3.2 Problems - Periodic Trends

(dd) Higher ionization energy: K or Ca

2. Provide a scientific explanation of the following trends.

(a) The radius of the Br atom (0.111 nm) is less than the radius of Br'ion (0.196 nm).

Br has the same number of protons as Br but it loses one more electron; there is a greater e-e repulsion in Br- so the radius is larger.

(b) A calcium atom (1.76 Å) is larger than a zinc atom (1.22 Å).

They are both in the same period i.e. sharing the same # of shells.

In these atom problems that are attracing the e- so 2n is smaller than Ca.
(c) The radius of a chlorine atom (0.99 Å) is smaller than the radius of the chlorine ion, Cl⁻ (1.81 Å).

They both have the same P but Cl⁻ has more e-e-repulsion so Cl⁻ is larger.

(d) The radius of Ca²⁺ (0.99 Å) is smaller than the radius of Cl⁻ (1.81 Å), even though they are isoelectric.

\[ ^{17} \text{Cl} \text{ has 18e⁻} \]
\[ ^{20} \text{Ca} \text{ has 22e⁻} \]

The ratio of P to e⁻ is lower in Cl⁻ so there is less e-e-repulsion. Therefore it is smaller.

(e) Potassium (418.8 kJ/mol) has a lower first-ionization energy than sodium (495.8 kJ/mol).

Because K has more orbitals so its e⁻ are farther from the protons.

(f) The first ionization energies of Si, P, and Cl are 786, 1012, and 1251 kJ/mol respectively.

Because Cl is a diatomic and only needs 1 e⁻ to have a full valence shell it is harder to remove an e⁻ than Si which needs 8e⁻ to fill its outer shell.

(g) The first ionization energy of selenium (941.0 kJ/mol) is less than bromine (1139.9 kJ/mol), but greater than tellurium (896.3 kJ/mol).

Because Se has less orbitals and it's e⁻ are closer to the nucleus.

(h) The second ionization energy of K (3052 kJ/mol) is greater than the second ionization energy of Ca (1145 kJ/mol).

Because Ca has 2 valence e⁻ whereas K only has one. In order to remove an e⁻ from a full valence shell it will require more energy.