

Period 3 trends in radius, energy and melting

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

Model answers and mark schemes follow. Award each mark only when the idea is stated clearly, for example nuclear charge, same shell, subshell energy, electron pairing, or the specific force overcome.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.2.1

Question 1 Ionisation energy (2 marks)

(a) The energy needed to remove one mole of electrons from one mole of gaseous atoms to form one mole of gaseous 1+ ions.

(b) $\text{Na(g)} \rightarrow \text{Na}^+(\text{g}) + \text{e}^-$

Marking: 1 mark for gaseous atoms and one mole; 1 mark for the correct equation with state symbols.

Question 2 Shrinking atoms (3 marks)

Nuclear charge increases from +11 to +17. The extra electrons are added to the same shell, so shielding by the inner electrons is about constant. The attraction on the outer electrons becomes stronger, pulling them closer. **Radius decreases.**

Marking: 1 for increasing nuclear charge; 1 for same shell and similar shielding; 1 for stronger attraction giving smaller radius.

Question 3 Sulfur and phosphorus (3 marks)

Phosphorus has $3p^3$ with three unpaired electrons. Sulfur has $3p^4$, so two electrons share one 3p orbital. The repulsion between the paired electrons makes one of them easier to remove, so **sulfur's first ionisation energy is lower.**

Marking: 1 for the two configurations; 1 for pairing in one orbital; 1 for repulsion making removal easier.

Question 4 Kelvin gap (2 marks)

$\text{Na} = 98 + 273 = 371 \text{ K}$. $\text{Mg} = 650 + 273 = 923 \text{ K}$. Difference = $923 - 371 = 552 \text{ K}$.

Marking: 1 for both conversions; 1 for the difference.

Question 5 Reading the melting point graph (3 marks)

(a) D is silicon, a giant covalent lattice.

(b) E (phosphorus) is made of P_4 molecules, so only weak London forces are overcome, not covalent bonds.

(c) H (argon) is monatomic with only 18 electrons, so it has the weakest London forces: **84 K**.

Marking: 1 mark per part.

Question 6 Percentage change in radius (2 marks)

Decrease = $160 - 104 = 56$ pm. Percentage = $56 / 160 \times 100 = \mathbf{35.0\%}$.

Marking: 1 for 56 pm; 1 for 35.0 %.

Question 7 Magnesium and aluminium (3 marks)

Magnesium's outer electron is in the 3s subshell. Aluminium's outer electron is in the 3p subshell, which is higher in energy. It is also partly shielded by the 3s electrons, so less energy is needed to remove it: **578 against 738 kJ/mol**.

Marking: 1 for 3p higher in energy than 3s; 1 for shielding by 3s electrons; 1 for conclusion.

Question 8 Chlorine and sulfur (2 marks)

Electrons per molecule: $S_8 = 128$ and $Cl_2 = 34$. The larger electron cloud of S_8 gives stronger London forces, so more energy is needed to separate the molecules.

Marking: 1 for the electron counts (or size comparison); 1 for stronger London forces.