Unit Title: Periodic Trends	**Content Area:** Chemistry	**Grade Level:** High School

Unit Summary: Periodic trends give students a basis to begin understanding how and why elements interact. Without a clear understanding of these topics students cannot understand how or why compounds form. And if there is no knowledge of compounds then students cannot progress on to learning about chemical reactions. This unit will teach vocabulary terms such as valence electrons, stable octet, electronegativity, atomic radius, electron affinity, ion size, cations and anions that will continue to inform our discussions for the remainder of the year. Note, cations and anions may have been taught in the previous unit, but if these terms were left out then they should definitely be introduced now.

Cross Cutting Concepts:

1. Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
6. Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Science and Engineering Practices

2. Developing and using models
5. Using mathematics and computational thinking

Unit Essential Questions:	**Unit Enduring Understandings:**
• Why are some elements 'more reactive' than others? • What causes elements to form ions and how does this drive reactions?	• Elements create compounds in order to create a stable octet of electrons. Elements that are closer to a stable octet will react more readily to achieve this goal than others. • All elements want to achieve eight valence electrons. This drives not only the ions they form but also their compounds and chemical reactions.

Possible Student Misconceptions: Students often get confused with which trend follows which direction. There are two ways to combat this misconception: 1) have students constantly put into words the rationale for a trend or an answer they are giving. If they remember the reason the trend exists they won't have to memorize directions for trends. 2) have students make a 'study card' of each trend as they learn it. They may be able to recognize patterns of which trends are the same, similar or opposites.

NJCCCS: 5.2.12.A.3 In the Periodic Table, elements are arranged according to the number of protons (the atomic number). This organization illustrates commonality and patterns of physical and chemical properties among the elements. http://www.state.nj.us/education/cccs/standards/5/5-2-A.htm

NGSS Performance Expectations: Students who demonstrate understanding can…

- 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.]

Primary CCSS ELA/Literacy Connections: WHST.9-12.7Conduct 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-PS1-6) 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) 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)	**Primary CCSS Mathematics Connections:** MP.2 Reason abstractly and quantitatively. (HS-PS1-5), (HS-PS1-7) MP.4 Model with mathematics. (HS-PS1-8)

Lesson Pace & Sequence

Lesson Title/Number: Lesson 1: Atomic Radius and Effective Nuclear Charge	**Learning Objective(s):** Justify ordering elements in terms of their atomic radius using trends in effective nuclear charge	**Lesson Duration:** 40 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Do now: Have students either write the electron configuration of a series of elements from the same family or draw the Bohr model for a family. Classes can even be split in half so that both tasks are complete. Then have students look for patterns or similarities in the number of electrons, types of electrons and size of the Bohr model. Follow up their findings with the introduction of the term 'periodic trends'		Developing and Using Models Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)		
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	The teacher can get students motivated by explaining how important trends are to everyday life. Meteorologists predict weather by studying trends in weather over time. City planners predict traffic and housing needs by studying trends in human movements. Fashion designers predict upcoming changes in fashion by studying trends of consumers. If students study trends of elements they can begin to predict the properties of elements and later on the outcomes of chemical reactions.				Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Direct Instruction: The teacher needs to explain the term atomic radius through a mini lesson before giving students time with a hands on activity to explore this	• See example of line plot on Pg. 136 of Holt chemistry. For the sake of time you could split the class into groups and have each	Obtaining, Evaluating, and Communicating Information Communicate scientific and technical information (e.g. about the process of development and	PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in	

	term. Students should be given one or more visual representations of atomic radii. They can view slide shows of Bohr models from PSI Chemistry (linked right), they can build a model with straws cut to appropriate lengths and glued to a periodic table (3D model), or they can create a bar graph/line plot of atomic radii data (2D model that re-enforces graphing skills). The second two options take more time, but do enforce other skills and provide students with hands-on learning.	group only plot one period. They can then place their plots on the board to see that the trend is consistent for each period. • Link to slide show: https://njctl.org/courses/science/chemistry/periodic-trends/periodic-trends-presentation/# • Model of atomic radii (also can be done with straws and hot glue) http://www.friendlychemistry.com/Playdough%20Radius%20Activity.htm	the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) Developing and Using Models Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)	columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)PS2.B: Types of Interactions 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. (secondary to HS-PS1-1),(secondary to HS-PS1-3),(HS-PS2-6)	
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students must complete practice problems on atomic radii. As mentioned in the misconceptions section of this unit, students MUST be forced to explain trends they observe with textual explanations. Students should discuss how the addition of orbitals causes a larger radius and also changes effective nuclear charge, Zeff. Without reinforcement of the WHY behind the atomic radii trend students will forget that "radius decreases to the right."		Constructing Explanations and Designing Solutions Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)	ETS1.C: Optimizing the Design Solution 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. (secondary to HS-PS1-6)	Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Administer an exit ticket, quiz or other assessment	• Pg. 141 Holt Chemistry TE #4, 6, 11, 15			
Lesson Title/Number: Lesson 2 Trends with Ions		**Learning Objective(s):** • Order elements in terms of their ion size • Create an isoelectronic series for a given number of electrons • Determine how many valence electrons are in an element • Determine the charge of a given element			**Lesson Duration:** 80 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the***	***Science and Engineering Practices*** ***What specific practices do students need to use in order***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and***

learning objectives(s)? ****Elements do not have to be in conducted in sequence.***	***mastery of the learning objective(s)?***	***implementation of the learning activities?***	***to progress towards mastery of the learning objective(s)?***	***the learning objective(s)?***	***their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Have students make a list of what they already know about ions and the formation of ions from the previous unit. After a few minutes of silent brainstorming create a class list on the board. SECOND SUGGESTION: Have students write the electron configurations of a series of Nobel Gases. Ask what each of those electron configurations have in common.			PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Teacher leads class discussion. Ask students to put the knowledge they just shared in the do now into the context of the unit. Can they come up with any trends that deal with ions? Students may come up with some ideas but most will get stuck. It will be hard for them to find trends without knowledge of valence electrons and stable octets. These two ideas will ground the discussion for the entire lesson so start with these concepts. IF THE SECOND APPROACH WAS USED: This will also segue into stable octets. Hopefully students will realize that all noble gases end with the same configuration. Point out that the s and p electrons added together create 8 - a Stable octet. This approach may lead to some confusion as to why d electrons are not included in valence counts.			PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Explore: What hands-on/minds-on common	Direct Instruction: Mini Lesson on valence electrons, Ion Charges,	• Pg. 160 of Holt - student friendly reminder of	Obtaining, Evaluating, and Communicating Information	PS1.A The periodic table orders elements horizontally by the	Different patterns may be observed at each of the scales at

experience(s) will you provide for students?	ion sizes and isoelectronic series. Once students have an understanding of stable octets and valence electrons, they can explore the charges that elements will have in order to gain stable octets. If the students think of the periodic table like a board game, remind them to take whichever path requires fewer steps - adding electrons and moving forward or loosing electrons and moving backwards. Students can also be asked to draw Bohr models of neutral elements and their parents. Or be shown them on slides. This will help them remember that anions are smaller than cations. To understand isoelectronic series you can show them 2D models with the same number of electrons or have them build a series as a group. If the second approach is used split students into groups and give each group member a different isoelectronic element to build. Then have them compare in their group how many electrons are present.	difference between anion and cation	Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)Constructing Explanations and Designing Solutions Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)	number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) ETS1.C: Optimizing the Design Solution 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. (secondary to HS-PS1-6)	which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	In addition to completing practice problems with the ionic trends, students can complete graphic organizers where ion charges and sizes are included on a periodic table. Again, emphasis should not be on memorizing trends, but explaining rationale behind them.	• Holt Pg. 162 - periodic table with charges		PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the	Ion size can be explained on a deeper level by including discussions of effective nuclear charge. Have students draw a		Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including	PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with	Patterns Different patterns may be observed at each of the scales at which a system is studied and

concept/topic?	Bohr model for a neutral element and its most common ion. They have them write about how changes in the numbers of electrons will change Zeff.		students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)Developing and Using Models Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)	similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)PS2.B: Types of Interactions 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. (secondary to HS-PS1-1),(secondary to HS-PS1-3),(HS-PS2-6)	can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Administer an exit ticket, quiz or other assessment	• Pg. 165 Holt #1-13 (stable octets, ion charges) • Many additional problems for this unit : https://njctl.org/courses/science/chemistry/periodic-trends/periodic-trends-practice-problems-3/#			
Lesson Title/Number: Lesson 3 Reactivity Periodic Trends		**Learning Objective(s):** • Order elements in terms of their ionization energies • Order elements in terms of their electronegativity • Justify uses of an element based on metallic character			**Lesson Duration:** 80 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***

Elicit: How will you access students' prior knowledge?	Do Now : Have students do some recall on the octet rule and valence electrons through guiding questions. These can be questions missed on exit ticket or the previous day's lesson. They should also recall effective nuclear charge. These topics are fundamental in understanding ionization energy and electronegativity			PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Teacher-Lead Discussion: Students can be motivated by explaining the importance of trends. Meteorologists predict weather by studying trends in weather over time. City planners predict traffic and housing needs by studying trends in human movements. Fashion designers predict upcoming changes in fashion by studying trends of consumers. If students study trends of elements they can begin to predict the properties of elements and later on the outcomes of chemical reactions.			PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Direct Instruction: After the vocabulary terms are explaining for the lesson, students should be given/create one or more visual representations of electronegativity trends, ionization trends and metallic character. This can be done through slide shows, graphing or visuals in a slide show. Some ideas are linked to the right.	• Ionization Energy graph: Pg. 134 Holt • Electronegativity graph Pg. 138 Holt • Metallic Character Pg138-131 in Holt • Graphing activity on atomic radii, valence, electronegativity, ionization energy and more: http://vitalnj.pbslearningmedia.org/resource/lsps07.sci.phys.matter.graphperiodic/graphing-the-periodic-table/	Developing and Using Models Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) Obtaining, Evaluating, and Communicating Information Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)	PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)PS2.B: Types of Interactions 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. (secondary to HS-PS1-1),(secondary to HS-PS1-3),(HS-PS2-6)	Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students should complete practice problems ordering elements by increasing/decreasing trends, choosing the highest/lowest of various trends and also answering short answer questions explaining the choices they make in such questions. Once again the focus should be on rationale behind trends so that students will remember them.			PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) ETS1.C: Optimizing the Design Solution 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. (secondary to HS-PS1-6)	Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students can create problems for one another on each of the trends taught this unit.		Constructing Explanations and Designing Solutions Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)	PS1.A The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	Patterns Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Administer an exit ticket, quiz or other assessment	• This website has many practice problems for this unit: https://njctl.org/courses/science/chemistry/periodic-trends/periodic-trends-practice-problems-3/# • Pg. 141 Holt Chemistry Section 3 Review • Pg. 151 Holt Chemistry #27-33 of Chapter Review			
Lesson Title/Number: Lesson 4 Test		**Learning Objective(s):** Review video of mostly entire unit**:** http://vitalnj.pbslearningmedia.org/resource/a9626bce-29aa-49ae-a0eb-40e6e1e0f0b5/chemistry-403-trends-in-the-periodic-table/			**Lesson Duration:** 40 minutes
Lesson Title/Number: Lesson 5 Mendeleev Lab of 1869		**Learning Objective(s):** Students will complete an experiment investigating the creation of the periodic table and trends in elements. Found on Pg. 778-779 of Holt Chemistry TE			**Lesson Duration:** 40 minutes