Washington Township School District

The mission of the Washington Township Public Schools *is to provide a safe, positive, and progressive educational environment that provides opportunity for all students to attain the knowledge and skills specified in the NJ Learning Standards at all grade levels, so as to ensure their full participation in an ever-changing world as responsible, self-directed and civic-minded citizens.*

Course Title:	**Fundamentals of Organic Chemistry**
Grade Level(s):	**11th and 12th**

Duration:	*Full Year:*	**x**	*Semester:*		*Marking Period:*	
Course Description:	This course provides an introduction to Organic Chemistry, focusing primarily on the basic principles necessary to understand the structure and reactivity of organic molecules. The course emphasizes active participation in team work and creative problem-solving skills. Upon completion, students should be able to demonstrate an understanding of the fundamental concepts of organic chemistry and will be well-prepared to succeed in a collegiate level organic chemistry course.					
Grading Procedures:	Tests - 50% Quizzes - 20% Team Problem Solving - 20% Independent Practice - 10%					
Primary Resources:	Get Ready for Organic Chemistry, Second Edition by Joel Karty					

Washington Township Principles for Effective Teaching and Learning

- Implementing a standards-based curriculum
- Facilitating a learner-centered environment
- Using academic target language and providing comprehensible instruction
- Adapting and using age-appropriate authentic materials
- Providing performance-based assessment experiences
- Infusing 21st century skills for College and Career Readiness in a global society

Designed by:	Amy Muermann
Under the Direction of:	Dr. Patricia Hughes

Written: ___**July 2017**_____

Revised: _____

BOE Approval: _____

Unit Title: UNIT 1 – Organic Nomenclature

Unit Description: This unit will provide the student with an introduction to the structure and nomenclature of common organic functional groups including alkanes, alkenes, alkynes, alcohols, thiols, amines, and important carbonyl and carboxyl compounds.

Unit Duration: 5-6 weeks

Desired Results

Standard(s): HS-PS1-1

Indicators: PS1.A – Structure and Properties of Matter, ETS1.C – Optimizing the Design Solution

Understandings:
Students will understand that…

- It is necessary to learn essential and fundamental vocabulary related to organic compounds and organic chemistry.
- Organic molecules are often represented by line skeleton drawings in which the placement of the atoms is assumed based on certain rules.
- Organic molecules can be categorized by the presence of functional groups.
- Organic molecules are named systematically according to IUPAC rules.

Essential Questions:

How Do Organic Chemists Name and Categorize Molecules?

Assessment Evidence

Performance Tasks:

- Use the periodic table as a model to predict the common bonding patterns for elements in organic compounds.
- Construct and revise names for organic compounds based on systematic application of IUPAC rules.
- Develop models to illustrate the positions of atoms in named organic compounds.

Other Evidence:

Unit 1 Team Problem Solving Exercises

"FUN"ctional Group Team Competition

Unit 1: Quiz 1 -Hydrocarbons

Unit 1: Quiz 2 – Functional Groups

Benchmarks:

Unit 1 Test

Learning Plan

Unit 1: Module 1 – Hydrocarbons (2-3 weeks)

- Draw carbon line skeleton diagrams.
- Distinguish between saturated and unsaturated hydrocarbons.
- Correctly identify and count the longest carbon chain in an organic molecule.
- Assign the appropriate prefix for a hydrocarbon name based on the number of carbons in the longest chain.
- Identify and name common alkyl substituents.
- Accurately name alkanes, cycloalkanes, alkenes, alkynes, and aromatic compounds by the systematic application of IUPAC rules.

Unit 1: Module 2 – Functional Groups (2-3 weeks)

- Identify the following organic functional groups: alkyl halides, alcohols, thiols, ethers, epoxides, aldehydes, ketones, carboxylic acids, acid anhydrides, esters, acyl halides, amines, amides & other nitrogen-containing groups.
- Make connections between structures and properties of functional groups.
- Accurately name organic molecules containing functional groups by the systematic application of IUPAC rules.
- Build and share structures representing named organic molecules.

Suggeted activities include but are not limited to:

Textbook Reading:
Modern Chemistry (Tro) - Chapter 20

Textbook Practice Problems:
Modern Chemistry (Tro) **–** pg. 945-949 q. 43-90

Online Reading and Practice Problems:
https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/nomen1.htm
http://www.chem.ucalgary.ca/courses/351/WebContent/orgnom/structureToName.html
http://www.chembio.uoguelph.ca/educmat/chm19104/nomenclature/quizes.html

Video Analysis:
Crash Course Chemistry #40 - #44: “Hydrocarbon Power”, “Alkenes and Alkynes”, “Aromatics and Cyclic Compounds”, “Hydrocarbon Derivatives”, “Nomenclature”

Resources:
NGSS
NJSLS
Tro, Nivaldo J., *Chemistry: A Molecular Approach*. Pearson, 2008.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): PS1.A “Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. ”	
4.0	**Students will be able to:** • **Identify common organic functional groups, describe their properties, and explain how these properties are related to the structure.**
3.0	**Students will be able to:** • **Identify common organic functional groups and describe their properties.**
2.0	**Students will be able to:** • **Identify common organic functional groups.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): ETS1.C “Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.”	
4.0	**Students will be able to:** • **Derive correct systematic names based on the application of IUPAC rules for organic hydrocarbon molecules, organic molecules containing heteroatoms, and organic molecules containing multiple functional groups.**
3.0	**Students will be able to:** • **Derive correct systematic names based on the application of IUPAC rules for organic hydrocarbon molecules and organic molecules containing heteroatoms.**
2.0	**Students will be able to:** • **Derive correct systematic names based on the application of IUPAC rules for organic hydrocarbon molecules.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments in order to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Special Needs Learners	Follow IEP modifications and work with special education department to create modifications and use Differentiated Instruction Activities. http://www.nj.gov/education/udl/

Interdisciplinary Connections

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),(HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),(HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4),(HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),

Integration of 21st Century Skills

Indicators:

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit Title: UNIT 2 – Organic Structures

Unit Description: This unit will provide the student with the skills and techniques needed to represent organic molecules with 2-dimensional and 3-dimensional line drawings.

Unit Duration: 4-5 weeks

Desired Results

Standard(s): HS-PS1-1, HS-PS1-3, HS-PS2-6

Indicators: PS1.A – Structure and Properties of Matter, PS2.B – Types of Interactions, ETS1.C – Optimizing the Design Solution

Understandings:

Students will understand that…

- Lewis structures are used to represent molecules and can be drawn based on the information contained in a molecular formula.
- Formal charge is used as a way of keeping track of electrons in a molecule.
- Some structures are hybrids of two or more resonance contributors.
- VSEPR theory can be used to predict molecular geometry and orbital hybridization.
- Dash-wedge notation is used to draw 3-dimensional representations of organic molecules.
- Isomers are different molecules with the same molecular formula.
- A molecule's stereochemistry must always be considered since subtle differences in spatial arrangements can produce major effects.
- A chiral center is a tetrahedral atom bonded to four other groups.
- Enantiomers are stereoisomers that are mirror images, while diastereomers are stereoisomers that are not mirror images.

Essential Questions:

How Do Organic Chemists Draw and Depict Molecules?

Assessment Evidence

Performance Tasks:

- Construct and revise Lewis Structures for organic compounds.
- Use the periodic table as a model to identify atoms with irregular bonding patterns and assign formal charges.
- Develop models to illustrate three dimensional organic molecules.
- Analyze organic structures to determine relationships between pairs of enantiomers and diastereomers.

Other Evidence:

Unit 2 Team Problem Solving Exercises

Model and Draw 3-Dimensional Molecular Representations Using Molecular Modeling Kit

Unit 2: Quiz 1 – Organic Structures

Unit 2: Quiz 2 – Stereochemistry

Benchmarks:

Unit 2 Test

Learning Plan

Unit 2: Module 1 – Organic Structures (2 weeks)

- Draw Lewis structures for organic molecules.
- Identify irregular bonding patterns and assign formal charges.
- Draw all resonance contributors for an organic molecule.
- Distinguish between resonance structures, conformers and isomers.
- Draw all possible structural isomers given a chemical formula.

Unit 2: Module 2 – Stereochemistry (2-3 weeks)

- Draw and analyze 3D representations of organic molecules using dash-wedge notation.
- Define and identify stereocenters and chiral centers.
- Distinguish between chiral and achiral molecules.
- Define and identify enantiomers and diastereomers.
- Draw all stereoisomers of a chiral molecule.

Suggeted activities include but are not limited to:

Textbook Reading:
Get Ready for Organic Chemistry (Karty) – Chapters 2, 3, and 4

Textbook Practice Problems:
Get Ready for Organic Chemistry (Karty) – pg. 41-43 q. 2.1-2.10, pg. 85-87 q.3.1-3.6**,** pg. 120-121 q. 4.1-4.7

Online Reading and Practice Problems:
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_05%3A_Stereochemistry_at_Tetrahedral_Centers
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Questions/General/resnce1.htm
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Jmol-11/hbrdprb2.htm
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Jmol-11/hbrdprb1.htm
http://legacy.chemgym.net/as_a2/topics/isomerism/quiz_1.html
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Questions/Stereocem/symmetr2.htm
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Questions/Stereocem/cipnomen1.htm
http://www.colby.edu/chemistry/OChem/STEREOCHEM/index.html#choices
https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Questions/Stereocem/rscnfg1.htm
http://www.chem.uiuc.edu/weborganic/organictutorials.htm
http://www.utdallas.edu/~scortes/ochem/OChem1_Lecture/exercises/ch5_stereo1.pdf

Video Analysis:
“Chirality” by Ziff Edu

Resources:
NGSS
NJSLS
Karty, Joel, *Get Ready for Organic Chemistry: 2nd Edition*. Pearson, 2012.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): PS1.A "The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms."	
4.0	**Students will be able to:** • **Analyze all resonance contributors for a particular molecule and determine which will be the major contributor.**
3.0	**Students will be able to:** • **Draw a Lewis Structure for a given molecule including all resonance contributors, and assign formal charges to each atom.**
2.0	**Students will be able to:** • **Draw a Lewis Structure for a given molecule.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): PS2.B "Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects."	
4.0	**Students will be able to:** • **Model a chiral molecule with a molecular modeling kit and draw all of its stereoisomers (enantiomers and diastereomers) using dash-wedge notation.**
3.0	**Students will be able to:** • **Evaluate a three-dimensional representation of a molecule, identify chiral centers within the molecule, and determine whether they have (R) or (S) stereochemistry.**
2.0	**Students will be able to:** • **Draw a three-dimensional representation of a molecule using dash-wedge notation.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments in order to create challenge and foster discovery of knowledge
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Indicators:

ELA/Literacy –

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Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4),(HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),

Integration of 21st Century Skills

Indicators:

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
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Unit Title: UNIT 3 – Introduction to Mechanisms

Unit Description: This unit will provide the student with an introduction to reaction mechanisms, including free-energy diagrams, transition states, reactive intermediates, and the rules of curved arrow notation.

Unit Duration: 4-5 weeks

Desired Results

Standard(s): HS-PS1-2, HS-PS1-4

Indicators: PS1.B – Chemical Reactions, ETS1.C – Optimizing the Design Solution

Understandings:
Students will understand that…

- Organic compounds participate in three main types of chemical reactions.
- A reaction mechanism is a precise sequence of steps resulting in the conversion of reactants into products.
- Reactive intermediates are short-lived species which react as quickly as they are formed.
- Free energy diagrams are used to show reaction progress.
- A transition state is the highest energy state in a reaction, and cannot be isolated.
- The Hammond Postulate states that related species that are similar in energy are also similar in structure.
- Nucleophiles are electron-rich, and electrophiles are electron-poor.
- Curved arrows are used in organic chemistry to represent the movement of electrons.

Essential Questions:

How Do Organic Chemists Show the Movement of Electrons?

Assessment Evidence

Performance Tasks:

- Develop and use models to illustrate that energy of a molecule is associated with the relative positions of its particles as a reaction progresses.
- Construct and revise an explanation to illustrate a single-step organic mechanism such as a proton transfer based on knowledge of bonding patterns and electron movement.

Other Evidence:

Unit 3 Team Problem Solving Exercises

Unit 3: Quiz 1 - Mechanism Basics

Unit 3: Quiz 2 – Arrow Pushing Basics

Benchmarks:

Unit 3 Test

Learning Plan

Unit 3: Module 1 – Mechanism Basics (1-2 weeks)

- Classify organic reactions as substitution, addition, or elimination.
- Define and identify reactive intermediates.
- Distinguish between carbocations, carbanions, carbenes and carbon radicals.
- Define reaction mechanism.
- Distinguish between reactive intermediates and transition states.
- Draw and interpret free energy diagrams.

Unit 3: Module 2 – Arrow Pushing Basics (2-3 weeks)

- Define and identify nucleophiles and electrophiles.
- Recognize nucleophilic and electrophilic centers within a molecule.
- Explain rules for curved arrow notation.
- Draw curved arrows to illustrate proton transfer mechanisms.
- Draw curved arrows to illustrate carbocation rearrangement mechanisms.

Suggeted activities include but are not limited to:

Textbook Reading:
Get Ready for Organic Chemistry (Karty) – Chapter 5

Textbook Practice Problems:
Get Ready for Organic Chemistry (Karty) – pg. 151-154 q. 5.1-5.7

Online Reading and Practice Problems:
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_05%3A_Stereochemistry_at_Tetrahedral_Centers
http://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/questions/general/react1.htm
https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/questions/General/polarbnd.htm
https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/questions/Match/match6n.htm
https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/questions/Match/match6.htm
http://www.reed.edu/chemistry/roco/Arrows/curved_problems.html

Video Analysis:
"Practice: Electrophiles and Nucleophiles" – Dr. Benjamin Norris, "Identifying Nucleophilic and Electrophilic Centers" – Khan Academy, "Intro to Organic Mechanisms" – Khan Academy

Resources:
NGSS
NJSLS
Karty, Joel, *Get Ready for Organic Chemistry: 2nd Edition*. Pearson, 2012.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): PS1.B - "Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy."	
4.0	**Students will be able to:** • **Draw a free-energy diagram for a multi-step endergonic or exergonic reaction and identify the transition states and intermediates.**
3.0	**Students will be able to:** • **Interpret free-energy diagrams to identify endergonic and exergonic reactions.**
2.0	**Students will be able to:** • **Define endergonic and exergonic reactions.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): PS1.B - "The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions."	
4.0	**Students will be able to:** • **Draw a mechanism using curved arrow notation illustrating the loss of a leaving group to form a carbocation, followed by a nucleophilic attack.**
3.0	**Students will be able to:** • **Show a nucleophile attacking an electrophile using curved arrow notation.**
2.0	**Students will be able to:** • **Identify nucleophiles and electrophiles.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments in order to create challenge and foster discovery of knowledge
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Interdisciplinary Connections

Indicators:

ELA/Literacy –

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Mathematics -

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MP.4 Model with mathematics. (HS-PS1-4),(HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),

Integration of 21st Century Skills

Indicators:

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
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Unit Title: UNIT 4 – Molecular Stability

Unit Description: This unit will provide the student with an overview of the various electronic effects and steric effects which, taken together, determine the relative stability of an organic species.

Unit Duration: 4 weeks

Desired Results

Standard(s): HS-PS1-3, HS-PS2-6, HS-PS3-4

Indicators: PS1.A – Structure and Properties of Matter, PS2.B – Types of Interactions.

Understandings:

Students will understand that…

- Induction is the permanent displacement of shared electrons toward a more electronegative atom or group.
- Electron donating groups help to stabilize a positive charge, and electron withdrawing groups help to stabilize a negative charge.
- Resonance allows for electron delocalization which lowers the overall energy and stabilizes a molecule.
- Due to resonance, both positive and negative charges are more stable at allylic and benzylic positions.
- Saytzeff's Rule states that the major product in an elimination reaction will be the most substituted alkene since more highly substituted alkenes are more stable.
- Due to resonance, conjugated dienes are more stable than isolated or cumulate dienes.
- Aromatic compounds such as benzene display much more stability than predicted by the simple resonance delocalized structure.
- Hyperconjugation is a stabilizing interaction between an empty p orbital or pi bond and adjacent sigma bonds.
- Steric hindrance is the interference of bulky substituents with each other, and hindered reactions proceed more slowly, or not at all.
- Ring strain is the instability that exists when bonds in a cyclic molecule form angle that are abnormal.

Essential Questions:

How Do Organic Chemists Determine Reactivity?

Assessment Evidence

Performance Tasks:

- Apply scientific principles and evidence to analyze the relative stabilities of organic structures.
- Plan and conduct an investigation to compare different organic structures to infer their reactivities.

Other Evidence:

Unit 4 Team Problem Solving Exercises

Team Competition – Jeopardy: https://www.superteachertools.us/jeopardyx/jeopardy-review-game.php?gamefile=2267372

Unit 4: Quiz 1 – Electronic Effects

Unit 4: Quiz 2 – Steric Effects

Benchmarks:

Unit 4 Test, Midterm Exam

Learning Plan

Unit 4: Module 1 – Electronic Effects (2 weeks)

- Define and identify electron donating and withdrawing groups.
- Recognize and evaluate inductive effects within a molecule.
- Evaluate the effect of resonance on molecular stability.
- Define and identify conjugated systems.
- Define and identify aromatic molecules.
- Analyze the effect of hyperconjugation on molecular stability.

Unit 4: Module 2 – Steric Effects (2 weeks)

- Define steric hindrance and recognize molecules which are sterically hindered.
- Compare the relative stabilities of mono-, di-, tri- and tetra-substituted alkenes.
- Define and identify ring strain.
- Recognize and identify the two stable conformers of cyclohexane – chair and boat.

Suggeted activities include but are not limited to:

Textbook Reading:
Get Ready for Organic Chemistry (Karty) – Chapter 6

Textbook Practice Problems:
Get Ready for Organic Chemistry (Karty) – pg. 191-192 q. 6.1-6.13

Online Reading and Practice Problems:
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_14%3A_Conjugated_Compounds_and_Ultraviolet_Spectroscopy/14.01_Stability_of_Conjugated_Dienes%3A__Molecular_Orbital_Theory
http://www.masterorganicchemistry.com/2012/03/07/7-factors-that-stabilize-positive-charge-in-organic-chemistry/
http://www.masterorganicchemistry.com/2012/02/27/7-factors-that-stabilize-negative-charge-in-organic-chemistry/
http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Questions/Match/aromat10.htm
http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Questions/Match/aromat11.htm

Video Analysis:
"Carbocation Stability and Hyperconjugation in Organic Chemistry" – Knowbee, "Alkene Stability - Most Stable, Rank / Order - Cis & Trans Practice - Organic Chemistry" – The Organic Chemistry Tutor, "Stability of Conjugated Systems" – AK Lectures, "Carbocation rearrangement practice" – Khan Academy

Resources:
NGSS
NJSLS
Karty, Joel, *Get Ready for Organic Chemistry: 2nd Edition*. Pearson, 2012.

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): PS2.B "Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects."	
4.0	**Students will be able to:** • **Determine the contribution of all relevant electronic effects to the molecular stability of two different molecules, and determine which is the most reactive.**
3.0	**Students will be able to:** • **Determine the contribution of all relevant electronic effects to molecular stability, including: electron donating or withdrawing groups, resonance, conjugation, aromaticity, and hyperconjugation.**
2.0	**Students will be able to:** • **Identify electron donating and electron withdrawing groups.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): PS3.B "Uncontrolled systems always evolve toward more stable states — that is, toward more uniform energy distribution."	
4.0	**Students will be able to:** • **Draw a correct mechanism for a carbocation rearrangement leading to a ring expansion.**
3.0	**Students will be able to:** • **Recognize when a carbocation rearrangement leading to a ring expansion is likely to occur because of ring strain.**
2.0	**Students will be able to:** • **Define ring strain.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments in order to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Special Needs Learners	Follow IEP modifications and work with special education department to create modifications and use Differentiated Instruction Activities. http://www.nj.gov/education/udl/

Interdisciplinary Connections

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),(HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),(HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4),(HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),

Integration of 21st Century Skills

Indicators:

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit Title: UNIT 5 – Nucleophilic Mechanisms

Unit Description: This unit will provide an overview of nucleophilic mechanisms, including nucleophilic addition to aldehydes and ketones, nucleophilic substitution (S_N1 and S_N2), and nucleophilic elimination (E1 and E2) reactions.

Unit Duration: 4 weeks

Desired Results

Standard(s): HS-PS1-2, HS-ETS1-2

Indicators: PS1-A – Structure and Properties of Matter, PS2-B – Types of Interactions, ETS1-C – Optimizing the Design Solution

Understandings:
Students will understand that…

- Nucleophilic strength can be predicted based on charge and periodic trends.
- A Grignard (orgomagnesium halide) reagent can be used to create new carbon to carbon bonds in an organic compound.
- Nucleophilic attack generally occurs as a backside attack.
- Water, in the presence of an acid or base, adds to a carbonyl in a reversible reaction to form a diol.
- A unimolecular nucleophilic substitution (S_N1) reaction occurs in two steps and involves the formation of a carbocation.
- S_N1 reactions often involve carbocation rearrangements.
- A bimolecular nucleophilic substitution (S_N2) reaction takes place in a single concerted step.
- S_N2 reactions are stereospecific and always result in inversion of the stereocenter.
- Elimination (E1 and E2) reactions often occur under the same conditions as substitution reactions – they are competing processes.
- Product mixtures can result in elimination reactions with more than one adjacent hydrogen, and Saytzeff's Rule can be used to predict the major product.
- Structure of the substrate and nucleophile, and the reaction conditions all play a part in determining which type of reaction will occur – S_N1, S_N2, E1 or E2.

Essential Questions:

How Do Organic Chemists Predict and Represent Nucleophilic Mechanisms?

Assessment Evidence

Performance Tasks:

- Construct and revise an explanation for the outcome of a nucleophilic mechanism based on knowledge of the patterns of chemical properties.
- Develop a model to illustrate electron movement during a reaction involving a nucleophilic mechanism.

Other Evidence:

Unit 5 Team Problem Solving Exercises

Unit 5: Quiz 1 – Nucleophilic Addition & Substitution

Unit 5: Quiz 2 – S_N1, S_N2, E1 & E2 Reactions

Benchmarks:

Unit 5 Test

Learning Plan

Unit 5: Module 1 – Nucleophilic Addition and Substitution (2 weeks)

- Compare and contrasting nuclophilic strength and base strength.
- Define and identify Grignard reagents.
- Write and interpret nucleophilic addition mechanisms.
- Write and interpret S_N1 reaction mechanisms.
- Write and interpret S_N2 reaction mechanisms.
- Compare and contrast S_N1 and S_N2 mechanisms.

Unit 5: Module 2 – S_N1, S_N2, E1 & E2 Reactions (2 weeks)

- Write and interpret E1 reaction mechanisms.
- Write and interpret E2 reaction mechanisms.
- Compare and contrast E1 and E2 mechanisms.
- Analyze combinations of nucleophile and substrate to determine which mechanisms will occur.

Suggeted activities include but are not limited to:

Textbook Reading
Get Ready for Organic Chemistry (Karty) - Chapters 7 and 8
Organic Chemistry (Wade & Simek) – Chapter 10 pg. 475-481, Chapter 6 pg. 260-286, Chapter 7 pg. 318-331, Chapter 11 pg. 527-529

Textbook Practice Problems
Get Ready for Organic Chemistry (Karty) - pg. 220-222 q. 7.1-7.6, pg. 253-255 q. 8.1-8.10
Organic Chemistry (Wade & Simek) – pg. 480 q. 10-13 & 10-14, pg. 481 q. 10-15, pg. 286 q. 6-27, pg. 328 q. 7-24, pg. 329 q. 7-25, pg. 530 q. 11-22

Online Reading and Practice Problems:
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_11%3A_Reactions_of_Alkyl_Halides%3A_Nucleophilic_Substitutions_and_Eliminations
http://www.masterorganicchemistry.com/2012/11/21/deciding-sn1sn2e1e2-1-the-substrate/
http://www.masterorganicchemistry.com/2012/11/30/deciding-sn1sn2e1e2-2-the-nucleophilebase/
http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Questions/MechPrb/mechprb.htm
https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/questions/FuncReac/halidrx1.htm
https://www.sporcle.com/games/sproutcm/sn1-sn2-or-neither
https://www.sporcle.com/games/sproutcm/sn1-sn2-e1-e2-or-none

Video Analysis:
"Acid and base catalyzed formation of hydrates and hemiacetals" – Khan Academy, "Practice Problem: Grignard Reactions" – Professor Dave Explains, "SN1 SN2 E1 E2 Reactions Multiple Choice Practice Test Exam Review Problems" – The Organic Chemistry Tutor, "Choosing SN1 SN2 E1 E2 Reaction Mechanism Given Reactant and Product" – Leah4sci

Resources:
NGSS
NJSLS
Karty, Joel, *Get Ready for Organic Chemistry: 2nd Edition*. Pearson, 2012.
Wade, L.G. and Simek, Jan, *Organic Chemistry: 9th Edition*, Pearson, 2017

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): PS1.A "Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects."	
4.0	**Students will be able to:** • **Predict the product and write a complete mechanism for the addition of a Grignard reagent to an aldehyde or ketone.**
3.0	**Students will be able to:** • **Predict the product for the addition of a Grignard reagent to an aldehyde or ketone.**
2.0	**Students will be able to:** • **Identify a Grignard reagent.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): ETS1.C "Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed."	
4.0	**Students will be able to:** • **Evaluate given reagents to determine whether the resulting reaction will be S_N1, S_N2, E1 or E2, and write the complete mechanism for the reaction.**
3.0	**Students will be able to:** • **Identify S_N1, S_N2, E1 and E2 reactions when shown the reactants and products.**
2.0	**Students will be able to:** • **Define S_N1, S_N2, E1 and E2 reactions.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments in order to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Special Needs Learners	Follow IEP modifications and work with special education department to create modifications and use Differentiated Instruction Activities. http://www.nj.gov/education/udl/

Interdisciplinary Connections

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),(HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),(HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4),(HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),

Integration of 21st Century Skills

Indicators:

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit Title: UNIT 6 – Electrophilic Mechanisms

Unit Description: This unit will provide an overview of electrophilic mechanisms, including electrophilic addition to alkenes and alkynes, and electrophilic aromatic substutution.

Unit Duration: 4-5 weeks

Desired Results

Standard(s): HS-PS1-2, HS-ETS1-2

Indicators: PS1-A – Structure and Properties of Matter, PS2-B – Types of Interactions, ETS1-C – Optimizing the Design Solution

Understandings:
Students will understand that…

- Pi electrons in double and triple bonds commonly attack electrophiles.
- In a hydrogenation reaction of an alkene, H_2 is added across the double bond, resulting in a saturated alkane.
- A hydrogenation reaction requires a metal catalyst such as Pt, Pd, or Ni.
- A special partially-deactivated catalyst must be used to stop the hydrogenation of an alkyne at the alkene stage.
- Hydrohalic acids such as HCl and HBr are commonly added across double and triple bonds in electrophilic addition mechanisms.
- Markovnikov's Rule states that in the addition of an acid to an alkene or alkyne, the acid hydrogen attaches to the carbon that already has the greater number of hydrogens attached.
- Alkenes form alcohols in the presence of aqueous acid via electrophilic addition.
- A vinylic alcohol product (enol) is unstable and immediately rearranges to form a ketone in a process called keto-enol tautomerism.
- Halogens add to alkenes via a halonium ion intermediate to produce vicinal dihalides with anti regiochemistry.
- If a halogenation reaction takes place in water, halohydrins are produced.
- Benzene rings will not engage in electrophilic addition, but participate in electrophilic aromatic substitution (EAS) reactions instead.
- EAS reactions require very strong electrophiles, so Lewis Acid catalysts are often added to increase electrophilic strength.
- Substituents on a benzene ring can affect further substitutions on that ring.

Essential Questions:

How Do Organic Chemists Predict and Represent Electrophilic Mechanisms?

Assessment Evidence

Performance Tasks:

- Construct and revise an explanation for the outcome of an electrophilic mechanism based on knowledge of the patterns of chemical properties.

Other Evidence:

Unit 6 Team Problem Solving Exercises

Unit 6: Quiz 1 – Electrophilic Addition

Unit 6: Quiz 2 – Electrophilic Aromatic Substitution

• Develop a model to illustrate electron movement during a reaction involving an electrophilic mechanism.	

Benchmarks:

Unit 6 Test

Learning Plan

Unit 6: Module 1 – Electrophilic Addition (2-3 weeks)

- Identify hydrogenation mechanisms for alkenes and alkynes.
- Write hydrohalogenation mechanisms for alkenes and alkynes.
- Write hydration mechanisms for alkenes and alkynes.
- Define and identify keto-enol tautomers.
- Write halogenation mechanisms for alkenes and alkynes.
- Write halohydration mechanisms for alkenes and alkynes

Unit 5: Module 2 – Electrophilic Aromatic Substitution (2 weeks)

- Write the basic electrophilic aromatic substitution mechanism.
- Evaluate substituent effects on electrophilic aromatic substitution reactions.
- Devise a synthetic scheme for a desired multi-substituted aromatic product.

Suggeted activities include but are not limited to:

Textbook Reading
Organic Chemistry (Wade & Simek) – Chapter 8 pg. 359-365, pg. 370-372, and pg. 382-388, Chapter 9 pg. 443-446, and Chapter 17 pg. 809-837

Textbook Practice Problems
Organic Chemistry (Wade & Simek) – pg. 365-366 q. 8-1 & 8-2, pg. 372 q. 8.5 & 8.6, pg. 385 q. 8-17 & 8-18, pg. 387 q. 8-19, pg. 388 q. 8-21, pg. 446 q. 9-15 & 9-16, pg. 870 q. 17-50 & 17-52

Online Reading and Practice Problems:
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_08%3A_Alkenes%3A_Reactions_and_Synthesis/8.06_Reduction_of_Alkenes%3A_Hydrogenation
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_09%3A_Alkynes%3A_An_Introduction_to_Organic_Synthesis/9.05_Reduction_of_Alkynes
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_08%3A_Alkenes%3A_Reactions_and_Synthesis/8.02_Halogenation_of_Alkenes%3A_Addition_of_X2
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_08%3A_Alkenes%3A_Reactions_and_Synthesis/8.03_Halohydrins_from_Alkenes%3A_Addition_of_HOX
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_09%3A_Alkynes%3A_An_Introduction_to_Organic_Synthesis/9.03_Reactions_of_Alkynes%3A_Addition_of_HX_and_X2
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(McMurry)/Chapter_16%3A_Chemistry_of_Benzene%3A_Electrophilic_Aromatic_Substitution
http://ww2.chemistry.gatech.edu/~collard/quiz/quiz8-1.htm
http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Questions/FuncReac/aromsub1.htm
https://www.stolaf.edu/depts/chemistry/courses/toolkits/247/js/aromatic/arosel.htm

Video Analysis:

"Alkene Reactions Practice Problems and Mechanism" – The Organic Chemistry Tutor, "Alkyne Reduction, H2, Lindlar's Catalyst, Li or Na & NH3, Cis & Trans Alkenes Reaction Mechanism" – The Organic Chemistry Tutor, "Alkyne Reaction Mechanism - Hydrogen Halides, Halogenation & Hydrohalogenation Pi Complex" – The Organic Chemistry Tutor, "Practice Problem: Electrophilic Aromatic Substitution Retrosynthesis" – Professor Dave Explains, "Hydride Shift, Ring Expansion, Carbocation Rearrangement, ALL IN ONE Example" – Leah4sci

Resources:
NGSS
NJSLS
Wade, L.G. and Simek, Jan, *Organic Chemistry: 9th Edition*, Pearson, 2017

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): ETS1.C "Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed."	
4.0	**Students will be able to:** • **Given the reagents and solvent, predict the products of an electrophilic addition reaction, and write a complete mechanism for the reaction.**
3.0	**Students will be able to:** • **Given the reagents and solvent, predict the products of an electrophilic addition reaction.**
2.0	**Students will be able to:** • **Define electrophilic addition.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): ETS1.C "Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed."	
4.0	**Students will be able to:** • **Devise a synthesis for the production of a substituted benzene product starting from a benzene ring.**
3.0	**Students will be able to:** • **Given the reagents and solvent, predict the products of an electrophilic aromatic substitution reaction to substituted benzenes.**
2.0	**Students will be able to:** • **Given the reagents and solvent, predict the products of an electrophilic aromatic substitution reaction to benzene.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments in order to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Special Needs Learners	Follow IEP modifications and work with special education department to create modifications and use Differentiated Instruction Activities. http://www.nj.gov/education/udl/

Interdisciplinary Connections

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),(HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),(HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4),(HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),

Integration of 21st Century Skills

Indicators:

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit Title: UNIT 7 – Free Radical Mechanisms

Unit Description: This unit will provide an introduction to free radicals and an overview of free radical mechanisms, including radical addition to alkenes and alkynes, carbon-centered radicals, and intramolecular radical cyclization reactions.

Unit Duration: 5 weeks

Desired Results

Standard(s): HS-PS1-2, HS-ETS1-2

Indicators: PS1-A – Structure and Properties of Matter, PS2-B – Types of Interactions, ETS1-C – Optimizing the Design Solution

Understandings:
Students will understand that…

- Free radicals are chemical species with an odd (unpaired) number of valence electrons.
- Like carbocations, free radicals are electron deficient species. Therefore, factors affecting their stability are the same as for carbocations.
- Homolytic bond cleavage is the even breaking of a bond, where one electron stays with each atom.
- Free radical chain reactions consist of initiation, propagation, and termination steps.
- Free radical initiators are compounds with weak bonds (i.e. peroxides) that undergo homolytic cleavage to form radicals.
- Free radical propagation steps often involve hydrogen abstraction or the addition of the radical to pi bonds.
- Free radical termination occurs when two radical species react with each other to form a stable non-radical species.
- Free radical inhibitors slow or stop a free radical chain reaction.
- N-bromosuccinimide (NBS) is a common reagent for free radical bromination at the allylic position.
- Radical addition of HBr to alkenes and alkynes results in anti-Markovnikov regiochemistry.
- Many radical reactions involve the loss of a small, stable molecule such as N_2 or CO_2 which is called fragmentation.
- A radical initiator and an alkyl tin hydride can be used to abstract a halogen to form carbon-based radicals.
- When there is a radical and a pi bond in the same molecule, there is the possibility for intramolecular radical addition, which will lead to a cyclic product.
- Organic synthesis is the process of creating a desired organic molecule from simpler organic molecules.

Essential Questions:

How Do Organic Chemists Predict and Represent Free Radical Mechanisms?

Assessment Evidence

Performance Tasks:	**Other Evidence:**
• Construct and revise an explanation for the outcome of a free radical mechanism based on knowledge of the patterns of chemical properties. • Develop a model to illustrate electron movement during a reaction involving a free radical mechanism.	Unit 7 Team Problem Solving Exercises Unit 7: Quiz 1 – Free Radicals Unit 7: Quiz 2 – Radical Mechanisms

Benchmarks:

Unit 7 Test

Learning Plan

Unit 7: Module 1 – Free Radicals (2 weeks)

- Define and identify free radicals.
- Evaluate the relative stabilities of radical species.
- Identify the steps in a free radical chain reaction mechanism.
- Write a mechanism for the free radical halogenation of an alkane.

Unit 7: Module 2 – Free Radical Mechanisms (3 weeks)

- Write and interpret mechanisms for allylic bromination of alkenes.
- Write and interpret mechanisms for bromination by free radical addition of HBr.
- Write and interpret mechanisms for generation of carbon-centered radicals.
- Write and interpret mechanisms for intramolecular radical cyclization reactions.

Suggeted activities include but are not limited to:

Textbook Reading
Organic Chemistry (Wade & Simek) – Chapter 4 pg. 157-161, Chapter 8 pg. 366-369, and Chapter 15 pg. 728-730

Textbook Practice Problems
Organic Chemistry (Wade & Simek) – pg. 158 q. 4-1, pg. 160 q. 4-2, pg. 369 q. 8-4, pg. 729 q. 15-9, pg. 730 q. 15-10 and 15-11

Online Reading and Practice Problems:
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(Smith)/Chapter_15%3A_Radical_Reactions
http://www.masterorganicchemistry.com/2013/09/06/initiation-propagation-termination/
https://www.proprofs.com/quiz-school/story.php?title=organic-chem-ch-15-radical-reactions
https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/questions/General/halalkan.htm
http://www.mendelset.com/chapters/1084/solomons-10e-chapter-10-radical-reactions

Video Analysis:
"Free Radicals" – Professor Dave Explains, "Free Radical Substitution Reactions" – Allery Chemistry, "Photobromination of Alkyl Benzenes" – Hegelrast, "What IS Organic Synthesis" – Chemistryisthegame, "Free Radical Substitution Reactions, Initiation, Propagation, Termination, NBS, Allylic Halogenation" – The Organic Chemistry Tutor

Resources:
NGSS
NJSLS
Wade, L.G. and Simek, Jan, *Organic Chemistry: 9th Edition*, Pearson, 2017

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): ETS1.C "Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed."	
4.0	**Students will be able to:** • **Write a complete mechanism for the free radical halogenation of an alkane.**
3.0	**Students will be able to:** • **Classify each step in a free radical chain reaction as either initiation, propagation, or termination.**
2.0	**Students will be able to:** • **Identify free radicals from their Lewis structures.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): ETS1.C "Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed."	
4.0	**Students will be able to:** • **Write a complete mechanism for the free radical intramolecular cyclization of 6-bromohex-1-ene starting with the initiation of AIBN, showing its subsequent reaction with tributyl tin hydride, proceeding to the bromine abstraction and finally the cyclization reaction.**
3.0	**Students will be able to:** • **Write a mechanism showing the initiation of AIBN and its subsequent reaction with tributyl tin hydride.**
2.0	**Students will be able to:** • **Write a mechanism showing the initiation of AIBN.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments in order to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Special Needs Learners	Follow IEP modifications and work with special education department to create modifications and use Differentiated Instruction Activities. http://www.nj.gov/education/udl/

Interdisciplinary Connections

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),(HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),(HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4),(HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7),(HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),

Integration of 21st Century Skills

Indicators:

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit Title: UNIT 8 – Real-World Applications

Unit Description: This unit exposes students to some of the current frontiers in real-world organic chemistry research, focusing on four main areas: polymers, fullerenes and graphene, pharmaceutical chemistry, and environmental toxicology.

Unit Duration: 4 weeks

Desired Results

Standard(s): HS-PS1-2, HS-PS1-3, HS-PS2-6, HS-ESS3-3, HS-ESS3-4, HS-ETS1-2

Indicators: PS1-A – Structure and Properties of Matter, PS1-B – Chemical Reactions, PS2-B – Types of Interactions, ESS3.C – Human Impacts on Earth Systems, ETS1-C – Optimizing the Design Solution

Understandings:
Students will understand that…

- A polymer is a large molecule built up by repetitive covalent bonding of smaller molecules called monomers.
- Polymers generally do not have a well-defined structure or molecular weight.
- Polymers have an extraordinary range of physical properties.
- There are two main types of polymerization reactions – chain-reaction (or addition) and step-reaction (or condensation).
- Fullerenes and graphene are allotropes of carbon recently discovered within the past few decades.
- Fullerenes and graphene have extraordinary mechanical properties and hold great promise for future technologies.
- Pharmaceutical Chemistry is the study and development of new drugs.
- Despite technological advances, modern drug discovery is a lengthy and very expensive process.
- Most effective drugs are small molecules (less than 500 daltons).
- Computer-generated structure-based models are an important part of the modern drug discovery process.
- Environmental Toxicology is the study of sources, pathways, transformations, and effects of chemicals that are harmful in the environment.
- The field of environmental toxicity really began with the release of Rachel Carson's book, "Silent Spring" in 1962.
- Environmental pollution can be divided into pollution of water supplies, the atmosphere, and the soil.
- The dose of a chemical determines its overall effects and most chemicals can be dangerous at high exposures.

Essential Questions:

What Are Some of the Things Organic Chemists Are Working On Today?

Assessment Evidence

Performance Tasks:

- Analyze and describe the strengths and weaknesses of recent advances in the field of organic chemistry with respect to each criterion and constraint, as well as social and cultural acceptability and environmental impacts.
- Describe possible barriers to implementing new technologies, such as cultural, economic, or other sources of resistance to potential solutions.

Other Evidence:

Final Project: Independently Researched Paper and Presentation

Unit 8: Quiz 1 – Polymers, Fullerenes & Graphene

Unit 8: Quiz 2 – Pharmaceutical Chemistry & Environmental Toxicology

Benchmarks:

Final Exam

Learning Plan

Unit 8: Module 1 – Polymers, Fullerenes & Graphene (2 weeks)

- Define polymers and explain the importance of polymers in our society.
- Research and discuss the extraordinary range of physical properties in polymers.
- Identify the main types of polymerization reactions.
- Research and discuss the unusual properties of fullerenes & graphene.
- Model the structures of graphene, buckminsterfullerene, and carbon nanotubes.
- Research and discuss the tremendous promise of polymers, fullerenes & graphene for future technologies and smart materials.

Unit 8: Module 2 – Pharmaceutical Chemistry & Environmental Toxicology (2 weeks)

- Explore careers in pharmaceutical chemistry and environmental toxicology.
- Explain the drug discovery process.
- Research and discuss the use of computers to generate structure-based models in drug design.
- Evaluate the effects of anthropogenic activities on ecosystems and our environment.
- Describe the major pathways for toxins to enter our environment.
- Research and discuss the responsibility and privilege of organic chemists to design a brighter, healthier, safer future for our planet and the human race.

Suggested activities include but are not limited to:

Textbook Reading
Organic Chemistry (Wade & Simek) – Chapter 16 pg. 790-791, Chapter 26

Textbook Practice Problems
Organic Chemistry (Wade & Simek) – pg. 1306 q. 26-21 – 26-26

Online Reading and Practice Problems:
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(Smith)/Chapter_31%3A_Synthetic_Polymers
https://www.decodedscience.org/fullerenes-graphene-super-molecules-nanotechnology/49012
https://pharmchem.cop.ufl.edu/about/articles/what-is-pharmaceutical-chemistry/
http://www.toxicologyguide.com/886-environmental/

Video Analysis:

“Polymers” - Crash Course Chemistry #45, “From DNA to Silly Putty, the diverse world of polymers - Jan Mattingly” – TED-Ed, “Buckyball: Tiny Carbon Soccer Balls” – SciShow, “Graphene: The Next Big (But Thin) Thing” – SciShow, Graphene science | Mikael Fogelström | TEDxGöteborg” – TEDx Talks, “Carbon Nanotubes” – Nova, “Drug discovery and development process” – Michell Fern, “Air Pollution” – Bozeman Science, “Water Pollution” – Bozeman Science

Resources:
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Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): PS1.B "The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions."	
4.0	**Students will be able to:** • **Given a monomer, describe the type of polymerization reaction that will occur, and draw the structure of the resulting polymer.**
3.0	**Students will be able to:** • **Classify a given polymerization reaction as a chain or step reaction.**
2.0	**Students will be able to:** • **Define a polymer.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): ESS3.C "The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources."	
4.0	**Students will be able to:** • **Relate molecular structure to primary pathway for environmental pollutants.**
3.0	**Students will be able to:** • **Classify environmental pollutants by their primary pathway – air, water, or soil.**
2.0	**Students will be able to:** • **Define environmental toxicology.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
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