

Solutions

Original marking guidance; accept equivalent notation.

2.1 16 protons and 18 neutrons, 16 electrons in the neutral atom, 18 electrons in the 2- ion. The nucleus is unchanged by electron gain.

2.2 The instrument separates m/z , not mass alone. A single mass-40 isotope could form both 1+ and 2+ ions. Determine the ion charges independently, or obtain a charge-resolved spectrum before assigning two isotope masses. The peak pair alone cannot distinguish these possibilities.

2.3 s: one orbital/two electrons; p: three/six; d: five/ten. Shell $n = 3$ contains 3s, 3p and 3d, with maximum $2 + 6 + 10 = 18$ electrons. A single d orbital holds two, not ten.

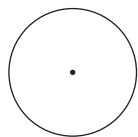
3.1 K: $[\text{Ar}]4s^1$; Br: $[\text{Ar}]3d^{10}4s^24p^5$; Cu^+ : $[\text{Ar}]3d^{10}$. Neutral copper is $[\text{Ar}]3d^{10}4s^1$; its 4s electron is removed first when the positive ion forms.

3.2 Difference in logarithms $= 4.2 - 3.0 = 1.2$, so energy ratio $= 10^{1.2} = 15.8$. A large jump after removal of two electrons supports two outer electrons, assuming the stated jump separates outer and inner shells. $\text{X}^{2+}(\text{g}) \rightarrow \text{X}^{3+}(\text{g}) + \text{e}^-$; the energy change is positive/endothermic.

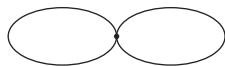
3.3 The 3p electron is higher in energy and more easily removed than a 3s electron; this outweighs the increase in nuclear charge across Mg to Al. For P to S, removal remains from 3p; sulfur has the first paired 3p electrons, whose repulsion makes one easier to remove despite the greater nuclear charge. An extra inner shell is not added in either comparison.

3.4

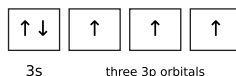
P: $[\text{Ne}]3s^23p^3$



s orbital: spherical



one p orbital: two lobes



3s

three 3p orbitals

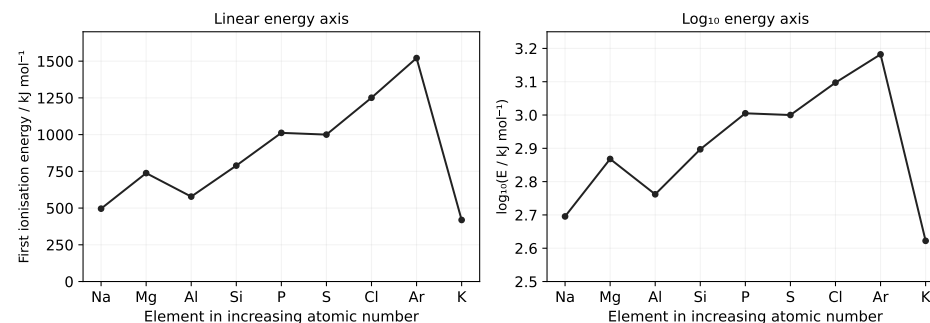
S adds ↓ to one 3p box.

Spherical s region; two-lobed p region about the nucleus; either orbital holds up to two electrons with opposite spins. The electron-box panel is additional occupancy teaching, not a third spatial orbital.

3.5 Both have one outer electron and tend to form 1+ ions, giving similar chemical behaviour. Potassium's outer electron is further from the nucleus with greater shielding by occupied inner shells; these outweigh its higher nuclear charge, so it is more easily removed.

3.6 Relative molecular mass $= 29 \times 2 = 58$. $\text{C}_3\text{H}_6\text{O}$ has mass $3 \times 12 + 6 + 16 = 58$; the other candidates are 46 and 74. Structural isomers such as propanal and propanone share $\text{C}_3\text{H}_6\text{O}$ and the same molecular mass, so further structural evidence is needed.

3.7



Award labelled axes/consistent scales, correct linear points, and correct logarithmic points. K begins a new occupied outer shell, increasing distance and shielding relative to Ar; the large decrease after a noble-gas maximum is part of the repeating periodic pattern. A logarithmic axis preserves order but compresses large values.