

Electron configurations, PES and periodic trends

AP Chemistry · Test answers (mark scheme)

Marks are awarded for the correct idea, the correct use of Coulomb's law and clear units.
Accept equivalent wording where the same physical reasoning appears.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 1

Question 1 Configurations of manganese (2 marks)

- a. **[Ar] 4s² 3d⁵.**
- b. Mn²⁺ is **[Ar] 3d⁵** with **5 unpaired electrons**.

Marking: 1 mark each part.

Question 2 Reading a PES spectrum (3 marks)

- a. Heights 2 : 2 : 6 : 2 mean 1s² 2s² 2p⁶ 3s², which is **magnesium**.
- b. From left to right the peaks are **1s, 2s, 2p, 3s**.
- c. 1s electrons are closest to the nucleus and least shielded, so they are bound most strongly.

Marking: 1 mark each part.

Question 3 Coulomb's law (3 marks)

- a. $F \propto Z_{\text{eff}}/r^2$. The factor is $2/1.5^2 = 2/2.25 = \mathbf{0.89}$.
- b. Mg²⁺ has 12 protons and Na⁺ has 11 for the same 10 electrons, so the attraction is stronger and the ion is smaller.

Marking: 1 mark for the relation; 1 mark for the answer; 1 mark for part (b).

Question 4 Successive ionisation energies (2 marks)

There is a very large jump between the second and third values, so the third electron comes from an inner shell. The element has **two valence electrons** and is in **group 2**.

Marking: 1 mark for identifying the jump; 1 mark for the group.

Question 5 Phosphorus and sulfur (3 marks)

The valence electron lost from phosphorus comes from a singly occupied 3p orbital. In sulfur it comes from a doubly occupied 3p orbital. The two electrons in the same orbital repel each other, so removing one needs **less energy**. This repulsion outweighs the higher nuclear charge.

Marking: 1 mark for the orbital occupancy; 1 mark for electron repulsion; 1 mark for the conclusion.

Question 6 Order of radii (2 marks)

Mg, Na, Cl, Cl⁻ from smallest to largest. Mg has a higher nuclear charge than Na in the same shell. Cl⁻ has the largest radius because added repulsion between electrons expands the cloud.

Marking: 1 mark for the order; 1 mark for the reason.

Question 7 Binding energy from kinetic energy (3 marks)

- a. $BE = 1487 - 1414 = \mathbf{73\ eV}$.
- b. This is the **2p** subshell.
- c. $KE(2s) = 1487 - 118 = \mathbf{1369\ eV}$.

Marking: 1 mark each part.

Question 8 Radius and effective charge (2 marks)

Na: $11 - 10 = 1$. Cl: $17 - 10 = 7$. Both have valence electrons in shell 3, but Cl's electrons feel a much stronger attraction, so **Cl is smaller**.

Marking: 1 mark for the Z_{eff} values; 1 mark for the explanation.