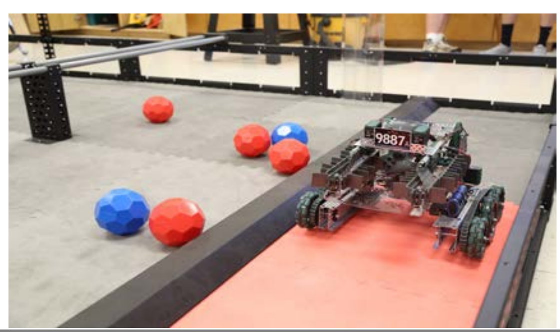
SUPPORT DOCUMENTS FOR THE HIGH SCHOOL CHEMISTRY SOUTH CAROLINA ACADEMIC STANDARDS AND PERFORMANCE INDICATORS FOR SCIENCE

Mick Zais, Ph.D.
State Superintendent of Education

South Carolina Department of Education
Columbia, South Carolina



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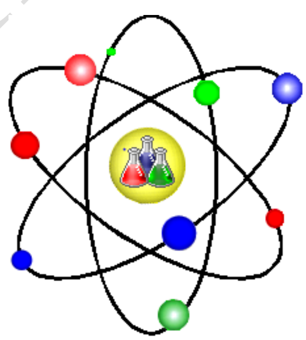
High School Chemistry Academic Standards and Performance Indicators for Science



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SOUTH CAROLINA DEPARTMENT OF EDUCATION

The explication of the standards and performance indicators included in this document were developed under the direction of Dr. Cindy Van Buren, Deputy Superintendent, Division of School Effectiveness, Dr. Briana Timmerman, Director, Office of Instructional Practices and Evaluations, and Cathy Jones Stork, Team Leader, Office of Instructional Practices and Evaluations.

The following South Carolina Department of Education (SCDE) staff members facilitated development and revision of this document:

Dr. Regina E. Wragg
Education Associate
Office of Instructional Practices and Evaluations

Dr. Deanna Boyd
Education Associate
Office of Instructional Practices and Evaluations

HIGH SCHOOL CHEMISTRY CURRICULUM DOCUMENT DEVELOPMENT TEAM

The following SC Educators collaborated with the SCDE to develop and draft the *Curriculum Support Guide for the South Carolina Academic Standards and Performance Indicators for Science,* and their efforts and input are appreciated.

Dominique Ragland, Coordinator (Dorchester 2)
Janet Latha (Richland 1)
Hunter O. Jolley (Spartanburg 2)
Elaine Smith (Marion)

CURRICULUM DOCUMENT REVISION TEAM

The following SC Educators collaborated with the SCDE to review, revise and compile the *Curriculum Support Guides for the South Carolina Academic Standards and Performance Indicators for Science*, and their time, service and expertise are appreciated.

Ed Emmer (Richland 2)
Tonya Smith (Richland 1)
Michael Carothers (Lexington/Richland 5)
Jennifer McLeod (Richland 2)
Kelli Bellant (Clarendon 2)
Chris White (Oconee)
Elaine Smith (Marion)
Dana S. Hutto (Lexington 2)
Susan Rhodes (Florence 1)
Kourtney Shumate (Darlington)
Debbie Bishop (Laurens 55)
Dominique Ragland (Dorchester 2)
Doreen Gallant Green (Williamsburg)
Michelle Spigner (Richland 2)

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Dr. Kirsten Hural, Education Associate
Amelia Brailsford, Education Associate

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Don Doggett, Program Associate
Dr. Sandra Enger, Program Consultant

INTRODUCTION

Local districts, schools and teachers may use this document to construct standards-based science curriculum, allowing them to add or expand topics they feel are important and to organize content to fit their students' needs and match available instructional materials. The support document includes essential knowledge, extended knowledge, connections to previous and future knowledge, and assessment recommendations. Educators may use a feedback form until October 31, 2014 to constructively critique this document and suggest resources and instructional strategies for each performance indicator (see pg. 9).

ACADEMIC STANDARDS

In accordance with the South Carolina Education Accountability Act of 1998 (S.C. Code Ann. § 59-18-110), the purpose of academic standards is to provide the basis for the development of local curricula and statewide assessment. Consensually developed academic standards describe for each grade and high school core area the specific areas of student learning that are considered the most important for proficiency in the discipline at the particular level.

Operating procedures for the review and revision of all South Carolina academic standards were jointly developed by staff at the State Department of Education (SCDE) and the Education Oversight Committee (EOC). According to these procedures, a field review of the first draft of the revised South Carolina science standards was conducted from March through May 2013. Feedback from that review and input from the SCDE and EOC review panels was considered and used to develop these standards.

The academic standards in this document are not sequenced for instruction and do not prescribe classroom activities; materials; or instructional strategies, approaches, or practices. The *South Carolina Academic Standards and Performance Indicators for Science* is not a curriculum.

STATEWIDE ASSESSMENT

The academic standards and performance indicators for Chemistry should be the basis for the development of classroom and course-level assessments. Test questions will measure the practice and/or the core content of the performance indicator. In addition, most performance indicators may be assessed with items that utilize any of the science and engineering practices. For example, an assessment item for a performance indicator that requires students to *construct explanations* may also ask students to use other practices such as *asking questions*, *using models*, or *analyzing data* around the core content in the original indicator. Items may also assess students' understanding of the core content without a science and engineering practice.

The academic standards and performance indicators for Chemistry should be the basis for the development of classroom and course-level assessments.

HIGH SCHOOL CHEMISTRY OVERVIEW

The academic standards and performance indicators establish the practices and core content for all Chemistry 1 courses in South Carolina high schools. The core ideas within the standards are not meant to represent an equal division of material and concepts. Therefore the number of indicators per core idea should not be expected to be equal, nor should equal numbers of performance indicators within each standard be expected.

The six core areas of the Chemistry 1 standards include:

- Atomic Structure and Nuclear Processes
- Bonding and Chemical Formulas
- States of Matter
- Solutions, Acids, and Bases
- Chemical Reactions
- Thermochemistry and Chemical Kinetics

The eight science and engineering practices describe how students should learn and demonstrate knowledge of the content outlined in the content standards. Engaging in these practices will help students become scientifically literate and astute consumers of scientific information. The seven core concepts (patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change) are reinforced in the appropriate context of the core science content through hands-on instruction in the classroom.

Students should engage in scientific and engineering practices as a means to learn about the specific topics identified for the course. It is critical that educators understand the Science and Engineering Practices are *not* to be taught in isolation. There should *not* be a distinct "Inquiry" unit at the beginning of each school year. Rather, the practices need to be employed *within the content* for each grade level.

DECIPHERING THE STANDARDS

KINDERGARTEN
LIFE SCIENCE: EXPLORING ORGANISMS AND THE ENVIRONMENT

Standard K.L.2: The student will demonstrate an understanding of organisms found in the environment and how these organisms depend on the environment to meet those needs.

K.L.2A. Conceptual Understanding: The environment consists of many types of organisms including plants, animals, and fungi. Organisms depend on the land, water, and air to live and grow. Plants need water and light to make their own food. Fungi and animals cannot make their own food and get energy from other sources. Animals (including humans) use different body parts to obtain food and other resources needed to grow and survive. Organisms live in areas where their needs for air, water, nutrients, and shelter are met.

Performance Indicators: Students who demonstrate this understanding can:

K.L.2A.1 Obtain information to answer questions about different organisms found in the environment (such as plants, animals, or fungi).

K.L.2A.2 Conduct structured investigations to determine what plants need to live and grow (including water and light).

Figure 1: Example from the Kindergarten Curriculum Standards

The code assigned to each performance indicator within the standards is designed to provide information about the content of the indicator. For example, the **K.L.2A.1** indicator decodes as the following--

- **K: The first part of each indicator denotes the grade or subject.** The example indicator is from Kindergarten. The key for grade levels are as follows—

K: Kindergarten	7: Seventh Grade
1: First Grade	8: Eighth Grade
2: Second Grade	H.B: High School Biology 1
3: Third Grade	H.C: High School Chemistry 1
4: Fourth Grade	H.P: High School Physics 1
5: Fifth Grade	H.E: High School Earth Science
6: Sixth Grade	

- **L: After the grade or subject, the content area is denoted by an uppercase letter.** The L in the example indicator means that the content covers Life Science. The key for content areas are as follows—

  E: Earth Science
  EC: Ecology
  L: Life Science
  P: Physical Science
  S: Science and Engineering Practices

- **2: The number following the content area denotes the specific academic standard.** In the example, the 2 in the indicator means that it is within the second academic standard with the Kindergarten science content.

- **A: After the specific content standard, the conceptual understanding is denoted by an uppercase letter.** The conceptual understanding is a statement of the core idea for which students should demonstrate understanding. There may be more than one conceptual understanding per academic standard. The A in the example means that this is the first conceptual understanding for the standard.

- **1: The last part of the code denotes the number of the specific performance indicator.** Performance indicators are statements of what students can do to demonstrate knowledge of the conceptual understanding. The example discussed is the first performance indicator within the conceptual understanding.

FORMAT OF THE CURRICULUM SUPPORT DOCUMENT

The format of this document is designed to be structurally uniformed for each of the academic standards and performance indicators. For each, you will find the following sections--

- **Standard**
  - This section provides the standard being explicated.
- **Conceptual Understanding**
  - This section provides the overall understanding that the student should possess as related to the standard.
- **Performance Indicator**
  - This section provides a specific set of content with an associated science and engineering practice for which the student must demonstrate mastery.
- **Assessment Guidance**
  - This section provides guidelines for educators and assessors to check for student mastery of content utilizing interrelated science and engineering practices.
- **Previous and Future Knowledge**
  - This section provides a list of academic content along with the associated academic standard that students will have received in prior or will experience in future grade levels. Please note that the kindergarten curriculum support document does not

contain previous knowledge. Additionally, although the high school support document may not contain future knowledge, this section may list overlapping concepts from other high school science content areas.

- **Essential Knowledge**
  - This section illustrates the knowledge of the content contained in the performance indicator for which it is fundamental for students to demonstrate mastery. Mastery of the information in the Essential Knowledge section is measured by state-wide assessments in grades four-eight and high school biology 1.
- **Extended Knowledge**
  - This section provides educators with topics that will enrich students' knowledge related to topics learned with the explicated performance indicator.
- **Science and Engineering Practices**
  - This section lists the specific science and engineering practice that is paired with the content in the performance indicator. Educators should reference the chapter on this specific science and engineering practice in the *Science and Engineering Practices Support Guide.*

EVALUATING THE SUPPORT DOCUMENTS

As part of the development process, the SCDE would like to give the education community an opportunity to provide constructive feedback on the support documents including the grade/subject curriculum guides, 2005 to 2014 indicator crosswalks, and Science and Engineering Practices Guide. You may provide your comments or suggest curriculum resources by accessing the *Academic Standards and Performance Indicators for Science 2014 Support Document Feedback Form* which is available online—

https://adobeformscentral.com/?f=-fVAZrJqa9jZezpijXmmRg

You will be able to share only one comment per submission, but you may refresh the form to submit additional comments. The feedback form will close at noon on Oct. 31, 2014. If you have questions regarding this process, please contact Dr. Regina E. Wragg at 803-734-0564 or rwragg@ed.sc.gov.

HIGH SCHOOL CHEMISTRY SCIENCE SUPPORT DOCUMENT

Standard
H.C.2: The student will demonstrate an understanding of atomic structure and nuclear processes.

Conceptual Understanding
H.C.2A: The existence of atoms can be used to explain the structure and behavior of matter. Each atom consists of a charged nucleus, consisting of protons and neutrons, surrounded by electrons. The interactions of these electrons between and within atoms are the primary factors that determine the chemical properties of matter. In a neutral atom the number of protons is the same as the number of electrons.

Performance Indicator
H.C.2A.1 Obtain and communicate information to describe and compare subatomic particles with regard to mass, location, charge, electrical attractions and repulsions, and impact on the properties of an atom.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to describe and compare subatomic particles with regard to mass, location, charge, electrical attractions and repulsions, and impact on the properties of an atom. Therefore, the primary focus of assessment should be for students to obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models of atom, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gap in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations regarding what factors impact the properties of atom. This could include but is not limited to students using computer simulations and virtual labs that describes the impact of subatomic particles on properties like Electron configuration, Ionization energy, Electron Affinity, Relative size of atoms .Students communicate the cause and effect relationships that affect properties using presentations, discussions, digital publications, and digital media.

In addition to *obtain information and communicate information*, students should be asked to ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; and construct devices or define solutions.

Previous Knowledge
7.P.2A.2 (Organization of the Periodic Table)

Essential Knowledge

- Atoms are comprised of three subatomic particles. The mass of proton and neutron are similar, yet much larger than that of the electron. The protons and neutrons comprise the nucleus. The electrons are located within an electron cloud outside of the nucleus. Refer to chart for charges.

- Atoms have a positively charged nucleus (made from protons and neutrons) surrounded by negative electrons. The atom is mostly empty space.
- Atomic number gives identity to atom, mass is determined mostly by number of protons and neutrons, and chemical properties are determined by valence electrons.

Subatomic particle	Symbol	Mass (g)	Atomic mass (amu)	Atomic Charge	Location
Proton	P^+	1.673×10^{-24}	1.0073	+1	Nucleus
Neutron	n^0	1.675×10^{-24}	1.0078	0	Nucleus
Electron	e^-	9.109×10^{-28}	0.005485	-1	Electron cloud

- Understand the following atomic characteristics and properties (in terms of atomic structure) and understand what variables influence the magnitude of the characteristics or properties for a given element.
    - Electron configuration
    - Ionization energy
    - Electron Affinity
    - Relative size of atoms
    - Ionic size

Science and Engineering Practices
S.1.A.8

Standard H.C.2 The student will demonstrate an understanding of atomic structure and nuclear processes.
Conceptual Understanding H.C.2A The existence of atoms can be used to explain the structure and behavior of matter. Each atom consists of a charged nucleus, consisting of protons and neutrons, surrounded by electrons. The interactions of these electrons between and within atoms are the primary factors that determine the chemical properties of matter. In a neutral atom the number of protons is the same as the number of electrons.
Performance Indicator H.C.2A.2 Use the Bohr and quantum mechanical models of atomic structure to exemplify how electrons are distributed in atoms.
Assessment Guidance The objective of this indicator is to *obtain and communicate information* to describe and compare subatomic particles with regard to mass, location, charge, electrical attractions and repulsions, and impact on the properties of an atom. Therefore, the primary focus of assessment should be for students to obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models of atom, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gap in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations regarding what factors impact the properties of atom. This could include but is not limited to students using computer simulations and virtual labs that describes the impact of subatomic particles on properties like Electron configuration, Ionization energy, Electron Affinity, Relative size of atoms .Students communicate the cause and effect relationships that affect properties using presentations, discussions, digital publications, and digital media. In addition to *obtain information and communicate information*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models*; and *construct devices or define solutions*
Previous Knowledge 7.P.2A.1 (Atomic Models)
Essential Knowledge • The Bohr model of the atom can be utilized to explain the arrangement of electrons within the hydrogen atom. The Bohr model was not sufficient in regard to explaining all electron arrangements. • The quantum mechanical model can be utilized to describe the arrangement and location of electrons. Electron configuration can be utilized to identify the approximate location of electrons. • Know orbital types, orbital designation, number of orbitals within an energy level, two electrons can occupy an orbital. • Utilize standard notation, orbital notation, and electron-dot structures using Hund's rule,

Aufbau's principle and Pauli's exclusion principle.
Extended Knowledge Students can draw Lewis dot notation for representative elements and construct electron configuration notation and orbital notation for representative elements. The noble gas convention and quantum numbers instruction could also prepare students for more advanced coursework.
Science and Engineering Practices S.1.A.2

Standard

H.C.2 The student will demonstrate an understanding of atomic structure and nuclear processes.

Conceptual Understanding

H.C.2A: The existence of atoms can be used to explain the structure and behavior of matter. Each atom consists of a charged nucleus, consisting of protons and neutrons, surrounded by electrons. The interactions of these electrons between and within atoms are the primary factors that determine the chemical properties of matter. In a neutral atom the number of protons is the same as the number of electrons.

Performance Indicator

H.C.2A.3 Analyze and interpret absorption and emission spectra to support explanations that electrons have discrete energy levels.

Assessment Guidance

The objective of this indicator is to *analyze and interpret* absorption and emission spectra to support explanations that electrons have discrete energy levels. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* regarding how absorption and emission of energy can cause movement of electrons between energy levels. This could include but is not limited to students organizing data collected from an analytic procedure (flame test) to detect the presence of certain elements, primarily metal ions, based on each element's characteristic emission spectrum.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous Knowledge

8.P.3A.2 (Basic Properties of Waves)

Essential Knowledge

- When electrons absorb energy, they move to higher energy levels, energy is released when they move to lower energy levels.
- Electrons move between energy levels.
- A photon of light will be emitted when electrons release gained energy.
-
- Transitions between the same energy levels always produce the same frequency emission. The frequency is the cause of visible color.
- An element's emission spectra can be utilized to identify the element.

Extended Knowledge

Plank's constant ($E=hv$), ($E=mc^2$), and utilization of ($c=lv$) to determine wavelength and frequency.

Science and Engineering Practices

S.1.A.4

Standard H.C.2 The student will demonstrate an understanding of atomic structure and nuclear processes.
Conceptual Understanding H.C.2B: In nuclear fusion, lighter nuclei combine to form more stable heavier nuclei and in nuclear fission heavier nuclei are split to form lighter nuclei. The energies in fission and fusion reactions exceed the energies in usual chemical reactions
Performance Indicator H.C.2B.1 Obtain and communicate information to compare alpha, beta, and gamma radiation in terms of mass, charge, penetrating power, and their practical applications (including medical benefits and associated risks).
Assessment Guidance The objective of this indicator is to *obtain and communicate information* to compare alpha, beta, and gamma radiation in terms of mass, charge, penetrating power, and their practical applications (including medical benefits and associated risks).Therefore, the primary focus of assessment should be for students to obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gap in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations regarding the factors like mass, charge, penetrating power that affect the practical applications. This could include but is not limited to students using computer simulations and virtual labs that describe the medical benefits and associated risks of radiations. Students communicate the cause and effect relationships that affect practical applications using presentations, discussions, digital publications, and digital media. In addition to *obtain information and communicate information*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models*; and *construct devices or define solutions*
Previous and Future Knowledge 7.P.2A.1(Atomic Models) H.P.3G (Atomic Structure; Fission and Fusion; Radioactive Decay; Applications of Radioactive Decay) H.E.4A (Dating methods to estimate geologic time; Isotopic ratios)

Essential Knowledge

Type of radiation emitted & symbol	Nature of the radiation	Nuclear Symbol	Penetrating power, and what will block it	Effect of release of particles from the nucleus
α Alpha	a helium nucleus of 2 protons and 2 neutrons, mass = 4, charge = +2	$^{4}_{2}He$	Low penetration stopped by a few cm of air or thin sheet of paper	Reduces the atomic mass number by 4 Reduces the atomic number by 2
β Beta	high kinetic energy electrons, mass = 1/1850 of alpha, charge = -1	$^{0}_{-1}e$	Moderate penetration, most stopped by a few mm of metals like aluminum	Is the result of neutron decay and will increase the atomic number by 1 but will not change the mass number
γ Gamma	very high frequency electromagnetic radiation, mass = 0, charge = 0	$^{0}_{0}\gamma$	Very highly penetrating, most stopped by a thick layer of steel or concrete, but even a few cm of dense lead doesn't stop all of it!	Is electromagnetic radiation released from an excited nucleus. The atomic number and mass number do not change.

Chart Source: 2005 Science Standards Support Document

- Practical applications should include
  - Medical benefits and associated risks of procedures like x-ray, radiotherapy, radiation therapy, CAT scan, etc.
  - Real-world application of items like smoke detectors (Americium)

Science and Engineering Practices
S.1.A.8

Standard
H.C.2 The student will demonstrate an understanding of atomic structure and nuclear processes.

Conceptual Understanding
H.C.2B: In nuclear fusion, lighter nuclei combine to form more stable heavier nuclei and in nuclear fission heavier nuclei are split to form lighter nuclei. The energies in fission and fusion reactions exceed the energies in usual chemical reactions

Performance Indicator
H.C.2B.2 Develop models to exemplify radioactive decay and use the models to explain the concept of half-life and its use in determining the age of materials (such as radiocarbon dating or the use of radioisotopes to date rocks).

Assessment Guidance
The objective of this indicator is for students to *develop models* to exemplify radioactive decay and use the models to explain the concept of half-life and its use in determining the age of materials (such as radiocarbon dating or the use of radioisotopes to date rocks).Therefore, the primary focus of assessment should be for students to develop and use models to(1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others to understand and explain the concept of half-life and use it to determine age. This could include but not limited to students designing and manipulating simulations using computer software to illustrate radioactive decay and communicate the relationship between half-life and the age of materials. Students may also use mathematical formulae to illustrate and evaluate half-life.

In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information*; and *construct devices or define solutions*.

Previous and Future Knowledge
7.P.2A.1(Atomic Models)
H.P.3G (Radioactive Decay; Applications of Radioactive Decay)
H.E.4A (Dating methods to estimate geologic time; Isotopic ratios)

Essential Knowledge
- Develop illustrative models (such as drawings on poster board) as well as physical models (such as pennies in a container) to explain radiochemical decay.
    - Students' explanation should include applications of radiocarbon dating to determine the age of artifacts that were once part of living organisms (radiocarbon dating, Carbon-14) as well as the use of radioisotopes to date older materials, such as rocks (Uranium dating).
- Students will not memorize equations; however, utilize equations to explain the process.

Extended Knowledge
Students can also calculate the half-life of an isotope as well as the mass of an isotope remaining after a given number of half-lives.

Science and Engineering Practices
S.1A.2

Standard
H.C.2 The student will demonstrate an understanding of atomic structure and nuclear processes.

Conceptual Understanding
H.C.2B: In nuclear fusion, lighter nuclei combine to form more stable heavier nuclei and in nuclear fission heavier nuclei are split to form lighter nuclei. The energies in fission and fusion reactions exceed the energies in usual chemical reactions

Performance Indicator
H.C.2B.3 Obtain and communicate information to compare and contrast nuclear fission and nuclear fusion and to explain why the ability to produce low energy nuclear reactions would be a scientific breakthrough.

Assessment Guidance
The objective of this indicator is to *obtain and communicate information* to compare and contrast nuclear fission and nuclear fusion and to explain why the ability to produce low energy nuclear reactions would be a scientific breakthrough. Therefore, the primary focus of assessment should be for students to obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gap in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student research regarding nuclear fission and fusion This could include but is not limited to students using computer simulations and virtual labs that compare nuclear fission and fusion. Students communicate the cause and effect relationships to explain why the ability to produce low energy nuclear reactions would be a scientific breakthrough using presentations, discussions, digital publications, and digital media.

In addition to *obtain information and communicate information*, students should be asked to ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; and construct devices or define solutions.

Future Knowledge
H.P.3G- (Radioactive Decay; Applications of Radioactive Decay)

Essential Understanding
- Describe the particles that are involved in each type of reaction and the changes that they undergo, as well as differentiate between fission in nuclear power plants and solar fusion.
- Disseminate information comparing low energy nuclear reactions with current energy products.

Extended Knowledge
Students could investigate and debate the environmental and societal impacts of nuclear energy.

Science and Engineering Practices
S.1.A.8

Standard H.C.2 The student will demonstrate an understanding of atomic structure and nuclear processes.
Conceptual Understanding H.C.2B: In nuclear fusion, lighter nuclei combine to form more stable heavier nuclei and in nuclear fission heavier nuclei are split to form lighter nuclei. The energies in fission and fusion reactions exceed the energies in usual chemical reactions
Performance Indicator H.C.2B.4 Use mathematical and computational thinking to explain the relationship between mass and energy in nuclear reactions (E=mc2).
Assessment Guidance The objective of this indicator is to *use mathematical and computational thinking* to explain the relationship between mass and energy in nuclear reactions (E=mc2*)*. Therefore the focus of assessment should be for students to *construct, use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data* to (1) identify the mass converted into energy, and (2) describe correlation between mass and energy of a nuclear reaction. This could include but is not limited to student's analyzing mass and energies data from nuclear reactions in reactors around them, comparing them with chemical reaction and writing a mathematical formula to describe the trend in the model. In addition to *use mathematical and computational thinking* students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate and communicate information;* and *construct devices or design solution*
Future Knowledge H.P.3G- (Radioactive Decay; Applications of Radioactive Decay)
Essential Knowledge The emphasis for this performance indicator should be on a conceptual understanding of mass defect rather than on computations. • Given examples students should be able to identify that mass can be converted into a surplus of energy through the utilization of a nuclear reaction. • Students should realize that nuclear energy releases vastly more energy.
Science and Engineering Practices S.1.A.5

Standard
H.C.3: The student will demonstrate an understanding of the structures and classification of chemical compounds.
Conceptual Understanding H.C.3A: Elements are made up of only one kind of atom. With increasing atomic number, a predictable pattern for the addition of electrons exists. This pattern is the basis for the arrangement of elements in the periodic table. The chemical properties of an element are determined by an element's electron configuration. Elements can react to form chemical compounds/molecules that have unique properties determined by the kinds of atoms combined to make up the compound/molecule. Essentially, the ways in which electrons are involved in bonds determines whether ionic or covalent bonds are formed. Compounds have characteristic shapes that are determined by the type and number of bonds formed.
Performance Indicator H.C.3A.1 Construct explanations for the formation of molecular compounds via sharing of electrons and for the formation of ionic compounds via transfer of electrons.
Assessment Guidance The objective of this indicator is to *construct explanations* for the formation of molecular compounds via sharing of electrons and for the formation of ionic compounds via transfer of electrons.; therefore the focus of assessment should be for students to *construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams* to describe the process of ionic and covalent bonding. This could include but is not limited to students using the periodic table to compare the types of elements used in chemical bonding through the use of models and being asked to explain why ionic and covalent bonds are formed differently. In addition to *construct explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*
Previous Knowledge 7.P.2A.4 (Ionic and Covalent Bonding, Chemical Formulas)
Essential Knowledge • Bonding occurs in order to achieve chemical stability in low energy state. • Atoms form bonds through the sharing or transfer of electrons to achieve noble gas configuration in their valence shells. • Valence electrons are shared between nonmetals to form molecular/covalent bonds. • Covalent bonds are common between two elements, each having one or more orbitals in the outer energy level containing only one electron. • Ionic bonds are formed from the transfer of electrons. Metals lose electrons to form cations (positive ions). Nonmetals gain electrons for form anions (negative ions).
Science and Engineering Practices S.1.A.6

Standard
H.C.3: The student will demonstrate an understanding of the structures and classification of chemical compounds.

Conceptual Understanding
H.C.3A: Elements are made up of only one kind of atom. With increasing atomic number, a predictable pattern for the addition of electrons exists. This pattern is the basis for the arrangement of elements in the periodic table. The chemical properties of an element are determined by an element's electron configuration. Elements can react to form chemical compounds/molecules that have unique properties determined by the kinds of atoms combined to make up the compound/molecule. Essentially, the ways in which electrons are involved in bonds determines whether ionic or covalent bonds are formed. Compounds have characteristic shapes that are determined by the type and number of bonds formed.

Performance Indicator
H.C.3A.2 Use the periodic table to write and interpret the formulas and names of chemical compounds (including binary ionic compounds, binary covalent compounds, and straight-chain alkanes up to six carbons).

Assessment Guidance
The objective of this indicator is to use the periodic table to write and *interpret* the formulas and names of chemical compounds (including binary ionic compounds, binary covalent compounds, and straight-chain alkanes up to six carbons).Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* to write chemical formulas and names correctly. This could include but is not limited to students organizing data from the periodic table to correctly identify the type of compound by bond type and creating a set of rules for naming and writing formulas based on the pattern in names and formulas.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous Knowledge
7.P.2A.4 (Ionic and Covalent Bonding, Chemical Formulas)

Essential Knowledge
- Identify substances as molecular or ionic compounds by type of elements in the compound.
    - Ionic compounds contain metals and nonmetals, molecular compounds contain nonmetals.
- Name and write formulas for binary ionic compounds with representative (main group) elements or transition elements given charge.
- Write formulas and name compounds with polyatomic ions. Emphasis should be placed on correct naming procedures, not memorization of polyatomic ion names.

- Polyatomic ions should be limited to those commonly used in high school chemistry laboratories, including but not limited to hydroxide, carbonate, hydrogen carbonate, nitrate, sulfate, and phosphate.

- Name and identify binary acid and simple carboxylic acids containing one to three carbons.
- Naming oxyacids using a flow chart or acid naming rules.
- Identify by name, formula, or structure straight-chain alkanes of up to six carbons.

Extended Knowledge

Students could name and write formulas for binary and ternary acids as well as ionic compounds containing polyatomic ions. More advanced course preparation could include the use of roman numeral stock system for both naming compounds and formula writing and name straight chain alkenes and alkynes.

Science and Engineering Practices

S.1.A.4

Standard H.C.3: The student will demonstrate an understanding of the structures and classification of chemical compounds.
Conceptual Understanding H.C.3A: Elements are made up of only one kind of atom. With increasing atomic number, a predictable pattern for the addition of electrons exists. This pattern is the basis for the arrangement of elements in the periodic table. The chemical properties of an element are determined by an element's electron configuration. Elements can react to form chemical compounds/molecules that have unique properties determined by the kinds of atoms combined to make up the compound/molecule. Essentially, the ways in which electrons are involved in bonds determines whether ionic or covalent bonds are formed. Compounds have characteristic shapes that are determined by the type and number of bonds formed.
Performance Indicator H.C.3A.3 Analyze and interpret data to predict the type of bonding (ionic or covalent) and the shape of simple compounds by using the Lewis dot structures and oxidation numbers.
Assessment Guidance The objective of this indicator is to *analyze and interpret data* to predict the type of bonding (ionic or covalent) and the shape of simple compounds by using the Lewis dot structures and oxidation numbers. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* to identify a compound's type of bonding and molecular shape. This could include but is not limited to students using periodic tables, ball and stick models, and computer simulations to construct explanations of shapes associated with VSEPR theory. In addition to *analyze and interpret data*, students should be asked to ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information; and construct devices or define solutions
Previous Knowledge 7.P.2A.4 (Ionic and Covalent Bonding, Chemical Formulas)
Essential Knowledge <u>Molecular compounds:</u> • The structure of molecules is the result of nonmetals sharing electrons in order to form stable outer-energy-level configuration (covalent bonds). • How single, double, and triple bonds are formed.   o The "s" and "p" orbitals in the outer energy level of each atom provide four possible bonding sites (except for the elements which achieve He structure) • Draw Lewis dot structure molecules containing single, double, or triple bonds and polyatomic ions. • The 3-dimensional nature of molecules (tetrahedral bonding site structure) • Hands-on models should be used to draw correct Lewis structures, including the presence of nonbonding electron pairs and multiple bonds.

- Molecular geometries are limited to linear, bent (angular), trigonal planar, trigonal pyramidal, and tetrahedral.
- Explain the shape of simple molecules such as methane, water and carbon dioxide using VESPR

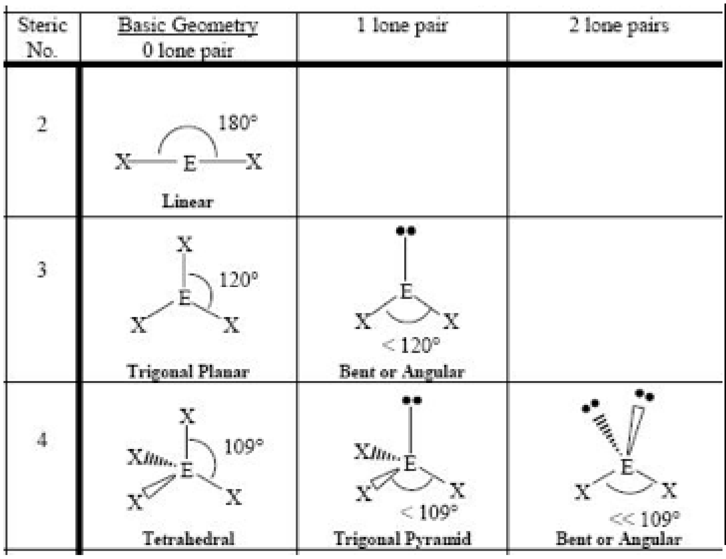
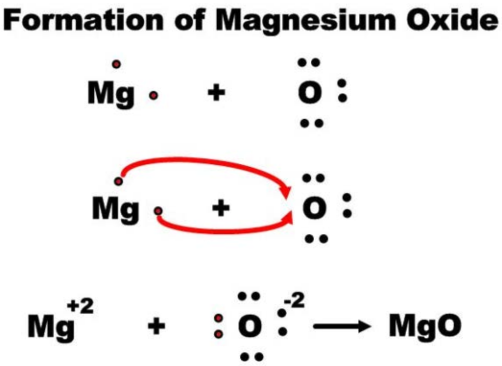


Image Source: Created by Dr. Regina Frey, Washington University in St. Louis (commons.wikimedia.org/wiki/File:VSEPR_geometries.PNG**)

<u>Ionic compounds:</u>

- Crystalline structure is the result of the ionic bonding of positive and negative ions, forming a neutral compound.
- The sum of the oxidation numbers in the formula of any neutral compound is zero
- The oxidation number of a monatomic ion is equal to its charge
- The oxidation number of the monoatomic ions formed from elements in the following groups of the periodic table:
    - Group 1, +1
    - Group 2, +2
    - Group 16, -2
    - Group 17, -1
- Some covalently bonded groups of atoms (similar in structure to molecules) act like single atoms in forming ions. These charged groups of covalently bonded atoms are called polyatomic ions and may be positive or negative.
- Polyatomic ions react exactly the same as monoatomic ions in chemical reactions
- Use Lewis dot formulas to demonstrate ionic bonding by showing the transfer of electrons from metals to nonmetals.

 Image Source: Created by Rachana Bhonsle, Colleton School District
Extended Knowledge More advance course preparation could include applying VSEPR Theory to predict molecular geometries for simple polyatomic ions; structure of organic molecules (having more than one carbon atom); hybridization that occurs in single, double, triple bonds, and delocalized pi bonds; and drawing resonance structures of molecules and polyatomic ions.
Science and Engineering Practices S.1.A.4

Standard

H.C.3: The student will demonstrate an understanding of the structures and classification of chemical compounds.

Conceptual Understanding

H.C.3A: Elements are made up of only one kind of atom. With increasing atomic number, a predictable pattern for the addition of electrons exists. This pattern is the basis for the arrangement of elements in the periodic table. The chemical properties of an element are determined by an element's electron configuration. Elements can react to form chemical compounds/molecules that have unique properties determined by the kinds of atoms combined to make up the compound/molecule. Essentially, the ways in which electrons are involved in bonds determines whether ionic or covalent bonds are formed. Compounds have characteristic shapes that are determined by the type and number of bonds formed.

Performance Indicator

H.C.3A.4 Plan and conduct controlled scientific investigations to generate data on the properties of substances and analyze the data to infer the types of bonds (including ionic, polar covalent, and nonpolar covalent) in simple compounds.

Assessment Guidance

The objective of this indicator is to *plan and conduct* controlled scientific investigations to generate data on the properties of substances and analyze the data to infer the types of bonds (including ionic, polar covalent, and nonpolar covalent) in simple compounds. Therefore the focus of this assessment should be for students to *plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form* to identify physical and chemical properties of ionic and covalently bonded compounds. This could include but is not limited to students designing, conducting, and presenting data from an experiment to answer the question "How do properties of ionic compounds differ from covalent compounds?", and then use the answer to that question to predict the type of bond within simple compounds.

In addition to *plan and conduct investigations,* students may be expected to *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *develop and use models*.

Previous Knowledge

7.P.2A.4 (Ionic and Covalent Bonding, Chemical Formulas)
7.P.2B.1 (Physical and Chemical Properties)
7.P.2B.4 (Physical and Chemical Changes)

Essential Knowledge

- Types of bonds include ionic, polar covalent, and nonpolar covalent. Ionic and covalent bonds differ in properties include melting point, boiling point, conductivity in aqueous solution, and solubility in water and nonpolar solvents. Data can also include temperature changes caused by the evaporations of two organic compounds of similar molecular weight.
- "Like dissolves like" – polar and ionic compounds will dissolve best in polar solvents

such as water, while nonpolar substances will dissolve best in nonpolar solvents, such as oil – and that aqueous solutions with ionic solutes are electrically conductive.

- Ionic bond and covalent bond are relative terms and that most bonds that we characterize as ionic or covalent actually have a character that lies somewhere between 100% ionic and 100% covalent
- Bonds between active metals and active nonmetals are characterized by a high degree of ionic character because electron transferred is virtually complete
    - Ionic bonds are very strong, substances with ionic bonds usually have high melting and boiling points
- Bonds between identical nonmetals (diatomic compounds) are characterized by zero percent ionic character because electrons are shared equally.
- Bonds between other substances (such as the bond between oxygen and hydrogen) have an intermediate nature; the shared electrons are not shared equitably but spend more time with whichever atom is more electronegative.
- The atom with the stronger attraction for electrons becomes partially negatively charged
- The atom with the lower electronegativity value becomes partially positively charged
- Covalent bonds that do not share the electrons equally are called polar covalent bonds
- Covalent bonds that do share the electrons equally are called non-polar covalent bonds
- If the polar bonds in a molecule are all alike, the polarity of the molecule as a whole depends only on the arrangement in space of the bonds (water molecules are polar due to bent structure)
- Polar molecules are attracted to one another, but the attraction is not a chemical bond so it is broken easily. These substances usually have moderate melting and boiling points
- Polar molecules are attracted to one another and to ionic substances as well
- Electronegativity trends and electronegativity differences should also be used to help identify the bond type.

Extended Knowledge
More advance course preparation could include inferring the types of intermolecular attractions present (hydrogen bonding, dipole-dipole, and van der Waals forces.).

Science and Engineering Practices
S.1.A.3

Standard H.C.3: The student will demonstrate an understanding of the structures and classification of chemical compounds.
Conceptual Understanding H.C.3A: Elements are made up of only one kind of atom. With increasing atomic number, a predictable pattern for the addition of electrons exists. This pattern is the basis for the arrangement of elements in the periodic table. The chemical properties of an element are determined by an element's electron configuration. Elements can react to form chemical compounds/molecules that have unique properties determined by the kinds of atoms combined to make up the compound/molecule. Essentially, the ways in which electrons are involved in bonds determines whether ionic or covalent bonds are formed. Compounds have characteristic shapes that are determined by the type and number of bonds formed.
Performance Indicator H.C.3A.5 Develop and use models (such as Lewis dot structures, structural formulas, or ball-and-stick models) of simple hydrocarbons to exemplify structural isomerism.
Assessment Guidance The objective of this indicator is for students to *develop and use models* (such as Lewis dot structures, structural formulas, or ball-and-stick models) of simple hydrocarbons to exemplify structural isomerism. Therefore, the primary focus of assessment should be for students to develop and use models to understand or represent phenomena, processes and relationships that include arrangement and structure of simple hydrocarbons. This could include but not limited to students designing simple diagrams, constructs, and computer generated models using teacher provided materials to illustrate isomerism in branch and chain hydrocarbons. In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information;* and *construct devices or define solutions*
Previous Knowledge This standard was not introduced in previous science courses.

Essential Knowledge
• Describe hybridization of simple molecules- alkanes and alcohols up to 6 carbons.
• Understand how the capacity to form four covalent bonds results in several bonding possibilities for carbon, including
    o single, double, and triple bonds
    o Ring structures
    o Covalent network
• IUPAC nomenclature should be used to illustrate the structural differences among isomers.

Science and Engineering Practices S.1.A.2

Standard H.C.3: The student will demonstrate an understanding of the structures and classification of chemical compounds.
Conceptual Understanding H.C.3A: Elements are made up of only one kind of atom. With increasing atomic number, a predictable pattern for the addition of electrons exists. This pattern is the basis for the arrangement of elements in the periodic table. The chemical properties of an element are determined by an element's electron configuration. Elements can react to form chemical compounds/molecules that have unique properties determined by the kinds of atoms combined to make up the compound/molecule. Essentially, the ways in which electrons are involved in bonds determines whether ionic or covalent bonds are formed. Compounds have characteristic shapes that are determined by the type and number of bonds formed.
Performance Indicator H.C.3A.6 Construct explanations of how the basic structure of common natural and synthetic polymers is related to their bulk properties.
Assessment Guidance The objective of this indicator is to *construct explanations* of how the basic structure of common natural and synthetic polymers is related to their bulk properties. Therefore the focus of assessment should be for students to *construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams* to describe the structure of these molecules and *make claims* about the function of these molecules based upon this evidence. This could include but is not limited to students comparing diagrams of synthetic hydrocarbons, such as polyethylene or nylon, and naturally occurring polymers, such as proteins or carbohydrates, and being asked to explain, using evidence from the diagrams, why each polymer has different functions based on structure. In addition to *construct explanations,* students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*
Previous Knowledge This standard was not introduced in previous science courses.
Essential Knowledge • Polymers are compounds having a molecular structure that is composed of a large number of similar units, called monomers, bonded together. The properties of a polymer depend on its molecular structure. Structural factors that can impact the properties of a polymer include cross-linking and hydrogen bonding. • Explain the structure, schematics and function biological, natural, and synthetic polymers. • Know the properties of common polymers, such as plastics. For biological polymers, students must be given a description of the polymer's functions in addition to structures or schematics.
Science and Engineering Practices S.1.A.6

Standard H.C.3: The student will demonstrate an understanding of the structures and classification of chemical compounds.
Conceptual Understanding H.C.3A: Elements are made up of only one kind of atom. With increasing atomic number, a predictable pattern for the addition of electrons exists. This pattern is the basis for the arrangement of elements in the periodic table. The chemical properties of an element are determined by an element's electron configuration. Elements can react to form chemical compounds/molecules that have unique properties determined by the kinds of atoms combined to make up the compound/molecule. Essentially, the ways in which electrons are involved in bonds determines whether ionic or covalent bonds are formed. Compounds have characteristic shapes that are determined by the type and number of bonds formed.
Performance Indicator H.C.3A.7 Analyze and interpret data to determine the empirical formula of a compound and the percent composition of a compound.
Assessment Guidance The objective of this indicator is to *analyze and interpret data* to determine the empirical formula of a compound and the percent composition of a compound. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* to identify the composition of a compound. This could include but is not limited to students organizing data collected experimentally or from data provided by the teacher to quantitatively identify empirical formula of compound. In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions*
Previous Knowledge 7.P.2B.2 (Physical and Chemical Properties)
Essential Knowledge • Differentiate between empirical and molecular formulas. • Calculate the percent composition of a substance, given its formula or masses of each element in a sample. • Calculate empirical formula from percent composition or mass of each element in a compound. • Determine molecular formula from given empirical formula, given the compound's molar mass
Extended Knowledge Students could calculate percent composition and empirical formulas of hydrates.
Science and Engineering Practices S.1.A.4

Standard

H.C.4 The student will demonstrate an understanding of the structure and behavior of the different states of matter.

Conceptual Understanding

H.C.4A Matter can exist as a solid, liquid, or gas, and in very high-energy states, as plasma. In general terms, for a given chemical, the particles making up the solid are at a lower energy state than the liquid phase, which is at a lower energy state than the gaseous phase. The changes from one state of matter into another are energy dependent. The behaviors of gases are dependent on the factors of pressure, volume, and temperature.

Performance Indicator

H.C.4A.1 Develop and use models to explain the arrangement and movement of the particles in solids, liquids, gases, and plasma as well as the relative strengths of their intermolecular forces.

Assessment Guidance

The objective of this indicator is for students to *develop and use models* to explain the arrangement and movement of the particles in solids, liquids, gases, and plasma as well as the relative strengths of their intermolecular forces .Therefore, the primary focus of assessment should be for students to *develop and use models* to understand or represent phenomena, processes and relationships that includes arrangement, movement of particles and intermolecular forces of matter. This could include but not limited to students designing simple diagrams, constructs, computer generated models or simulations using teacher provided materials to illustrate particle arrangement of solids, liquids and gases and communicate the relationship between the arrangement, movement and intermolecular force to the states of matter.

In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information;* and *construct devices or define solutions*

Previous Knowledge

3.P.2A (Properties of matter)
5.P.2A (Properties of matter)
7.P.2B.2 (Chemical and Physical Properties)

Essential Knowledge

- All matter is made up of atoms that are in constant random motion.
- The speed of the molecules along with the attraction due intermolecular forces causes substances to exist in different phases of matter.
- Matter exists in four different states of matter: Solid, liquid, gas, and plasma. Each state of matter has specific properties. Basic properties of each are below:

Solids	• The particles of solids are closely packed together due to strong intermolecular forces holding them together • The particles of solids are constantly vibrating, but they do not readily slip past one another. • Because the particles vibrate in place and do not readily slip past one another, a solid has a definite shape. • Particles are usually arranged in a regular pattern.

Liquids	• The particles of liquids are in contact with each other because intermolecular forces holding them together. • The particles of liquids have enough energy to partially overcome the intermolecular forces of the surrounding particles. Liquid particles can slip past surrounding particles and slide over one another. Because the particles slip past one another, a liquid does not have a definite shape and so takes the shape of the container. • Particles have no regular arrangement.
Gases	• The particles of gases are not in contact with each other because they have enough energy to completely overcome the intermolecular forces between or among the particles. • The particles of gases are moving randomly, in straight lines until they bump into other particles or into the wall of the container. When a particle hits another particle or the container, it bounces off and continues to move. • Because gas particles move independently, the particles move throughout the entire container. The forces between the particles are not strong enough to prevent the particles from spreading to fill the container in which the gas is located. • Particles have no regular arrangement.
Plasma	• Plasma is matter consisting of positively and negatively charged particles. • A substance is converted to the plasma phase at very high temperatures, such as those in stars (such as the sun). High temperature means that the particles of a substance are moving at high speeds. At these speeds, collisions between particles result in electrons being stripped from at • Plasma is the most common state of matter in the universe, found not only in stars, but also in lightning bolts, neon and fluorescent light tubes and auroras.

- Compare the intermolecular forces present in substances with high, low, and moderate melting and boiling points and how these forces affect a substance's state of matter.

Extended Knowledge
Students could conduct investigations to explain how specific intermolecular forces affect a substance's melting and boiling points.

Science and Engineering Practices
S.1.A.4

Standard H.C.4 The student will demonstrate an understanding of the structure and behavior of the different states of matter.
Conceptual Understanding H.C.4A Matter can exist as a solid, liquid, or gas, and in very high-energy states, as plasma. In general terms, for a given chemical, the particles making up the solid are at a lower energy state than the liquid phase, which is at a lower energy state than the gaseous phase. The changes from one state of matter into another are energy dependent. The behaviors of gases are dependent on the factors of pressure, volume, and temperature.
Performance Indicator H.C.4A.2 Analyze and interpret heating curve graphs to explain that changes from one state of matter to another are energy dependent.
Assessment Guidance The objective of this indicator is for students *analyze and interpret* the heating curve graphs to explain the changes from one state of matter to another are energy dependent. Therefore, the primary focus of assessment should be *analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions*. This could include but is not limited to students designing, conducting, and presenting data from an experiment to answer the question: how does variation in heat and energy affect the phase change? In addition to *plan and conduct investigations*, students may be expected to *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *develop and use models.*
Previous Knowledge 3.P.2A (Properties of Matter)

Essential Knowledge
• Illustrate and interpret phase changes in terms of kinetic energy of the particles, heat transfer, and particle orientation and arrangement.
    o melting
    o boiling
    o condensation
    o freezing
    o sublimation
• Differentiate the processes of evaporation and boiling
• Differentiate the terms gas and vapor
• Explain how atmospheric pressure and vapor pressure affect the boiling point of a substance
• Analyze a phase diagram (temperature vs. pressure)
    o Explain triple point
    o Critical point
• Create and analyze a graph of temperature vs time which illustrates the heating or cooling

of a substance over the range of phase change. o Explain the shape of the graph in terms of kinetic energy, potential energy, and heat transfer
Extended Knowledge Students could calculate energy absorbed or released using phase diagram.
Science and Engineering Practices S.1.A.4

Standard H.C.4 The student will demonstrate an understanding of the structure and behavior of the different states of matter.
Conceptual Understanding H.C.4A Matter can exist as a solid, liquid, or gas, and in very high-energy states, as plasma. In general terms, for a given chemical, the particles making up the solid are at a lower energy state than the liquid phase, which is at a lower energy state than the gaseous phase. The changes from one state of matter into another are energy dependent. The behaviors of gases are dependent on the factors of pressure, volume, and temperature.
Performance Indicator H.C.4A.3 Conduct controlled scientific investigations and use models to explain the behaviors of gases (including the proportional relationships among pressure, volume, and temperature).
Assessment Guidance The objective of this indicator is to *plan and conduct investigations* to explain the behaviors of gases (including the proportional relationships among pressure, volume, and temperature).; therefore the focus of this assessment should be for students to *plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form.* This could include but is not limited to students designing, conducting, and presenting data from an experiment to answer the question: how does variation in pressure, volume and temperature affect the behavior of gases? In addition to *plan and conduct investigations*, students may be expected *to ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *develop and use models*.
Previous Knowledge 3.P.2A.5 (Properties of matter) 5.P.2B (Properties of Mixtures and Solutions) 7.P.2B.2 (Chemical and Physical Properties)
Essential Knowledge • Use the Kinetic Molecular Theory as a model to explain the relationship between, pressure, and volume in a gas sample. • Use Kelvin scale to convert temperature. • Convert pressures measured in Pa, kPa, mm Hg, atm, or torr. • Explain the relationship between temperature and average kinetic energy. • Explain the significance of the absolute temperature scale in terms of the Kinetic Molecular Theory. • Construct explanations regarding the relationships due the kinetic molecular theory and solve problems mathematically using Charles's law, Boyles's law, and combined gas laws. • Explain the ideal gas law in terms of the Kinetic Molecular Theory.

• Understand the ideal gas constant, R has various forms and must be consistent with the units for the other variables. • Use the ideal gas law equation (PV=nRT) to find pressure, volume, temperature, or number of moles.
Extended Knowledge Students could relate number of particles and volume using Avogadro's principles and also relate the amount of gas present to it pressure, temperature, and volume using the ideal gas law. Students could also explain the difference between real gases and ideal gases.
Science and Engineering Practices S.1.A.3

Standard

H.C. 5 The student demonstrate an understanding of the nature and properties of various types of chemical solutions

Conceptual Understanding

H.C.5A Solutions can exist in any of three physical states: gas, liquid, or solid. Solution concentrations can be expressed by specifying the relative amounts of solute and solvent. The nature of the solute, the solvent, the temperature, and the pressure can affect solubility. Solutes can affect such solvent properties as freezing point, boiling point, and vapor pressure. Acids, bases, and salts have characteristic properties. Several definitions of acids and bases are used in chemistry.

Performance Indicator

H.C. 5A1 Obtain and communicate information to describe how a substance can dissolve in water by dissociation, dispersion, or ionization and how intermolecular forces affect solvation.

Assessment Guidance

The objective of this indicator is to *obtain and communicate information* to describe how a substance can dissolve in water by dissociation, dispersion, or ionization and how intermolecular forces affect solvation. Therefore, the primary focus of assessment should be for students to *obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge*. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations regarding what factors affect solvation. This could include but is not limited to students using computer simulations and virtual labs to obtain evidence regarding how factors like dissociation, dispersion, or ionization affect solvation. Students could communicate the cause and effect relationships that affect solvation using presentations, discussions, digital publications, and digital media.

In addition to *obtain information and communicate information*, students should be asked to ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; and construct devices or define solutions

Previous Knowledge

5.P.2B (Properties of Mixtures and Solutions)

Essential Knowledge

- Explain how intermolecular forces affect how a substance will dissolve in water.
- Differentiate between dissociation, dispersion, and ionization as different manners for dissolving.
- Identify which of these manners is used to dissolve ionic, polar, and nonpolar compounds in water. Describe the formation of a liquid solution
- Breaking up of the solute into individual components (expanding the solute)
- Overcoming intermolecular forces in the solvent to make room for the solute (expanding the solvent)
- Interaction between the solvent and the solute to form the solution

• Distinguish among strong electrolytes, weak electrolytes, and nonelectrolytes
Extended Knowledge Students could solve stoichiometry calculations based on reactions involving aqueous solutions, write net ionic equations, calculate the solubility of a compound from its solubility product constant, and also determine equilibrium concentrations of reactants and products.
Science and Engineering Practices S.1.A.8

Standard H.C. 5 The student demonstrate an understanding of the nature and properties of various types of chemical solutions
Conceptual Understanding H.C.5A Solutions can exist in any of three physical states: gas, liquid, or solid. Solution concentrations can be expressed by specifying the relative amounts of solute and solvent. The nature of the solute, the solvent, the temperature, and the pressure can affect solubility. Solutes can affect such solvent properties as freezing point, boiling point, and vapor pressure. Acids, bases, and salts have characteristic properties. Several definitions of acids and bases are used in chemistry.
Performance Indicator H.C. 5A.2 Analyze and interpret data to explain the effects of temperature and pressure on the solubility of solutes in a given amount of solvent
Assessment Guidance The objective of this indicator is to *analyze and interpret data* to explain the effects of temperature and pressure on the solubility of solutes in a given amount of solvent. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* regarding how the temperature and pressure affect the solubility of solid, liquid, and gas solutes in solvents. This could include but is not limited to students organizing data collected from solubility experiments graphically and examining the graphs for relationships between temperature or pressure and solubility. In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*
Previous Knowledge 5.P.2B (Properties of Mixtures and Solutions)
Essential Knowledge • The solubility of most solids in a liquid is directly proportional to temperature of that system; however the degree to which temperature affects the solubility of a solid varies with the structure and amount of the solid. • The solubility of most gasses in a liquid is inversely proportional to temperature of that system. • The solubility of most gases and solids in a liquid is directly proportional to the pressure of that system.
Science and Engineering Practices S.1.A.4

Standard
H.C. 5 The student demonstrate an understanding of the nature and properties of various types of chemical solutions

Conceptual Understanding
H.C.5A Solutions can exist in any of three physical states: gas, liquid, or solid. Solution concentrations can be expressed by specifying the relative amounts of solute and solvent. The nature of the solute, the solvent, the temperature, and the pressure can affect solubility. Solutes can affect such solvent properties as freezing point, boiling point, and vapor pressure. Acids, bases, and salts have characteristic properties. Several definitions of acids and bases are used in chemistry.

Performance Indicator
H.C.5A.3 Use mathematical representations to analyze the concentrations of unknown solutions in terms of molarity and percent by mass.

Assessment Guidance
The objective of this indicator is to *use mathematical representations* to analyze the concentrations of unknown solutions in terms of molarity and percent by mass. Therefore the focus of assessment should be for students to *construct use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data* to analyze the concentrations of unknown solutions in terms of molarity and percent by mass. This could include but is not limited to students use experimentally acquired data to calculate and express relationships among concentration, mass, and volume in terms of molarity and percent by mass.

In addition to *use mathematical and computational thinking* students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate and communicate information;* and *construct devices or design solutions.*

Previous Knowledge
5.P.2B (Properties of Mixtures and Solutions)

Essential Knowledge
- Solve problems involving the Molarity (M) of a solution (moles of solute per volume of solution) (moles/liter)
- Solve problems involving percent by mass (mass of solute per mass of solution x 100%)

Extended Knowledge
Advanced course preparation could include having students describe concentration using different units, determine the concentration of solutions, calculate preparation protocols of molar solutions, and calculate methods for diluting solutions. They could also calculate molality, mole fractions, and percent by volume.

Science and Engineering Practices
S.1.A.5

Standard
H.C. 5 The student demonstrate an understanding of the nature and properties of various types of chemical solutions

Conceptual Understanding
H.C.5A Solutions can exist in any of three physical states: gas, liquid, or solid. Solution concentrations can be expressed by specifying the relative amounts of solute and solvent. The nature of the solute, the solvent, the temperature, and the pressure can affect solubility. Solutes can affect such solvent properties as freezing point, boiling point, and vapor pressure. Acids, bases, and salts have characteristic properties. Several definitions of acids and bases are used in chemistry.

Performance Indicator
H.C 5A.4. Analyze and interpret data to describe the properties of acids, bases, and salts.

Assessment Guidance
The objective of this indicator is to *analyze and interpret data* to describe the properties of acids, bases, and salts. Therefore, the primary focus of assessment should be for students to *analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* to identify physical and chemical; properties of acids, bases, and salts. This could include but is not limited to students organizing data collected from texts, laboratory experiments, or teacher given data to identify common household substances such as vinegar and ammonia as acids or bases.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous Knowledge
7P.2B.3 (Physical and chemical properties of acids and bases)

Essential Knowledge
<u>ACIDS</u>

- The Arrhenius definition of an acid is a substance that ionizes or releases hydrogen ions (H^+) when it is mixed with water.
- The reaction of these acids with metals that are chemically active produce hydrogen gas
- The effect of acids on indicators
- Neutralization of bases with acids
- Water solutions of acids taste sour
- Have a pH less than 7

<u>BASES</u>
The Arrhenius Definition of a base is a substance that ionizes or releases hydroxide ions (OH-) when it is mixed with water

- Bases are electrolytes
- The effect of bases on indicators

• Neutralization of acids with bases • Water solutions of bases taste bitter and feel slippery • Have a pH greater than 7 Salts are defined as ionic compounds containing a positive ion other than the hydrogen ion and a negative ion other than the hydroxide ion. They have high melting points and are good conductors of electric current either when molten or when dissolved in water.
Extended Knowledge Students may also differentiate between strong/weak bases and acids, explain the relationship between the strengths of acids and bases and the values of their ionization constants, compare the strength of a weak acid with the strength of its conjugate base, calculate pH and pOH from hydrogen and hydroxide concentrations, or also explain the relationship of hydrogen concentration and hydroxide concentration in $K_{W,}$ K_{OH}, and K_{H} in relation to strong and weak acids and bases.
Science and Engineering Practices S.1.A.4

Standard H.C.6The student will demonstrate an understanding of the types, the causes, and the effects of chemical reactions.
Conceptual Understanding H.C.6A A chemical reaction occurs when elements and /or compounds interact, resulting in a rearrangement of the atoms of these elements and/or compounds to produce substance with unique properties. Mass is conserved in chemical reactions. Reactions tend to proceed in a direction that favors lower energies. Chemical reaction can be categorized using knowledge about the reactant to predict products. Chemical reactions are quantifiable. When stress is applied to a chemical system that is in equilibrium, the system will shift in a direction that reduces the stress.
Performance Indicator H.C.6A.1 Develop and use models to predict the products of chemical reactions (1) based upon movements of ions; (2) based upon movements of protons; and (3) based upon movements of electrons.
Assessment Guidance The objective of this indicator is for students to *develop and use models* to predict the products of chemical reactions (1) based upon movements of ions; (2) based upon movements of protons; and (3) based upon movements of electrons. Therefore the focus of this assessment should be for students *to plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form* to identify the type of reaction and predict the product. This could include but not limited to students designing models using teacher provided materials to illustrate and give analogies for types of reactions and citing examples of oxidation and reductions. In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information;* and *construct devices or define solutions*
Previous Knowledge 7.P.2B. (Physical and chemical properties)
Essential Knowledge Given a set of reactants for each type of reaction, students must be able to predict the products of the reaction. <u>Reactions based upon movements of ions:</u> • For the purposes of this indicator, chemical reactions that involve the movement of ionic particles are limited to those that produce an insoluble solid from two aqueous solutions. • To model these reactions, students should first conceptualize the solutes of aqueous solutions as dissociated ions. The ions that form insoluble solids come together through electrostatic attraction and precipitate. Models should progress from particle drawings to traditional chemical equations that include phase notation. Students should have the

opportunity to carry out some reactions during the modeling process.

- Example: MgSO4(aq) + Na2CO3(aq) --> MgCO3(s) + Na2SO4(aq)
- These reactions are usually referred to in textbooks as double replacement, metathesis, and precipitation reactions. Memorization of solubility rules is not assessed.

<u>Reactions based upon movements of protons</u>

- For the purposes of this indicator, chemical reactions based upon the movement of protons are acid-base neutralization reactions; the reactions covered in this section are limited to those between Bronsted-Lowry acids and bases.
- To model these reactions, students should conceptualize acids as proton donors and bases as proton acceptors and then progress to predicting products using traditional chemical reactions. Student models should demonstrate understanding of conjugate acid-base pairs. Students should also have the opportunity to carry out some reactions during the modeling process.
- Example: HCl(aq) + KOH(aq) --> KCl(aq) + H2O(l)
- These reactions are usually referred to in textbooks as neutralization and metathesis reactions.

<u>Reactions based upon movements of electrons:</u>

- For the purposes of this indicator, chemical reactions based upon movements of electrons are limited to simple oxidation-reduction reactions in which only one element is oxidized and another is reduced.
- To model these reactions, students should first conceptualize one or more electrons moving from one species to another to form new products. Models should progress from particle drawings to traditional chemical equations that include phase notation. Students should have the opportunity to carry out some reactions during the modeling process.
- These oxidation-reduction reactions are usually referred to in textbooks as synthesis, combination, decomposition, and single replacement reactions.
    - Predicting the products of decomposition reactions should be limited to simple binary compounds decomposing to their elements.
- “Oxidation” is defined as the process of losing electrons, “reduction” is defined as process of gaining electrons
    - A substance that is “oxidized” has lost electrons
    - A substance that is “reduced” has gained electrons
    - When a substance is oxidized, it “gives” electrons to another substance, causing that substance to gain electrons or be reduced.
        - A substance that causes another substance to be reduced is called a “reducing agent”
        - Any substance that is oxidized is a reducing agent
    - When a substance is reduced, it “takes” electrons from another substance, causing that substance to lose electrons or be oxidized.
        - A substance that causes another substance to be oxidized is called an “oxidizing agent”
        - Any substance that is reduced is called an oxidizing agent

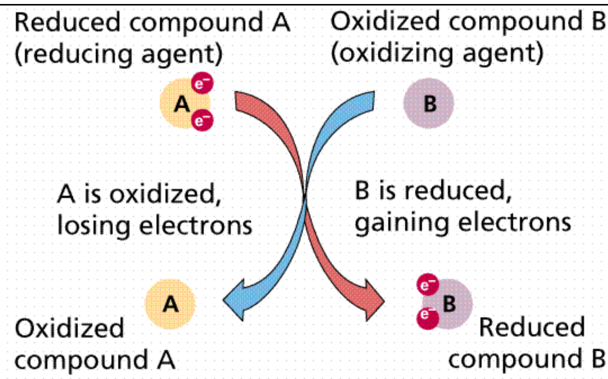


Image Source: 2005 Science Standards Support Document

- Examples:

  Mg(s) + Br2(l) --> MgBr2(s)

  NaCl(s) --> Na(s) + Cl2(g)

  Zn(s) + CuSO4(aq) --> ZnSO4(aq) + Cu(s)

Extended Knowledge

Students may construct and use net ionic equations to model reactions involving the production of carbonic acid which subsequently decomposes to water and carbon dioxide. Students may also obtain, evaluate, and communicate information regarding Lewis acid-base theory and hydrolysis. Students may also develop and use models to identify oxidizing and reducing agents and illustrate half-reactions.

Science and Engineering Practices

S.1.A.2

Standard

H.C.6 The student will demonstrate an understanding of the types, the causes, and the effects of chemical reactions.

Conceptual Understanding

H.C.6AA chemical reaction occurs when elements and /or compounds interact, resulting in a rearrangement of the atoms of these elements and/or compounds to produce substance with unique properties. Mass is conserved in chemical reactions. Reactions tend to proceed in a direction that favors lower energies. Chemical reaction can be categorized using knowledge about the reactant to predict products. Chemical reactions are quantifiable. When stress is applied to a chemical system that is in equilibrium, the system will shift in a direction that reduces the stress

Performance Indicator

H.C.6A.2 Use Le Châtelier's principle to predict shifts in chemical equilibria resulting from changes in concentration, pressure, and temperature.

Assessment Guidance

The objective of this indicator is to *construct explanations* based on La Châtelier's principle to predict shifts in chemical equilibria resulting from changes in concentration, pressure, and temperature.; therefore the focus of assessment should be for students *to construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams* to observe equilibrium as it applies to solubility, phase change and make claims about the influence of pressure , temperature and concentration based upon this evidence. This could include but is not limited to students identifying cause (change in pressure, temperature and concentration) and effect on equilibrium.

In addition to *construct explanations*, students should be asked to *ask questions; plan and carry out investigations; engage in argument from evidence; obtain, evaluate and communicate information; develop and use models;* and *construct devices or design solutions.*

Previous Knowledge

7P.2B.5 (Law of Conservation of Matter)

Essential Knowledge

- Equilibrium is a dynamic condition in which two opposing changes occur at equal rates in a closed system.
- Illustrate that equilibrium as it applies to
  - Reversible chemical reactions
  - Solubility
  - Phase change
- Showcase and apply La Châtelier's Principle in reference to the following stresses
  - A change in concentration
  - A change in temperature
  - A change in pressure

Extended Knowledge

Students could define and manipulate K_{sp} in order to predict solubility.

Science and Engineering Practices

S.1.A6

Standard

H.C.6 The student will demonstrate an understanding of the types, the causes, and the effects of chemical reactions.

Conceptual Understanding

H.C.6A A chemical reaction occurs when elements and /or compounds interact, resulting in a rearrangement of the atoms of these elements and/or compounds to produce substance with unique properties. Mass is conserved in chemical reactions. Reactions tend to proceed in a direction that favors lower energies. Chemical reaction can be categorized using knowledge about the reactant to predict products. Chemical reactions are quantifiable. When stress is applied to a chemical system that is in equilibrium, the system will shift in a direction that reduces the stress

Performance Indicator

H.C.6A.3 Plan and conduct controlled scientific investigations to produce mathematical evidence that mass is conserved in chemical reactions

Assessment Guidance

The objective of this indicator is to *plan and conduct controlled scientific investigations* to produce mathematical evidence that mass is conserved in chemical reactions. Therefore the focus of this assessment should be for students to *plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment , technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form* to gather evidence of mass, moles, before and after the reaction . This could include but is not limited to students designing, conducting, and presenting data from an experiment to perform stoichiometric calculations, calculate the number of molecules, formula units, or ions in a given molar amount of a chemical compound.

In addition to *plan and conduct investigations,* students may be expected to *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *develop and use models*.

Previous Knowledge

7.P.2B.4 (Physical and Chemical Changes)

7.P.2B.5 – (Law of Conservation of Matter)

Essential Knowledge

- Classify typical chemical equations based on the composition of the reactants
  - Single replacement
  - Double replacement
  - Synthesis (composition)
  - Decomposition
  - Combustion
- Balance any chemical reaction when given the reactants and the products, including the notations used to indicate the phase of the substance.
  - $Cl_2(g)$ chlorine gas
  - $H_2O(l)$ water as a liquid

- NaCl(s) sodium chloride as a solid - NaCl(aq) sodium chloride dissolved in water
Science and Engineering Practices S.1.A.3

Standard

H.C.6 The student will demonstrate an understanding of the types, the causes, and the effects of chemical reactions.

Conceptual Understanding

H.C.6A A chemical reaction occurs when elements and /or compounds interact, resulting in a rearrangement of the atoms of these elements and/or compounds to produce substance with unique properties. Mass is conserved in chemical reactions. Reactions tend to proceed in a direction that favors lower energies. Chemical reaction can be categorized using knowledge about the reactant to predict products. Chemical reactions are quantifiable. When stress is applied to a chemical system that is in equilibrium, the system will shift in a direction that reduces the stress

Performance Indicator

H.C.6A.4 Use mathematical and computational thinking to predict the amounts of reactants required and products produced in specific chemical reactions.

Assessment Guidance

The objective of this indicator is to *use mathematical and computational* thinking to predict the amounts of reactants required and products produced in specific chemical reactions. Therefore the focus of assessment should be for students to construct, use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data to calculate the limiting and excess reactants in chemical reaction. This could include but is not limited to students use experimentally acquired data, to identify the limiting reactant in a chemical reaction.

In addition to *use mathematical and computational thinking* students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate and communicate information;* and *construct devices or design solutions.*

Previous Knowledge

7.P.2B.4 (Physical and Chemical Changes)
7.P.2B.5 – (Law of Conservation of Matter)

Essential Knowledge

- The quantity 6.02×10^{23} of any object is defined as a "mole" of the object.
- The atomic mass of a substance, as found on the periodic table, represents the average mass (in atomic mass units) of the naturally occurring isotopes of the element.
- The molar mass of a pure substance is the mass (in grams) of one mole of the substance (the molar mass of carbon atoms is the mass (in grams) of one mole of carbon atoms).
- The molar mass of an element (measured in grams) is numerically equal to the atomic mass of the element (measured in atomic mass units)
- The formula mass is the term used for ionic substances. It is the sum of the atomic masses of all of the elements contained in one formula unit of an ionic compound.
- The molecular mass is the term used for molecular compounds. It is the sum of the atomic masses of all of the elements in the molecular formula of the substance.
- Calculate the formula mass or molecular mass of any given compound.
- Use molar mass, formula mass, or molecular mass to convert between mass in grams and amount in moles of a chemical compound.

• Calculate the number of molecules, formula units, or ions in a given molar amount of a chemical compound.
• Calculate the percent composition of a given chemical compound.
• Perform stoichiometric calculations
  o Mass-mass
  o Limiting reactant
  o Percent yield

Science and Engineering Practices S.1.A.5

Standard

H.C.7 -The student will demonstrate an understanding of the conservation of energy and energy transfer.

Conceptual Understanding

H.C.7A The first law of thermodynamics states that the amount of energy in the universe is constant. An energy diagram is used to represent changes in the energy of the reactants and products in a chemical reaction. Enthalpy refers to the heat content that is present in an atom, ion, or compound. While some chemical reactions occur spontaneously, other reactions may require that activation energy be lowered in order for the reaction to occur.

Performance Indicator

H.C.7A.1 Analyze and interpret data from energy diagrams and investigations to support claims that the amount of energy released or absorbed during a chemical reaction depends on changes in total bond energy.

Assessment Guidance

The objective of this indicator is for students to *analyze and interpret data* from energy diagrams and investigations to support claims that the amount of energy released or absorbed during a chemical reaction depends on changes in total bond energy. Therefore, the primary focus of assessment should be *analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions* to exemplify how energy is conserved during a chemical reaction. This could include, but is not limited to, using student generated laboratory data or teacher provided data to support that energy is conserved in a chemical reaction.

In addition to *analyze and interpret data*, students should be asked to *ask questions; plan and carry out investigations; use mathematics and computational thinking; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate, and communicate information;* and *construct devices or define solutions.*

Previous Knowledge

3.P.2A. (Properties of Matter)
6.P.3A (Conservation of Energy)

Essential Knowledge

- The Law of Conservation of Energy states that the total energy of a system does not change.
  - For a chemical system, any energy transformations depend on changes in total bond energy.

- *Enthalpy* is a measure of the total energy of a system. The total enthalpy of a system cannot be measured directly, so the enthalpy *change* of a system is measured instead.
- The enthalpy change of a system can be conceptualized by $\Delta H = H_f - H_i$, where
  ΔH is the change in enthalpy of the system;
  H_f is the final enthalpy of the system; and
  H_i is the initial enthalpy of the system.
  - Each of these values is measured in Joules (J) or kilojoules (kJ) per mole of

reactant.

- The heat of reaction, or ΔH_{rxn}, is the change in the enthalpy of a chemical reaction that occurs at a constant pressure.
- If the chemical reaction is exothermic, then the value of ΔH_{rxn} is negative; endothermic reactions have a positive ΔH_{rxn} value.
- Energy diagrams are a useful means of visualizing the energy changes involved in chemical reactions.
  - The example below shows the energy changes typical of an exothermic and endothermic reaction.
  - Students should be able to identify the potential energy (PE) of the reactants, the PE of the products, the activation energy (E_{act}), and the heat of reaction (ΔH).

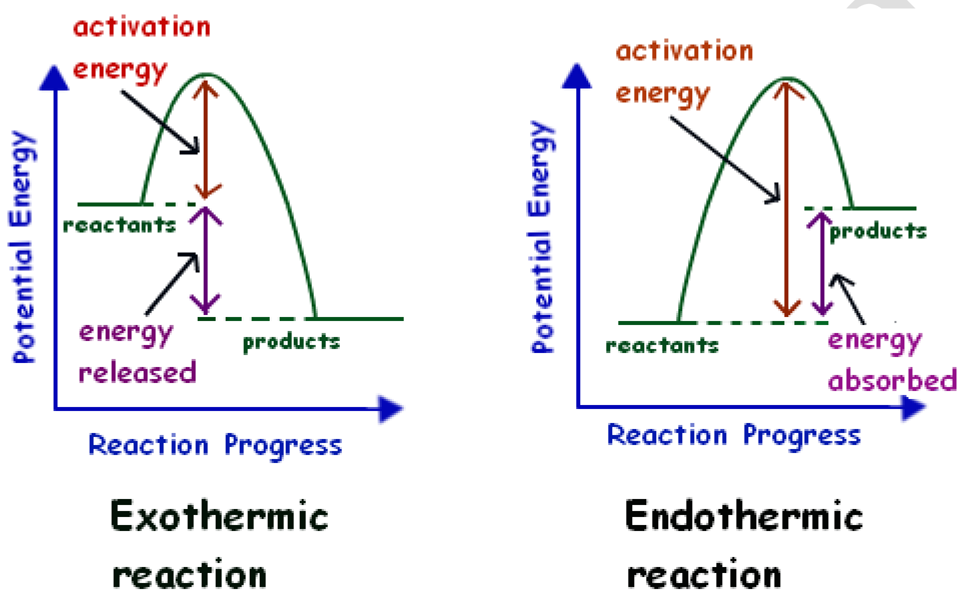


Image Source: images.tutorvista.com/cms/images/101/exothermic-and-endothermic-reaction.png

- Thermochemical equations include the word "energy" or the actual energy change, in kilojoules, in the chemical equation.
  - For endothermic reactions, the energy appears as a reactant, showing the absorption of energy from the surroundings.
  - For exothermic reactions, the energy appears as a product, showing a production or release of energy to the surroundings.
    - For example, the decomposition of water is shown as $2H_2O$ + energy → $2H_2 + O_2$, while the formation of water from its elements would be shown as $2H_2 + O_2$ → $2H_2O$ + energy.
- Identify every day and novel examples of endothermic and exothermic reactions.
  - Everyday examples of endothermic reactions include baking bread, cooking an egg, and photosynthesis.
  - Examples of exothermic reactions in everyday life include burning wood, rusting, and cellular respiration.
  - Students should also be able to identify novel examples that clearly release or absorb energy, based upon common everyday experiences.

Students should determine the enthalpy change in chemical reactions through investigations and interpretation of energy diagrams.
Extended Knowledge Students could interpret energy diagrams with respect to the reverse reaction, calculate molar enthalpies of reaction using Hess' Law and/or tables of bond energies, explain heat transfer though calorimetric calculations, and explain how specific heat of a substance affect how heat is transferred from one substance to another.
Science and Engineering Practices S.1.A.4

Standard H.C.7-The student will demonstrate an understanding of the conservation of energy and energy transfer
Conceptual Understanding H.C.7A The first law of thermodynamics states that the amount of energy in the universe is constant. An energy diagram is used to represent changes in the energy of the reactants and products in a chemical reaction. Enthalpy refers to the heat content that is present in an atom, ion, or compound. While some chemical reactions occur spontaneously, other reactions may require that activation energy be lowered in order for the reaction to occur.
Performance Indicator H.C.7A.2 Use mathematical and computational thinking to write thermochemical equations and draw energy diagrams for the combustion of common hydrocarbon fuels and carbohydrates, given molar enthalpies of combustion.
Assessment Guidance The objective of this indicator is to *use mathematical and computational* thinking to write thermochemical equations and draw energy diagrams for the combustion of common hydrocarbon fuels and carbohydrates, given molar enthalpies of combustion. Therefore the focus of assessment should be for students to *construct use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data* to analyze amount of energy given off during the combustion of different fuels. This could include but is not limited to students using teacher provided data to calculate amount of energy given off during common combustion reactions to draw energy diagrams. In addition to *use mathematical and computational thinking* students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; engage in argument from evidence; construct explanations; develop and use models; obtain, evaluate and communicate information;* and *construct devices or design solutions.*
Previous Knowledge Students should be familiar with the mole concept, since this performance indicator deals with molar enthalpies of combustion. 6.P.3A (Conservation of Energy) 7.P.2B.1 (Physical and Chemical Properties) 7.P.2B.5 (Chemical Changes)
Essential Knowledge • Combustion reactions are always exothermic. • Predict products for these combustion reactions, compare molar enthalpies of combustion of different fuels, and discern a relationship between the number and types of bonds and the amount of energy released during combustion. For example: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 889$ kJ $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O + 1300$ kJ $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O + 2220$ kJ Graph the energy changes involved in combustion reactions in the form of an energy diagram. Given molar enthalpies of combustion, students should be able to sketch an energy diagram

which correctly shows the magnitude of ΔH_{comb}. Only fuels that react with oxygen to produce carbon dioxide and water are considered.
Extended Knowledge Students can use mathematical and computational thinking to write equations that can be balanced with multiple moles of fuel and/or fractional moles of oxygen.
Science and Engineering Practices S.1.A.6

Standard

H.C.7-The student will demonstrate an understanding of the conservation of energy and energy transfer

Conceptual Understanding

H.C.7A The first law of thermodynamics states that the amount of energy in the universe is constant. An energy diagram is used to represent changes in the energy of the reactants and products in a chemical reaction. Enthalpy refers to the heat content that is present in an atom, ion, or compound. While some chemical reactions occur spontaneously, other reactions may require that activation energy be lowered in order for the reaction to occur.

Performance Indicator

H.C.7A.3 Plan and conduct controlled scientific investigations to determine the effects of temperature, surface area, stirring, concentration of reactants, and the presence of various catalysts on the rate of chemical reactions.

Assessment Guidance

The objective of this indicator is to *plan and conduct controlled scientific investigations* to determine the effects of temperature, surface area, stirring, concentration of reactants, and the presence of various catalysts on the rate of chemical reactions. Therefore the focus of this assessment should be for students to *plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form* identify factors that affect the rate of chemical reactions. This could include but is not limited to students designing, conducting, and presenting data from an experiment to answer the question: How do the factors listed affect the rate of chemical reactions?

In addition to *plan and conduct investigations*, students may be expected to *ask questions; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations;* and *develop and use models*.

Previous Knowledge

5.P.2B (Mixtures and Solutions)
7.P.2B.4 (Chemical and Physical Changes)

Essential Knowledge

- For many reactions, increases in temperature will increase reaction rates due to collisions between molecules having greater frequency and energy.
- As the surface area of a solid reactant increases, the reaction rate will increase, due to more of the reactant being exposed to other reactants, causing more collisions.
- Stirring will keep the reactant particles in motion, increasing the frequency of collisions.
- As the concentration of a reactant increases, the frequency of collisions increases, due to the presence of more reactant molecules.
- The presence of a catalyst increases the rate of a reaction by reducing the activation energy required for the reaction to occur.

Extended Knowledge Students could research and explain heterogeneous catalysts versus homogeneous catalysts.
Science and Engineering Practices S.1.A.3

Standard
H.C.7-The student will demonstrate an understanding of the conservation of energy and energy transfer

Conceptual Understanding
H.C.7A The first law of thermodynamics states that the amount of energy in the universe is constant. An energy diagram is used to represent changes in the energy of the reactants and products in a chemical reaction. Enthalpy refers to the heat content that is present in an atom, ion, or compound. While some chemical reactions occur spontaneously, other reactions may require that activation energy be lowered in order for the reaction to occur.

Performance Indicator
H.C.7A.4 Develop and use models to explain the relationships between collision frequency, the energy of collisions, the orientation of molecules, activation energy, and the rates of chemical reactions.

Assessment Guidance
The purpose of this indicator is for students to d*evelop and use models* to explain the relationships between collision frequency, the energy of collisions, the orientation of molecules, activation energy, and the rates of chemical reactions. Therefore, the primary focus of assessment should be for students to *develop and use models to understand or represent phenomena, processes and relationship* between collision energy and rates of reaction. This could include but not limited to students designing models using teacher provided data to create energy diagrams to illustrate and explain how catalysts decrease the amount of energy needed for a chemical reaction to occur.

In addition to *develop and use models*, students should be asked to *ask questions; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; engage in argument from evidence; construct explanations; obtain, evaluate, and communicate information;* and *construct devices or define solutions*

Previous Knowledge
This concept was not introduced in previous grades.

Essential Knowledge

- In order for a reaction to proceed, the reactant particles must collide. A chemical reaction only occurs if particles are oriented favorably. If the particles are not oriented correctly, a reaction will not occur.
- These collisions must have sufficient energy to break bonds of the reacting substances. The minimum amount of energy for a reaction to proceed is called the activation energy.
- A catalyst is a substance that increases the speed of a reaction but, is not used chemically in the reaction.
- Catalysts allow for a different activation pathway with lower activation energy for a reaction to occur faster.
- Energy diagrams should be used to differentiate between reaction pathways with and without a catalyst.

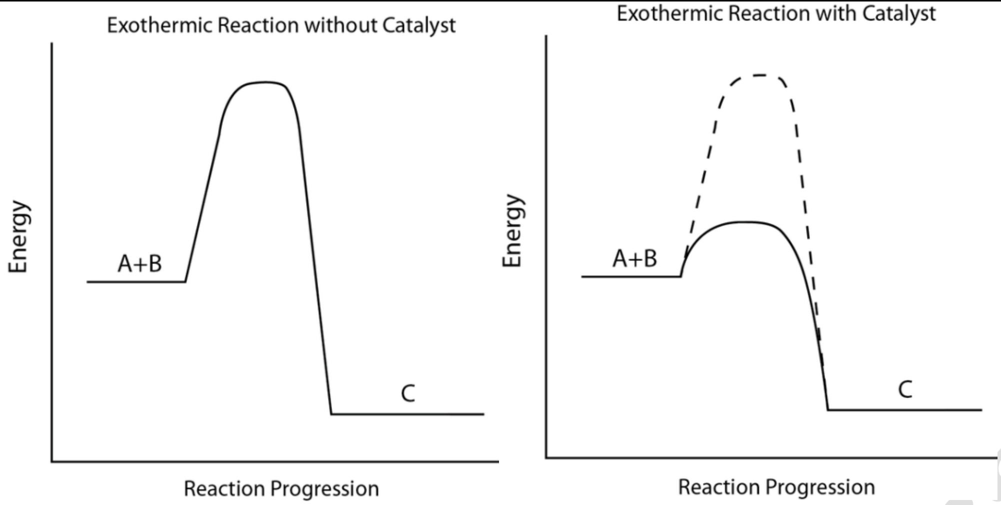


Image Source: Created by Brazosport College (commons.wikimedia.org/wiki/File:Exothermic_Reaction_without_Catalyst.png; commons.wikimedia.org/wiki/File:Exothermic_Reaction_with_Catalyst.png)

Science and Engineering Practices

S.1.A.2