The Next Generation Science Standards (NGSS)

CHAPTER 4, LESSON 1: PROTONS, NEUTRONS, AND ELECTRONS

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.

DISCIPLINARY CORE IDEAS

PS1.A: Structure and Properties of Matter

- Each atom has a charged sub-structure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)

Students conduct a static electricity investigation to see that like charges repel and opposite charges attract. Students are introduced to positively-charged protons, negatively-charged electrons and neutrally-charged neutrons. Students then apply these ideas to the structure of the carbon and hydrogen atom.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Students investigate the question: What makes objects attract and repel each other? In addition to rubbing strips of plastic to see if they attract or repel, students use illustrations and animated models of atoms to begin to understand the relationship between the protons in the nucleus of an atom and the electrons surrounding the nucleus. Students use and further develop this molecular model and apply it to evidence they have observed to explain their observations on the molecular level and to answer the question to investigate.

CROSSCUTTING CONCEPTS

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-PS1-1), (HS-PS1-3)

Students use a model of the positive protons and the negative electrons to understand their observations and to predict the movement of objects as a result of static electricity.

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CHAPTER 4, LESSON 2: THE PERIODIC TABLE

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.

DISCIPLINARY CORE IDEAS

PS1.A: Structure and Properties of Matter

- Each atom has a charged sub-structure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- 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), (HS-PS1-2)

Students apply what they have learned about protons, neutrons, and electrons to play a game to begin to learn about the structure of the periodic table. Students focus mainly on the meaning of atomic number, atomic mass, and the number of protons, neutrons, and electrons in an atom on the periodic table.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Analyzing and interpreting data

Using mathematics and computational thinking

Students use information from the periodic table such as atomic number and atomic mass as a type of model to represent an element. Students see that the number of protons equals the number of electrons in an atom. Students also see that the number of protons and the atomic mass can be used to determine the number of neutrons the element is likely to have.

CROSSCUTTING CONCEPTS

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-PS1-1), (HS-PS1-3)

Students will observe patterns in the way that each new element in the periodic table has one more proton than the element before. Students will also see that the number of electrons always equals the number of protons in an element on the periodic table. Students will see that they can always determine the number of neutrons an element is likely to have by determining what number they need to add to the atomic number (number of protons) to get close to the atomic mass.

The Next Generation Science Standards (NGSS)

CHAPTER 4, LESSON 3: THE PERIODIC TABLE AND ENERGY LEVEL MODELS

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.

DISCIPLINARY CORE IDEAS

PS1.A Structure and Properties of Matter

- Each atom has a charged sub-structure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- 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), (HS-PS1-2)
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3)

Students are introduced to the idea that the electrons surrounding the nucleus of an atom are on different levels and that each level can only hold a specific number of electrons. Students play a game to reinforce this concept. Students see that the periodic table is arranged in a way that atoms with the same number of electrons in their outermost level (valence electrons) are in columns. Students also see that atoms with the same number of valence electrons tend to react similarly.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1), (MS-PS1-4)
- Develop a model to describe unobservable mechanisms. (MS-PS3-2)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Students use energy level models to represent atoms in the periodic table. These energy level models can be used to determine the number of protons in the nucleus, the position of the element in the periodic table, and the likelihood that the element will react similarly to the element directly above or below it.

CROSSCUTTING CONCEPTS

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-PS1-1), (HS-PS1-3)

Students see patterns in the way each additional electron is added to an energy level until that level cannot accommodate more electrons. Students see that the structure of the periodic table is determined by energy levels and the number of electrons in those levels.

The Next Generation Science Standards (NGSS)

CHAPTER 4, LESSON 4: ENERGY LEVELS, ELECTRONS, AND COVALENT BONDING

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.

DISCIPLINARY CORE IDEAS

PS1.A Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each atom has a charged sub-structure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)

Students apply what they have learned about protons, electrons, and energy levels to learn about covalent bonding. Students see that two hydrogen atoms form hydrogen gas (H2), two hydrogen atoms and one oxygen atom form water (H2O), two oxygen atoms form oxygen gas (O2), and that four hydrogen atoms and one carbon atom form methane (CH4). The process of ionic bonding is covered in the next lesson.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Students see a molecular model animation of atoms forming covalent bonds to form molecules and then draw and describe the process. Students see that mutual attraction between the protons and electrons of the atoms and available space in the outer energy levels of the atoms is necessary for forming covalent bonds.

CROSSCUTTING CONCEPTS

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-PS1-1), (HS-PS1-3)

Students use models of atoms to understand the attractions and conditions necessary for forming a covalent bond. Students use these models to predict whether two or more atoms are likely to form a covalent bond.

The Next Generation Science Standards (NGSS)

CHAPTER 4, LESSON 5: ENERGY LEVELS, ELECTRONS, AND IONIC BONDING

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.

DISCIPLINARY CORE IDEAS

PS1.A Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each atom has a charged sub-structure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)

Students apply what they have learned about protons, electrons, and energy levels to learn about ionic bonding. Students see that sodium and chlorine atoms form ions which combine to make sodium chloride (NaCl). Students also see that calcium and chlorine atoms form ions which combine to make calcium chloride (CaCl2).

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Students see a molecular model animation of atoms forming ions and then the formation of an ionic bond. Students then draw and describe the process in the animation. Students also use Styrofoam balls as ions to further model the formation of ionic bonds in a crystal of sodium chloride.

CROSSCUTTING CONCEPTS

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-PS1-1), (HS-PS1-3)

Students use animations, drawings, and physical models of ions to understand the attractions and conditions necessary for forming an ionic bond. Students use these models to predict and better understand the cause of the cubic shape of an actual sodium chloride crystal.

The Next Generation Science Standards (NGSS)

CHAPTER 4, LESSON 6: REPRESENT BONDING WITH LEWIS DOT DIAGRAMS

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.

DISCIPLINARY CORE IDEAS

PS1.A Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each atom has a charged sub-structure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)

Students apply what they have learned about protons, electrons, and energy levels to learn a new way of representing atoms and bonding with Lewis dot structures. Students use this method to represent covalent and ionic bonding.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Students use Lewis dot structures as another way to model atoms and the covalent and ionic bonds they form.

CROSSCUTTING CONCEPTS

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-PS1-1), (HS-PS1-3)

Students use Lewis dot structures as a new model and to review the role of protons, electrons, and energy levels in influencing the different ways atoms bond to form compounds.

