

Periodic Trends

Atomic and Ionic Radius

1. Explain why atomic size decreases from Na to Cl in the periodic table.
The trend, as you go across a period, is that the radius decreases. This is because all electrons are being added to the same shell (the same distance from the nucleus) and the nucleus is becoming increasingly positive due to addition of protons (effective nuclear charge increases). Since Cl has more protons in the nucleus, it pulls electrons towards it more tightly.
2. Explain why the difference between the atomic radii of Na and K is relatively large compared to the difference between the atomic radii of Rb and Cs.
Sodium's last electron is added to the 3rd energy level, K's to the fourth. The difference between the size of Rb and Cs is between the fifth and sixth energy levels. The difference in energy of the lower shells is greater than the difference in energy of the higher shells.
$$-2.178 \times 10^{-18} \left(\frac{1}{n^2} - \frac{1}{n^2} \right); \left(\frac{1}{3^2} - \frac{1}{4^2} \right) = 0.0486; \left(\frac{1}{5^2} - \frac{1}{6^2} \right) = 0.0122$$

Also, due to electron shielding the effect of the nucleus on the outer shell electrons is much greater for sodium than it is for Rb and Cs.
3. Explain why a Ca atom is larger than a Zn atom.
Though Zn has more electrons than Ca, they were added to the third energy level, not the fourth. Both have the same number of outer electrons in the fourth energy level and Zn has a greater effective nuclear charge due to the larger number of protons in its nucleus. This makes Zn smaller than Ca.
4. The radius of the Ca atom is 0.197 nm; the radius of the Ca²⁺ ion is 0.099 nm. Account for this difference.
Ca has two electrons in the fourth energy level (4s²), while the Ca²⁺ ion has lost these two electrons and has a full third energy level. Both have the same number of protons. Therefore, with fewer electron shells, the calcium ion will be smaller.
5. Explain why the ionic radius of N³⁻ is larger than that of O²⁻.
N³⁻ has 7 protons and 10 electrons, O²⁻ has 8 protons and 10 electrons. Both have identical electron configurations, but oxygen ion has a more positive nucleus and therefore pulls the electrons in a little more tightly.
6. Ca²⁺ and Cl⁻ are isoelectronic. Which has the larger radius? Explain why.
Ca²⁺ has 20 p and 18 e, Cl⁻ has 17 p and 18 e. Electron configurations and shielding are the same, Ca²⁺ has a greater effective nuclear charge and therefore its radius will be a little smaller.

Ionization Energy

	Ionization Energy (kJ / mol)	
	First	Second
K	419	3050
Ca	590	1140