

# Orbitals, configurations and ionisation energy patterns

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Marks are given for method and for the final answer with its unit. Allow follow-through where an earlier error is carried forward correctly. Explanations must name the factor involved, not just state the trend.

**Level:** Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.1.1, IB S1.3

## Question 1 Configurations of nickel (2 marks)

a. **[Ar] 3d<sup>8</sup> 4s<sup>2</sup>.**

b. The 4s electrons are lost first: **[Ar] 3d<sup>8</sup>.**

Marking: 1 mark each; accept 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>6</sup> in place of [Ar].

## Question 2 Defining ionisation energy (2 marks)

It is the energy needed to remove one electron from each atom in one mole of gaseous aluminium atoms. **Al(g) → Al<sup>+</sup>(g) + e<sup>-</sup>.**

Marking: 1 mark for mole and gaseous atoms; 1 mark for the correct equation with states.

## Question 3 Reading the graph (4 marks)

a. The jump follows electron 2, so Z is in **group 2**.

b. **Z<sup>2+</sup>.**

c. The third electron comes from an inner shell, closer to the nucleus and less shielded, so it is held far more strongly and needs much more energy.

Marking: (a) 1; (b) 1; (c) 1 for inner shell, 1 for closer or less shielded.

## Question 4 Neon and argon (3 marks)

Argon's outer electron is in the third shell and neon's in the second. The third-shell electron is further from the nucleus and is shielded by more inner electrons. These effects outweigh the larger nuclear charge, so **less energy is needed**.

Marking: 1 for the shell, 1 for distance, 1 for shielding.

## Question 5 Energy for lithium (2 marks)

**E = 0.0500 mol × 520 kJ mol<sup>-1</sup> = 26.0 kJ.**

Marking: 1 for the multiplication; 1 for the correct answer with unit.

**Question 6 Carbon in boxes** (2 marks)

Carbon has **2 unpaired electrons**, in separate 2p orbitals with parallel spins, following **Hund's rule**.

*Marking: 1 for two; 1 for Hund's rule.*

**Question 7 Phosphorus and sulfur** (2 marks)

In sulfur, one 3p orbital holds a pair of electrons. The repulsion between the pair makes one of them **easier to remove** than the unpaired 3p electrons of phosphorus.

*Marking: 1 for paired electrons in one orbital; 1 for repulsion.*

**Question 8 Chromium** (3 marks)

Chromium is **[Ar] 3d<sup>5</sup> 4s<sup>1</sup>**. With one electron in each 3d orbital and one in 4s, there are six unpaired electrons and less repulsion than with a paired 4s<sup>2</sup>, and the 3d and 4s energies are close, so this arrangement has lower energy.

*Marking: 1 for the configuration; 1 for half-filled 3d; 1 for lower energy or lower repulsion.*