Explaining Two Exceptions in a Period Trend

Base your answers on the information provided and your knowledge of chemistry. Use the 2025 Chemistry Reference Tables as needed.

An exhibit compares four neutral atoms from period 3. First ionization energy is the energy required to remove the first electron from each atom in a mole of gaseous atoms. The table identifies the region of the electron that is removed and gives measured energies rounded to the nearest kJ/mol.

Atom	Protons	Region of removed electron	First ionization energy (kJ/mol)
Mg	12	3s	738
Al	13	3p	578
P	15	3p	1012
S	16	3p	1000

1 For which two changes does the proton count increase while the first ionization energy decreases?

(1) Mg to Al and Al to P

(2) Mg to Al and P to S

(3) Al to P and P to S

(4) Al to P only

A model of electron position shows that a 3p electron is generally less likely to be close to the nucleus and is more shielded than a 3s electron in these atoms.

2 Use the position model to explain the lower first ionization energy of Al compared with Mg. [1]

Answer and work

A second model shows the numbers of electrons sharing each part of the 3p region. Electrons in a shared part repel one another. The model treats that extra repulsion as making a paired electron easier to remove.

Atom	Electrons in part 1	Electrons in part 2	Electrons in part 3
P	1	1	1
S	2	1	1

3 Use the second model to explain why S can have a lower first ionization energy than P even though both lose a 3p electron. [1]

Answer and work

4 A student says the change from removing a 3s electron to removing a 3p electron explains both energy decreases. Evaluate the claim with the two comparisons. [1]

Answer and work