Patterns in the Elements

Use periodic trends to explain how atoms and ions behave.

CHE.3.2 "Analyze properties of atoms and ions (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity and electron affinity, ionization energy..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each statement that describes a trend across a period, and circle each statement that describes a trend down a group. Use your marks to support your answers.

Why Position Matters

1. A phone's metal contacts carry current, while its silicon chips control where current goes. These materials behave differently because of their atoms' positions on the periodic table. Metals cluster on the left and in the center; they usually conduct heat and electricity well because some electrons move freely through the solid. Nonmetals cluster on the right and usually conduct poorly as solids. Metalloids along the boundary, including silicon, can act as semiconductors, whose conductivity can be adjusted. In period 3, sodium, magnesium, sulfur, and chlorine appear in that left-to-right order.

2. An atom's radius is the distance from its nucleus to the outer region of its electrons, estimated from measurements of bonded atoms. Across a period, atomic radius generally shrinks: the nucleus gains protons, but new electrons enter the same main energy level, so the stronger attraction pulls them closer. Down a group, atoms add occupied energy levels, so radius increases. Potassium lies below sodium in group 1. Removing the first electron requires ionization energy. Across a period this energy generally increases, while down a group it generally decreases. These are broad patterns, not rules without exceptions.

3. Electronegativity describes how strongly an atom attracts shared electrons in a bond. It generally rises across a period and falls down a group. Electron affinity describes the energy change when a gas-phase atom gains an electron. For many nonmetals, gaining an electron releases energy; the tendency toward a more energy-releasing electron affinity generally grows toward the right, though there are important exceptions. An atom that loses electrons becomes a positive ion, smaller than its neutral atom because its remaining electrons feel a stronger pull, often after an outer energy level disappears. Gaining electrons makes a negative ion, usually larger than its atom.

2 ANSWER WITH EVIDENCE

Use the passage

1. Which has the larger atomic radius, sodium or potassium? Explain using their positions on the periodic table.

2. Which has the higher first ionization energy, sodium or magnesium? Explain using a periodic trend.

3. Compare sulfur and chlorine. Which should attract shared electrons more strongly, and which should have the more energy-releasing electron affinity?

4. Is an Mg^{2+} ion larger or smaller than a neutral magnesium atom? Explain why.

3 YOUR TURN

Your own words

Two unknown solids are A, a group 1 element in period 2, and B, a group 17 element in period 2. Predict which conducts electricity better as a solid, which has the larger atomic radius and lower first ionization energy, and which attracts shared electrons more strongly. Explain each prediction using periodic trends.

ANSWER KEY

Patterns in the Elements

PART 1 · READ AND MARK

Underline each statement that describes a trend across a period, and circle each statement that describes a trend down a group. Use your marks to support your answers. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Which has the larger atomic radius, sodium or potassium? Explain using their positions on the periodic table.	**Potassium. It lies below sodium in group 1, and atomic radius generally increases down a group as occupied energy levels are added.**
2	Which has the higher first ionization energy, sodium or magnesium? Explain using a periodic trend.	**Magnesium. It is to the right of sodium in period 3, and first ionization energy generally increases across a period.**
3	Compare sulfur and chlorine. Which should attract shared electrons more strongly, and which should have the more energy-releasing electron affinity?	**Chlorine should attract shared electrons more strongly and have the more energy-releasing electron affinity. It is to the right of sulfur in period 3.**
4	Is an Mg^{2+} ion larger or smaller than a neutral magnesium atom? Explain why.	**Mg^{2+} is smaller. Magnesium loses its two outer electrons to form the ion, removing an occupied energy level.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

A should conduct electricity better as a solid because group 1 elements are metals with mobile electrons, while group 17 elements are nonmetals. A should have the larger atomic radius because radius generally shrinks from left to right across a period. A should have the lower first ionization energy because that energy generally rises across a period. B should attract shared electrons more strongly because electronegativity also rises across a period.

Accept explanations that correctly connect each prediction to the elements' positions and the relevant trend. For electron affinity, accept wording such as “releases more energy when gaining an electron.”