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| **Lesson Title :** Introduction to Organic Chemistry and Fuels | **Unit #:****1** | **Lesson #:****1** | **Activity #:****2** |
| **Activity Title:**  Organic Molecules – Structure and Properties |

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| **Estimated Lesson Duration:** | 5 class periods (47 minutes each) |
| **Estimated Activity Duration:** | 3 class periods |

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| **Setting:** | Chemistry classroom/lab. |

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| **Activity Objectives:** |

Upon completion of the activity, students will be able to:

* define organic chemistry terms such as hydrocarbons, saturated, and unsaturated.
* name simple organic molecules using IUPAC rules.
* sketch organic molecules if given the IUPAC names.
* translate organic compounds between their IUPAC names and their structural formulas, molecular formulas or expanded molecular formulas.
* identify, draw, and name simple branched isomers of alkanes.
* explain how octane ratings are calculated.
* identify functional groups (ethers, alcohols, aldehydes, etc.) related to fuel chemistry.
* rank functional groups from least oxidized to most oxidized.
* conduct a laboratory investigation to learn how carbon chain length and presence of OH groups (H-bonding) affects evaporation rate of organic molecules—an important factor in fuel volatility.

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| **Activity Guiding Questions:** |

* What is a hydrocarbon?
* How are organic molecules categorized?
* How are organic molecules named?
* What are isomers, and why do they matter with regard to fuels?
* Why is the octane number of a fuel important?
* How is octane number calculated?
* What are some chemicals that have been added to fuels to improve their octane rating?
* As a fuel gets oxidized, what are the products that might form if it doesn’t completely oxidize to CO2?
* How does the presence of different functional groups (such as an OH group) affect the properties of the organic compound (such as volatility, tendency to cause “knocking” in an engine, etc.)?
* How does carbon chain length affect properties of an organic compound (such as volatility, tendency to cause “knocking,” and existence of the compound as a solid, liquid, or gas at room temperature)?

| **Next Generation Science Standards (NGSS)**  |
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| **Science and Engineering Practices (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
| ☒ Asking questions (for science) and defining problems (for engineering) | ☒ Patterns |
| ☒ Developing and using models | ☒ Cause and effect |
| ☒ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☒ Analyzing and interpreting data | ☐ Systems and system models |
| ☒ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☒ Constructing explanations (for science) and designing solutions (for engineering) | ☒ Structure and function.  |
| ☐ Engaging in argument from evidence | ☐ Stability and change.  |
| ☒ Obtaining, evaluating, and communicating information  |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☒ Demonstrating Science Knowledge **(D)** |
| ☒ Interpreting and Communicating Science Concepts **(C)** |
| ☒ Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** |
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| **Standards for Mathematical Practice (Check all that apply)** |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☒ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☒ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

AP Chemistry Curriculum Framework 2013-14

* Big Idea 2: Chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions, or molecules and the forces between them.
	+ Essential Knowledge 2.A.1: The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures.
* Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
	+ Enduring Understanding 3.C: Chemical and physical transformations may be observed in several ways and typically involve a change in energy.
* Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
	+ Essential Knowledge 5.B.3: Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions.
	+ Enduring Understanding 5.D: Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy.
* Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.
* Science Practice 4: The student can plan and implement data collection strategies in relation to a particular scientific question.
* Science Practice 5: The student can perform data analysis and evaluation of evidence.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

* Student handout with outlined notes on Introductory Organic Chemistry and Fuels
* *Chemistry with Vernier* (Holmquist, Randall, and Volz) Experiment #9 -- “Evaporation and Intermolecular Attractions”
* Supplemental Lab Instructions Handout

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| **Teacher Advance Preparation:** |

* A handout is prepared with an outline for notes on introductory organic chemistry and fuels.
* The chemicals and lab equipment need to be set out for the students.
* Vernier probes and interfaces need to be made available for the lab.

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| **Activity Procedures:** |

* Organic chemistry nomenclature is introduced through a lecture/discussion, with students filling in the outline on the handout , making sketches of structural formulas, naming compounds, etc.
* With the lab, the technique for measuring the evaporation off the end of a probe by using a “wick” needs to be demonstrated for the students.
* For the lab, it is also essential that students be made aware of the safety concerns regarding a room full of chemicals that are both volatile and flammable. Any bottles or test tubes containing organic samples not being immediately used should be capped. There should be no open flames or sparks made by anyone, and the room should be well ventilated. The used alkanes should not be poured down the sink; they need to be disposed of according to recommended guidelines.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

* Student knowledge and understanding was informally and continually assessed during both the lecture/discussion and the lab, by walking around, looking at individual student work, and asking individual questions to ensure that students understood what was happening.
* A formative assessment was done on the lab portion by having students submit a 1-2 minute voice recording on Moodle answering two prompts relating to the temperature changes in the probe and the strength of intermolecular forces. Students were given feedback on their responses *before* writing up the whole lab (an important thing to do, as approximately 20% of the students had their thinking “backwards”—assuming that a large temperature drop in the probe meant strong intermolecular forces were being broken rather than weak ones—a common misconception.)

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.Refer to Activity Template for details. |

* See formative assessment section for support and feedback provided to different learners.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

* The most obvious shortcoming of the lesson was time! It would have helped to have one or two more bells to really let the organic nomenclature and functional group concepts “gel” for the students, to give the students additional time for practice, and to give them a more relaxed experience in the lab.
* A success of this lesson was having the same groups that were formed for the “challenge” activity work together on the lab. They collaborated nicely, sharing the data from their runs and enabling all the groups to gather more data in less time than if they were working alone.
* The lab activity was highly successful as a guided inquiry lab, engaging students in *thinking* about and *deciding* what data to collect and why. Their lab reports showed that they understood the relationship between molecular structure, intermolecular forces, and resulting volatility.
* The scaffolded outline/notes worked very well as a way of keeping the students engaged during what was essentially a lecture/discussion. They asked a lot of good questions as we proceeded, which showed me that they were making important connections. There were a lot of “aha” moments as they began to understand the logic behind names that they’ve heard before but didn’t really understand, such as “isopropyl alcohol.”
* If I were teaching the unit again, one thing I would try to do better is to take the time to remind the students at opportune intervals how the content we were learning fit in with the upcoming challenge and with the essential and guiding questions we identified a few days earlier. I think that providing such reminders would increase the *relevance factor* behind learning the content.