PISCATAWAY
TOWNSHIP SCHOOLS

Dr. Frank Ranelli
Superintendent of Schools

Dr. William Baskerville
Assistant Superintendent for
Curriculum and Instruction

Introduction to Organic Chemistry (Honors)

Content Area: Introduction to Organic Chemistry (Honors)
Grade Span: 11-12
Revised by: Amina Elmahalawy
Presented by: Jessica Pritchard
Approval date: August 2022

Piscataway Township Schools
1515 Stelton Road
Piscataway, NJ 08854-1332
732 572-2289, ext. 2561
Fax 732 572-1540
www.piscatawayschools.org

COURSE OVERVIEW

Description

Introduction to Organic Chemistry is a 2.5 credit, semester course for students in grades 11-12. This is an Honors level elective course. Introduction to Organic Chemistry is an introductory program that will lead to a foundation in understanding the fundamental principles and applications of organic chemistry. This course will introduce topics that will be essential for a college organic chemistry course. Included in this program is a consideration of: naming organic compounds, drawing organic compounds, reactions of organic compounds and real-life applications of organic compounds.

Goals

This course provides an opportunity for students to explore and develop an appreciation and understanding of carbon based compounds and to prepare students for a course in Organic Chemistry at the college level. During the course of study, students will learn and develop the following skills: organization, use of content specific vocabulary, and the ability to understand and further investigate the basics of organic chemistry.

Scope and Sequence

Unit	Topic	Length
Unit 1	Bonding and Isomerism	5 days
Unit 2	Functional Groups in Organic Chemistry (Alkanes and Cycloalkanes; Alkenes and Alkynes; Alcohols, Phenols, and Thiols; Aldehydes and Ketones; Carboxylic Acids and their Derivatives)	20 days
Unit 3	Stereoisomerism	10 days
Unit 4	Organic Halogen Compounds: Substitution/Elimination Reactions	5 days
Unit 5	Spectroscopy and Structure Determination	5 days

UNIT 1: Bonding and Isomerism

Summary and Rationale

This unit will address a review of basic chemistry concepts and skills and how these skills apply to organic chemistry. These skills include: drawing Lewis dot structures efficiently with a focus on carbon compounds; understanding isomerism and different ways to draw molecules; and showcasing the three dimensional structure of these molecules.

Recommended Pacing

5 days

State Standards

HS-PS1-1 - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	
Clarification Statement	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.
Assessment Boundary	Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.
HS-PS1-2 - Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	
Clarification Statement	Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.
Assessment Boundary	Assessment is limited to chemical reactions involving main group elements and combustion reactions.
HS-PS1-3 - Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	
Clarification Statement	Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.
Assessment Boundary	Assessment does not include Raoult's law calculations of vapor pressure.
HS-PS1-4 - Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	
Clarification Statement	Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.
Assessment Boundary	Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.
HS-PS1-6 - Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.	
Clarification Statement	Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.
Assessment Boundary	Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.
HS-PS2-6 - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	

Clarification Statement	Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.
Assessment Boundary	Assessment is limited to provided molecular structures of specific designed materials.
HS-PS4-4 - Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	
Clarification Statement	Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.
Assessment Boundary	Assessment is limited to qualitative descriptions.
HS-ESS3.4 - Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.	
Clarification Statement	Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).
HS-LS2.7 - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	
Clarification Statement	Examples of human activities can include urbanization, building dams, and dissemination of invasive species.

Instructional Focus

Unit Enduring Understandings

- Chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions, or molecules and the forces between them.
- Molecules with the same molecular formula may have different structures and exhibit different properties.
- The reactivity of molecules is determined by the electron distribution with polarity/electronegativity being major factors.
- Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
- The type of bond between carbon atoms determines the reactivity of the hydrocarbons.

Unit Essential Questions

- What is the role of carbon in the molecular diversity of life?
- How does structure affect the behavior and properties of organic molecules?

Objectives

Students will know & be able to:

- Draw Lewis structures and predict the shapes of molecules.
- Determine hybridization of an element within a given molecule.
- Recognize and predict the existence of structural isomerism.
- Describe and draw examples of structural isomerism.
- Calculate formal charge on all atoms in a molecule.
- Draw all possible resonance structures of a compound.

UNIT 2: Functional Groups in Organic Chemistry

(Alkanes and Cycloalkanes; Alkenes and Alkynes; Alcohols, Phenols, and Thiols; Aldehydes and Ketones; Carboxylic Acids and their Derivatives)

Summary and Rationale

This unit includes identification of the major functional groups, naming different types of organic compounds, and providing a foundation for student understanding of chemical mechanisms and synthesis of organic compounds. Students work collaboratively in groups utilizing a project-based learning format where each group focuses their efforts on one functional group to peer-teach the rest of the class. Collaboration and discussions between peers are encouraged and recommended.

Recommended Pacing

20 days

State Standards

HS-PS1-1 - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	
Clarification Statement	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.
Assessment Boundary	Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.
HS-PS1-2 - Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	
Clarification Statement	Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.
Assessment Boundary	Assessment is limited to chemical reactions involving main group elements and combustion reactions.
HS-PS1-3 - Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	
Clarification Statement	Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.
Assessment Boundary	Assessment does not include Raoult's law calculations of vapor pressure.
HS-PS1-4 - Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	
Clarification Statement	Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.
Assessment Boundary	Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.
HS-PS1-6 - Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.	
Clarification Statement	Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.
Assessment Boundary	Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.
HS-PS2-6 - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	

Clarification Statement	Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.
Assessment Boundary	Assessment is limited to provided molecular structures of specific designed materials.
HS-PS4-4 - Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	
Clarification Statement	Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.
Assessment Boundary	Assessment is limited to qualitative descriptions.
HS-ESS3.4 - Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.	
Clarification Statement	Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).
HS-LS2.7 - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	
Clarification Statement	Examples of human activities can include urbanization, building dams, and dissemination of invasive species.

Instructional Focus

Unit Enduring Understandings

- The rules of systematic IUPAC nomenclature enable us to name a compound given a structure, and conversely, draw a structure given the systematic name.
- The reactivity of molecules is determined by the electron distribution with polarity/electronegativity being major factors.
- The structures of organic molecules can be understood as deriving from simple hydrocarbons.
- The type of bond between carbon atoms determines the reactivity of the hydrocarbons.
- Many reactions proceed through a series of elementary steps referred to as the reaction mechanism.
- Several mechanisms may be postulated for most reactions, and experimentally determining the dominant pathway of such reactions is a central activity of chemistry.
- Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism and by providing a new and faster mechanism.

Unit Essential Questions

- How does bond polarity affect the reactivity of the different functional groups?
- Why is a consistent system of nomenclature important in organic chemistry?
- How does the IUPAC system of nomenclature allow us to determine the structure of a molecule?
- What is the role a catalyst plays in increasing the reaction rate?

Objectives

Students will know & be able to:

- Sketch a line bond drawing of a given molecule.
- Given the IUPAC name, draw the structure of the molecule.
- Given the structure, give the formal IUPAC name for a compound.
- Recognize the common names of typical organic molecules.
- Predict the major product(s) of a reaction, given the reagents and reaction conditions.

UNIT 3: Stereoisomerism

Summary and Rationale	
This unit has students identify, name and determine reaction mechanisms using stereoisomers. The students will focus on properties of chiral compounds and compounds with multiple stereogenic centers and how they affect reactions with chiral compounds and interactions with biological processes.	
Recommended Pacing	
10 days	
State Standards	
HS-PS1-1 - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	
Clarification Statement	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.
Assessment Boundary	Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.
HS-PS1-2 - Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	
Clarification Statement	Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.
Assessment Boundary	Assessment is limited to chemical reactions involving main group elements and combustion reactions.
HS-PS1-3 - Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	
Clarification Statement	Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.
Assessment Boundary	Assessment does not include Raoult's law calculations of vapor pressure.
HS-PS1-4 - Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	
Clarification Statement	Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.
Assessment Boundary	Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.
HS-PS1-6 - Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.	
Clarification Statement	Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.
Assessment Boundary	Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.

HS-PS2-6 - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	
Clarification Statement	Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.
Assessment Boundary	Assessment is limited to provided molecular structures of specific designed materials.
HS-PS4-4 - Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	
Clarification Statement	Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.
Assessment Boundary	Assessment is limited to qualitative descriptions.
HS-ESS3.4 - Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.	
Clarification Statement	Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).
HS-LS2.7 - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	
Clarification Statement	Examples of human activities can include urbanization, building dams, and dissemination of invasive species.

Instructional Focus

Unit Enduring Understandings

- Molecules with the same molecular formula may have different structures and exhibit different properties.
- Stereoisomerism is responsible for significant differences in biological activity.
- Though drawn in rigid, static form, molecules are constantly bending, twisting, and vibrating.

Unit Essential Questions

- How does the three dimensional arrangement of atoms in a molecule determine its stereochemistry?
- How does stereochemistry affect the biological activity of molecules?

Objectives

Students will know & be able to:

- Given a chiral molecule, determine the stereo genic center.
- Distinguish between enantiomers and diastereomers.
- Assign R and S configurations to stereoisomers and draw compounds with these configurations.
- Comprehend that interconversion of configurational isomers requires breaking and remaking covalent bonds.
- Identify the properties of enantiomers.
- Define enantiomers and racemic mixtures and recognize compounds capable of exhibiting these structures.
- Draw pairs of enantiomers with one chiral carbon, using wedges/dashes and Fisher projections.
- Draw both the R and S enantiomer of Thalidomide and report on the difference in biological activity.

UNIT 4: Organic Halogen Compounds: Substitution/Elimination Reactions

Summary and Rationale

This unit will introduce substitution reactions and elimination reactions and the mechanisms by which they occur, including: nucleophilic substitution and the SN1 and SN2 mechanisms; elimination reactions and the E1 and E2 mechanisms. Finally, students will focus on polyhalogenated aliphatic compounds and their effect on the environment.

Recommended Pacing

5 days

State Standards

HS-PS1-1 - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	
Clarification Statement	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.
Assessment Boundary	Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.
HS-PS1-2 - Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	
Clarification Statement	Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.
Assessment Boundary	Assessment is limited to chemical reactions involving main group elements and combustion reactions.
HS-PS1-3 - Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	
Clarification Statement	Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.
Assessment Boundary	Assessment does not include Raoult's law calculations of vapor pressure.
HS-PS1-4 - Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	
Clarification Statement	Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.
Assessment Boundary	Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.
HS-PS1-6 - Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.	
Clarification Statement	Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.
Assessment Boundary	Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.

HS-PS2-6 - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	
Clarification Statement	Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.
Assessment Boundary	Assessment is limited to provided molecular structures of specific designed materials.
HS-PS4-4 - Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	
Clarification Statement	Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.
Assessment Boundary	Assessment is limited to qualitative descriptions.
HS-ESS3.4 - Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.	
Clarification Statement	Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).
HS-LS2.7 - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	
Clarification Statement	Examples of human activities can include urbanization, building dams, and dissemination of invasive species.

Instructional Focus

Unit Enduring Understandings

- The type of bond between carbon atoms determines the reactivity of the hydrocarbons.
- Many reactions proceed through a series of elementary steps referred to as the reaction mechanism.
- Several mechanisms may be postulated for most reactions, and experimentally determining the dominant pathway of such reactions is a central activity of chemistry.
- Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism and by providing a new and faster mechanism.

Unit Essential Questions

- What is the role a catalyst plays in increasing the reaction rate?
- By which mechanism can nucleophilic substitution reactions occur?
- How do we know whether an elimination or substitution reaction will occur when two reactants are mixed?

Objectives

Students will know & be able to:

- Determine the relative stabilities of carbocations.
- Write general and specific examples illustrating the mechanism of electrophilic addition of hydrogen halides, halogens, and water to alkenes.
- Identify catalysts involved in electrophilic addition.
- Analyze the role catalysts play in electrophilic addition.

UNIT 5: Spectroscopy and Structure Determination

Summary and Rationale

This unit will give a brief overview of spectroscopy, how it works and how spectra are used to determine the structure of organic compounds. The focus will not only be on the basic ideas behind spectroscopy, but also a survey of how spectroscopy techniques are utilized: nuclear magnetic resonance; infrared spectroscopy; how it works and how to read the spectra; UV-Vis spectroscopy and how it is used in organic chemistry; and mass spectrometry and its use in carbon dating.

Recommended Pacing

5 days

State Standards

HS-PS1-1 - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	
Clarification Statement	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.
Assessment Boundary	Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.
HS-PS1-2 - Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	
Clarification Statement	Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.
Assessment Boundary	Assessment is limited to chemical reactions involving main group elements and combustion reactions.
HS-PS1-3 - Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	
Clarification Statement	Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.
Assessment Boundary	Assessment does not include Raoult's law calculations of vapor pressure.
HS-PS1-4 - Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	
Clarification Statement	Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.
Assessment Boundary	Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.
HS-PS1-6 - Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.	
Clarification Statement	Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.
Assessment Boundary	Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.

HS-PS2-6 - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	
Clarification Statement	Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.
Assessment Boundary	Assessment is limited to provided molecular structures of specific designed materials.
HS-PS4-4 - Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	
Clarification Statement	Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.
Assessment Boundary	Assessment is limited to qualitative descriptions.
HS-ESS3.4 - Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.	
Clarification Statement	Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).
HS-LS2.7 - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	
Clarification Statement	Examples of human activities can include urbanization, building dams, and dissemination of invasive species.

Instructional Focus

Unit Enduring Understandings

- Highlighting the ways structure will determine function.

Unit Essential Questions

- What is the importance of spectroscopy?
- What type of information does each type of spectroscopy provide?

Objectives

Students will know & be able to:

- Describe how spectroscopy works
- Determine the number of peaks and their relative areas
- Analyze a NMR spectrum and describe the molecule's properties/functional groups
- Explain how IR spectroscopy works using the idea of energy absorption
- Explain how UV-Vis is used to detect conjugation and other functional groups
- Explain how carbon dating relates to mass spectrometry