Outside Looking In

Main Group Valence Electrons and Lewis Dot Structures

Grade Level	9th – 12th Grade
Subject	Science
Course	Chemistry, Physical Science

Essential Question

How are valence electrons counted and visually represented?

Summary

As a prerequisite, students should already be familiar with determining an element's electron configuration.

Snapshot

Engage

Students participate in an Always, Sometimes, or Never True formative assessment about electrons.

Explore

In small groups, students complete a card sort to discover relationships among electron configuration, valence electrons, and Lewis dot structures.

Explain

Students gain clarity on electron-specific terminology and understand conventions for identifying and representing valence electrons.

Extend

Students practice determining numbers of valence electrons and drawing Lewis dot configurations for various main group elements.

Evaluate

Students reflect on their learning and provide the electron configuration and Lewis dot structure for a self-selected element on the periodic table.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

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.

Oklahoma Academic Standards (Physical Science)

CH.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.
CH.PS1.1.2: 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.

Oklahoma Academic Standards (Physical Science)

PS.PS2: 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.
PS.PS1.1.2: 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.

Materials

- Periodic table handouts
- Card sort sets
- Lesson slides

Engage

Go to **slide 5**. Begin the lesson by having students participate in an Always, Sometimes, or Never True formative assessment exercise. Facilitate this as it works best for your class, for example: completed individually on paper, having students hold up index cards with always, sometimes, or never written on them, class voting, etc. It is not necessary to review the answers with the students at this point since it is just for your reference.

Explore

Next, students will work together to complete a Card Sort. Divide the class into six groups and give each group one set of cards. Together the cards contain the first 20 elements of the periodic table, distributed across all six sets of cards. There are duplicates of some elements but never in the same set. Each element card includes its full electron configuration to aid students in drawing conclusions throughout this activity.

Teacher's Note: Grouping students

Each of the card sorts are labeled 1-3 and either A or B. When combining groups, be sure to put like numbers together (e.g., group 1A should pair with group 1B). This design will ensure that every group sees at least one representative element from each of the eight main groups. Consider color coding the groups by number, or labeling the cards/container they're stored in so students know to which numbered group they belong.

Go to **slide 6**. Within their groups students should match up each of their five element cards with their corresponding Bohr model and Lewis dot structure. After completing the sort, give each group some time to look for patterns between where their elements are located on the periodic table and the information they used to match the cards. Go to **slide 7**. Now have the groups pair up so you end up with 3 large groups. In the expanded groups, students should work together to identify these same periodic table/card patterns among all 10 elements they now have. Once the three groups have had time to draw conclusions about the patterns they identified, bring the class back together to discuss their conclusions.

Teacher's Note: Conclusions and guidance

As a group, students should reach the understanding that Lewis dot structures correspond to the number of electrons on the outermost ring of their Bohr models, and that both of these correspond to the ends of the elements' electron configuration. When comparing to the periodic table they should see the relationship between the numerical pattern of electrons they identified and their arrangement in groups on the periodic table.

If students are struggling to identify patterns or make connections, consider having the three groups combine their information on a single periodic table all students can see (e.g., large poster, projected on the board, etc.). Additionally, you might ask guiding questions that ask them to look for similarities between pairs of cards within their card sorts (unhide **slide 8** for a visual representation):

- electron configuration and dot structure
- Bohr model and dot structure
- electron configuration and Bohr model
- any one of the three pieces of information and the element's location on the periodic table

Before moving on, go to **slide 9** and ask students to conclude what is (1) the maximum number of electrons that can be shown in the dot structures and (2) the maximum number of electrons that can be found in the outer ring of the Bohr models *for these elements* specifically. (The relevant relationship here only works for the first 3 energy levels, after which the d and f orbitals can hold >8.) Tell them at this point that those eight electrons (or two in the case of Helium), are the element's valence electrons. Be sure to collect the card sort cards before moving on to the rest of the lesson.

Explain

Teacher's Note: Shells, Orbitals, and Electron Configuration

In order to help students build a more thorough conceptual understanding of electrons, an abbreviated explanation for shells, subshells, orbitals, and their relationship to one another is included in the slides. The goal here is to walk students through the details so they understand where electron configuration notation comes from and how it relates to valence electrons, rather than just rote memorizing s, p, d, and f numbers.

You may want students to take notes over the material as you go through the slides. If you do not already have a procedure in place for note-taking in your class, consider using a strategy like Window Notes (Math Modification version) to help students summarize and record the most important details as you go.

Go to **slides 10-12** and walk students through the details about shells, subshells, and orbitals. Continue to **slide 13** to describe orbital geometry. Students are *not* expected to remember any details about the shapes of orbitals; the images are provided to support the concept that having more electrons results in more complicated orbits as they repel one another.

Continue to **slide 14**, which focuses specifically on the p-subshell to provide an example of where the numbers come from in electron configuration. The slide is animated to show:

1. the spatial relationship among the three p-orbitals,
2. that we can think about p6 as adding two electrons from each of the three orbitals, and
3. that p6 could also be thought of as multiplying 3 (p-orbitals) times 2 (electrons).

Go to **slide 15** which shows three annotated examples of partial electron configuration. Review the *shell, subshell,* and *orbital* summary on **slide 16**.

Go to **slide 17** to introduce valence electron details. The slide is animated to show one bullet point at a time. As you cover the information, ask students to reflect back on their card sort to provide explanations for how they know what number of valence electrons are in each group and why there are 8 valence electrons/where that number comes from (“s2 + p6 = 8 electrons”). Continue to **slides 18-19** to explain Lewis dot structures and how to draw them. Be sure to edit the 3rd bullet point on **slide 19** if you have a specific convention for where you want students to begin drawing.

Teacher's Note: Slide 19 Animation

This slide is animated to walk students through how to draw Lewis dot structures, beginning at the top of the chemical symbol and continuing clockwise. You will have to step through the animations manually. The final bullet point (>4 valence electrons) will show up after the first 4 dots are “drawn” on the structure. The remaining dots (5-8) will animate after this last bullet point is revealed.

Extend

After completing the Explain, provide each student with a copy of the **Extend Practice Problems** handout. This can be completed individually or in small groups. Go to **slide 20**. Give students some time to complete all ten elements and then review the answers as a class. Go to **slides 21-22**. Rather than just providing answers and moving on, be sure to ask students to explain their reasoning throughout the discussion:

- How did they determine the element's group number?
- How did they know the number of valence electrons?
- How did they draw their Lewis dot structure (describe their process)?

Teacher's Note: Facilitation Option

Rather than using the worksheet, this practice activity could also be done on whiteboards as a class. This option reduces paper and would create an engaging opportunity for the class to work through some or all of the problems together in a low-stakes way.

Evaluate

Cut the **Evaluate Activity and Reflection handout** in half and give one to each student. Go to **slide 23**. Provide students with the following list of elements and ask them to select one to complete the activity.

- As - Arsenic
- Ba - Barium
- Ga - Gallium
- I - Iodine
- Pb - Lead
- K - Potassium
- Se - Selenium

After completing the Lewis dot structure assessment portion, students will complete a What Did I Learn Today? reflection on the same sheet.

Resources

- Always, Sometimes, or Never True https://learn.k20center.ou.edu/strategy/145
- Card Sort https://learn.k20center.ou.edu/strategy/147
- Window Notes https://learn.k20center.ou.edu/strategy/189
- What Did I Learn Today? https://learn.k20center.ou.edu/strategy/169