, and interactions of matter?

Crosscutting Concepts

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

PS1.A: 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. (HS-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. (HS-PS1-1),(HS-PS1-2)

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),(secondary to HS-PS2-6)
- 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. (HS-PS1-4)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Corresponding CT Core Standards:

ELA/Literacy -

RST.9-10.7, RST.11-12.1, WHST.9-12.2, WHST.9-12.7, WHST.11-12.8, WHST.9-12.9 , MP.4, HSN-Q.A.1, HSN-Q.A.2 , HS-PS1-8,HS-PS2-6, HSN-Q.A.3

3. Energy

Overview

In Energy of Chemical Systems, students will understand energy as a quantitative property of a system—a property that depends on the motion and interactions of matter within that system. They will also understand that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- HS-PS 3-4: Evaluate the evidence needed to show that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system.

Unit Essential Questions

- How is energy transferred and conserved?

Crosscutting Concepts

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

- PS3.A: 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

- PS3.B: Conservation of Energy and Energy Transfer 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. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)

- PS3.D: Energy in Chemical Processes Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)

Corresponding CT Core Standards:

ELA/Literacy -

RST.11-12.1, WHST.9-12.7, WHST.11-12.8, WHST.9-12.9, SL.11-12.5, MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2

4. Chemical Reactions: Conceptual

Overview

Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students are also able to apply an understanding of the process of optimization in engineering design to chemical reaction systems.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- HS-PS 1-2: Determine the outcome of simple chemical reactions based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
- HS-PS 1-5: Determine how scientific principles can be applied to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
- HS-PS 1-6: Understand how can a chemical system can be refined by specifying a change in conditions that would produce increased amount of products at equilibrium.

Unit Essential Questions

- How do substances combine or change (react) to make new substances?
- How does one characterize and explain these reactions and make predictions about them?

Crosscutting Concepts

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

PS1.B: Chemical Reactions

- 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. (HS-PS1-4),(HS-PS1-5)

- 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. (HS-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. (HS-PS1-2),(HS-PS1-7)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)
- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)

Corresponding CT Core Standards:

ELA/Literacy -

RST.11-12.1, WHST.9-12.2, WHST.9-12.5, WHST.9-12.7, SL.11-12.5, MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3

5. Chemical Reactions: Quantitative

Overview

Chemical reactions and mathematical energy changes can be understood by students at this level by exploring the quantitative relationships between chemicals and relative bond strengths. Students are also able to design processes to optimize yield in chemical reaction systems.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- HS-PS 1-7: Utilize mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
- HS-PS 1-4: Use models to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Unit Essential Questions

- How does one investigate the mathematical relationships between chemicals?

Crosscutting Concepts

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

PS1.B: Chemical Reactions

- 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. (HS-PS1-4),(HS-PS1-5)
- 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. (HS-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. (HS-PS1-2),(HS-PS1-7)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)
- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)

Corresponding CT Core Standards:

ELA/Literacy -

RST.11-12.1, WHST.9-12.2, WHST.9-12.5, WHST.9-12.7, SL.11-12.5, MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3