# **Unit 4: Chemical Bonding & Nomenclature

Content Area: **Science**
Course(s):
Time Period: **December**
Length: **12 - 14 Blocks**
Status: **Published**

## Unit Summary

Atoms in ionic compounds are held together by chemical bonds formed by the attraction of oppositely charged ions. Ions are formed when atoms gain or lose valence electrons to achieve a stable octet electron configuration (noble gas electron configuration). Oppositely charged ions attract each other, forming electrically neutral ionic compounds. In written names and formulas for ionic compounds, the cation appears first, followed by the anion. Atoms in covalent compounds are held together by chemical bonds formed by the sharing of valence electrons. Atoms gain stability when they share electrons and form covalent bonds. Specific rules are used when naming binary covalent compounds and binary acids and oxoacids. Structural formulas show the relative positions of atoms within a molecule. The VSEPR theory is used to determine molecular shape. A chemical bond's character is related to each atom's attraction for the electrons in the bond

## Enduring Understanding

The properties of atomic particles affect the interactions of those atoms.

The composition, arrangement, structure, and properties of matter all determine how a substance behaves.

The behavior of the elements can be predicted using the periodic table. (number of valence electrons, metallic character, reactivity, type of bond)

## Essential Questioning

Why do bonds form?

What are the major similarities and differences between ionic and covalent bonds?

How are molecules held together?

What are the rules for ionic, covalent, and acid naming and formula writing?

What are the rules for naming simple organic compounds and functional groups?

## Student Learning Objectives (PE, SEP, DCI, CCC) & Aligned Standards

**Performance Expecations**

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-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]

HS-PS1-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

## Concepts & Formative Assessment

Describe the formation of an ionic bond and a covalent bond.
Describe the formation of an anion or cation from its neutral atom.
State the octet rule.
Draw Lewis dot structures for an element based on the number of valence electrons present. (Limit in Conceptual Chemistry to main group elements)
Name and write formulas for ionic compounds using IUPAC nomenclature (naming) rules.
Determine the correct ratio of cations to anions needed to form a neutral ionic compound.
Identify the properties of an ionic compound, including melting point and boiling point
Explain the difference between a monoatomic and polyatomic ion.
Understand that a formula unit represents one particle of an ionic compound.
Understand that a molecule represents one particle of a covalent compound.
Predict the molecular shape of a molecule using VSEPR theory (bent, linear, trigonal planar, trigonal pyramidal, and tetrahedral
Distinguish among ionic, molecular, and metallic substances given their properties.

## Resources

Practice Worksheets for each section

Molecule Shapes (phet simulation- online- HTML5) https://phet.colorado.edu/en/simulation/molecule-shapes (HS-PS1-1, HS-PS1-2) or Molecule Shapes: Basic (phet simulation-online-HTML5) https://phet.colorado.edu/en/simulation/molecule-shapes-basics or Molecular Polarity(phet simulation-online-Java) https://phet.colorado.edu/en/simulation/legacy/molecule-polarity

Molecular Shapes Lab

Making Compounds/ Formula Writing Activity

Bonding- Solids Properties POGIL

## Assessments

Assessments will be aligned to the Performance Expectations and will include a variety of assessment types such as labs, writing prompts, and projects.

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## Connecting with English Language Arts Literacy and Mathematics

*English Language Arts/Literacy*

- Make strategic use of digital media in presentations to enhance understanding of how photosynthesis transforms light energy into stored chemical energy.
- Use digital media in presentations to enhance understanding of the inputs and outputs of the process of cellular respiration.
- Cite specific textual evidence to support how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.
- Use evidence from multiple sources to clearly communicate an explanation for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.
- Revise an explanation for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant.
- Draw evidence from informational texts to describe how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

## Modification

*Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.*

- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.

- Collaborate with after-school programs or clubs to extend learning opportunities.

## Research on Student Learning

Students' meaning for "energy" both before and after traditional instruction is considerably different from its scientific meaning.  In particular, students believe energy is associated only with humans or movement, is a fuel-like quantity which is used up, or is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable.

Students tend to think that energy transformations involve only one form of energy at a time.  Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy change focus only on forms that have perceivable effects. The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no obvious temperature increase.  Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.

Some students of all ages have difficulty in identifying the sources of energy for plants and also for animals.  Students tend to confuse energy and other concepts such as food, force, and temperature. As a result, students may not appreciate the uniqueness and importance of energy conversion processes like respiration and photosynthesis.  Although specially designed instruction does help students correct their understanding about energy exchanges, some difficulties remain. [10] Careful coordination between The Physical Setting and The Living Environment benchmarks about conservation of matter and energy and the nature of energy may help alleviate these difficulties (NSDL, 2015).

## Prior Learning

*Physical science*

- 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.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the

original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

*Life science*

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

## Connections to Other Courses

*Physical science*

- Substances are made from different types of atoms, which combine with one another in various ways.
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(e.g., crystals).

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- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

*Life science*

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
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## References

*Adapted from the New Jersey NGSS Science Model Curriculum*