Becoming an Atom- Atomic Trends

Overview
Students will explore various periodic table trends and the mechanisms behind these trends through a visual and tactile activity. Students will then work in groups to organize their observations to create and propose definitions for each trend. Students will act as electrons in atoms to explore changes in atomic radius, ionic radius, Ionization energy, and Electronegativity, through scaffolded guided questions. Students will track observations and hypotheses mechanisms behind the observations. In groups, utilizing these observations and hypotheses, students will formulate potential explanations for each trend and present these explanations to the class for further review and expansion.

Key Search Words
High School, Science, Chemistry, Physical Science, Periodic Table Trends, Atomic Structure,Protons, Electrons, Atomic Size, Ionic Size, Ionization Energy, Electronegativity, Period, Group, Cation, Anion, Ion, Energy Levels, Shielding Effect, Effective Nuclear Charge, Kinesthetic Activity

Learning Objectives
At the end of this lesson, students will be able to:
- Identify subatomic particles and their properties.
- Model the structure of an atom.
- Compare effects of electron removal or addition on atomic radius and ionic radius (size).
- Hypothesize what mechanisms drive observed changes in atomic size, ionic size, ionization energy, and electronegativity.
- Organize observations and hypotheses in groups to create definitions and graphical representations of atomic size, ionic size, ionization energy, and electronegativity.
- Evaluate and critique proposed definitions of each periodic table trend.

Curriculum Alignment
NC Standards:

Chm.1.1.1 Analyze the structure of atoms, isotopes, and ions.
Chm.1.1.2 Analyze an atom in terms of the location of electrons.
Chm.1.3.3 Infer the atomic size, reactivity, electronegativity, and ionization energy of an element from its position on the Periodic Table.

Classroom time required
- This lesson works for a 90 minute block class or two 45-55 minute class periods

Materials & Technology
Check the weather ahead of time, the first part of this activity is best accomplished outside!
Chalk, whiteboards or paper, dry erase markers or markers, prepared questions (below), directions for both activities (below), preplanned groups (optional, details below), printer paper, poster paper, and markers, clipboards or notebooks

The following links are included in the procedure below as well as provided separately for your convenience:
Instructions for the first activity
Guided Questions/Instructions for the first activity
Instructions for the second activity

Safety
The first activity takes place outside on some sort of chalk-able pavement. Extra caution and observation will be needed to ensure all students remain with the group and behave appropriately

Teacher Preparation for Activity
1. Check weather ahead of time. The first activity takes place outside.
2. Select a safe area for the first activity. The area needs to be paved to allow for chalk drawings.
3. Chalk drawings can (ideally should) be completed ahead of time.

   a. In the center of your area, you will start with a large circle to represent the nucleus (ideally this circle would be about 3-4 feet in diameter and colored in to prevent confusion with energy level rings).
   b. From here you will draw the energy level rings that surround the nucleus. I recommend you take 3-4 heel-to-toe steps from the nucleus to draw the first ring, making your ring line pretty thick for good visibility. From here, draw remaining rings, each about 3-4 heel-to-toe steps apart.
      i. Your students will act as electrons, so you only need enough rings to support your number of students: for example a class of 32 would need 5 rings
         2 rings allow for 10 students, 3 rings - 18 students, 4 rings - 26 students, 5 rings - 34, 6 rings - 42 students
4. You will want to have 5 small whiteboards or 5 pieces of paper (with clipboards) ready with appropriate markers prepared to take outside with you.
5. You will want to have 5 poster sized papers ready in the classroom with markers/crayons/colored pencils.
6. If you have a large portable periodic table, have that ready to go outside. If not, small printed copies for each student may help.

Student Preparation for Activity

Students should be familiar with atom structure and subatomic particle properties. They should understand the basics of the periodic table (i.e. moving down/right means more protons, more mass, more electrons, metals vs nonmetals vs noble gasses, ect), but not trends.

Procedure

1. Before the first activity, it may be helpful to briefly review topics such as metal vs nonmetal vs noble gas groupings on the periodic table and/or what valence electrons are.
2. Explain that the periodic table is also used to look at patterns or trends and that today we will be learning about some of those trends. To do that, we will be going outside to model various atoms.
   a. Refer to the Instructions for the first activity.

Instructions for the first activity

**Written as a script for teacher to student with action steps below each section*

1. When we go outside, you will find a very large atom drawn on the ground. I will act as the nucleus which contains (*pause for them to answer protons and neutrons) and you all will act as the electrons.
   a. Have students reflect on the charges of the protons and electrons.
   b. Have students reflect on the effect those charges have on the relationship between protons and electrons, protons and protons, and electrons and electrons (attract or repel).
   c. Have students reflect on how many electrons fit on each ring (2, 8, 8, 8, 8, ect).
2. So we'll go outside and you all will orient yourselves with my help to be electrons on rings. Now as electrons, you have to behave as electrons, meaning you can move around, but only on your ring. This also means you can not touch one another because you're all negatively charged and will repel each other. I will stand in the center as your nucleus and direct you all to move in ways to model various atoms and ions.
3. I need [1 to 5 (either 1 student to write all observations and hypotheses for each of the 5 trends or 1 student per trend)] volunteers to be our data collectors. We will collect data on our observations and hypotheses during this activity before we come back inside. You will then work in groups to organize these observations and hypotheses to create definitions and graphics to represent the patterns you observed.
   a. Before you go outside, make sure data collectors have their materials.
   b. Have students remind you (each other) of how they can and can't move as electrons

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3. Take the students outside (with materials) to the atom structure you've previously drawn and arrange students (as electrons) on their rings, following the 2, 8, 8, 8, 8 rule (we will ignore the transition metals for this activity).
   a. Refer to the Guided Questions/Instructions for the first activity to complete the activity.

Guided Questions/ Instructions for the first activity

Before you begin, instruct data collectors to write down questions, answers, and observations relating to the trend for which they are collecting.

Atomic Size

1. Once you are outside and your kids are situated on their rings. Ask them what element they are (based on the number of electrons).
2. Tell them you want to see the structure of an atom that's smaller (ex: Fluorine). (instruct excess electrons to move to a certain area)
3. Ask them questions to help them understand the differences in size are due to energy levels and effective nuclear charge (even if they don't understand these words yet)
    a. For example:
        i. In terms of size, what is different between the first atom and the second atom?
        ii. How many rings did each atom have?
        iii. Did that make a difference in the size of the atom?
        iv. What is the relationship between the nucleus and the valence electrons of Fluorine compared to the relationship between the nucleus and valence electrons of the first atom?
    b. From here you can start to explain/review terms like energy levels and effective nuclear charge. I would stress the importance of the different charges and what effect they have on each other. (distant electrons in larger atoms experience less attractions to nucleus, ect)

Ionic size: Cation

1. Have students form the largest group 1 element possible.
2. Explain that atoms are happiest when their rings are either empty or have 8 electrons present.
3. Ask what needs to happen for this group 1 element to be happy (lose 1 electron or gain 7) and explain that losing 1 would be easier than trying to gain 7.
4. Have the 1 valence electron student join the excess electrons.
5. Ask students to observe what happened to the size of the atom when it lost its valence electron and became "satisfied". (it gets smaller due to decreased energy level)
6. Explain the term cation and walk them/ask them about the associated charge after 1 electron is lost (+1)

Ionic size: Anion

1. Have students form the largest group 7 element possible.
2. Again, explain that atoms are happiest when their rings are either empty or have 8 electrons present.
3. Ask what needs to happen for this group 7 element to be happy (lose 7 electrons or gain 1) and explain that gaining 1 would be easier than trying to lose 7.
4. Have 1 excess electron student join the 7 valence electrons.
5. This one is a bit tricky, the atom is getting larger because of the effective nuclear charge. To explain this ask questions like:
    a. What atom did we start with? How many protons and electrons did it have?
    b. What atom do we have when we added a valence electron to complete the shell? (same, but now it has 1 more electron)
    c. Ask them about the ratio of protons to electrons of the atom vs ion.
6. Explain that by having a complete valence ring with additional electrons, the protons have more electrons to attract, meaning it's harder to hold on to them, therefore, the electrons can spread out a little and the ion becomes larger than the neutral atom.
    a. Again, this is tougher to visualize, so spend some time here.
7. Explain the term anion and walk them/ask them about the associated charge after 1 electron is gained (-1)

Ionization Energy:

1. Have students return to the largest group 1 element possible
2. Have them remind you what needs to happen for this atom to be happy (lose 1 or gain 7 electrons)
3. Ask them how much energy (a lot or a little) they think it would take to remove that 1 valence electron if the atom already wants to get rid of it? (a little)
4. Ask students to move to make fluorine.
5. Have them remind you what needs to happen for this atom to be happy (lose 7 or gain 1 electron)
6. Ask them how much energy (a lot or a little) they think it would take to remove one valence electron if the atom desperately wants to gain one electron? (a lot)
7. Have them return to the largest group 7 element possible.
8. Ask them if the previous observation applies, still a lot of energy to remove 1 valence electron? (yes)
9. But now bring the charges back into it. Ask if the nucleus can hold these elements valence electrons as strongly as in Fluorine. Have them elaborate.

a. They might talk about the distance from the nucleus (Effective nuclear charge)
b. They might need prompting to recognize that inner electrons are blocking the valence electrons in large atoms (shielding effect)

Electronegativity:

4. Have students return to the largest group 1 element possible
5. Have them remind you what needs to happen for this atom to be happy (lose 1 or gain 7 electrons)
6. Ask them if they think this element wants to gain more electrons? (no)
7. Ask students to move to make fluorine.
8. Have them remind you what needs to happen for this atom to be happy (lose 7 or gain 1 electron)
9. Ask them if they think this element wants to gain more electrons? (yes)
10. Ask if they made a larger group 7 element if that element would attract electrons as well as fluorine?
11. Have students explain why or why not?
    a. Your looking for them to say no because the outer ring is further, preventing good nucleus attraction (effective nuclear charge)
    b. and no because there would be more inner electrons blocking the nucleus attractions (shielding effect)

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4. Bring the students back inside and refer to the [Instructions for the second activity]

Instructions for the second activity

1. When you bring the students back to the classroom, separate them into 5 groups and give each group one of the 5 batches of collected observations.
2. Explain that each group will be responsible for creating a definition and graphic/image to explain that trend on their poster board. They will have 15 minutes to work and will present their poster to the class
    a. Potential Poster ideas below and visual in the Appendices.
        i. Atomic Size, Ionization Energy, and Electronegativity should come with a periodic table with the trend labeled (increasing/decreasing up or down ect)
        ii. Ionic Size should be more visual about the atoms themselves (cations getting smaller, anions getting larger)
3. Give them 15-20 minutes to work and allow 15-20 minutes at the end for each group to present to the class and receive/give feedback.
    a. Do they agree with the definition?
    b. Does the graphic make sense?
    c. ect.

Modifications:

If the first activity is running long, skip electronegativity and work with that group directly during the second activity to help them create a definition and graphic.

Differentiation

This lesson will run well if good student/teacher rapport and classroom management strategies are already in place. If students need more structure, don't allow them to move on the rings (you can mark on the rings spots for them to stand still), and provide the class with a model of the poster they are to create.

Assessment/Check for Understanding

Teachers can check for understanding via the following:

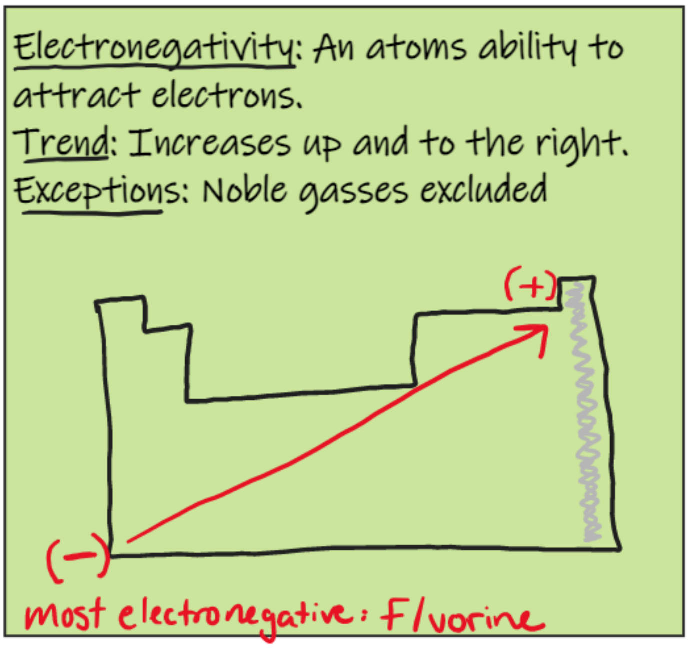
1. Answers to questions during the first activity
2. Data collected by data collectors
3. Definitions created by groups
4. Graphics/images created by groups
5. Presentations to class
6. Class critiques

Author comments

If the weather does not accommodate this activity being outside or if a safe, paved area is not available, this activity can be modified for a gym space or classroom space (move desks for large activity area). Use easily removable tape (masking, painters, etc.) to mark nucleus and rings.

Appendices

Potential Definition and Poster:



Activity 1 Birds Eye View: