

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.

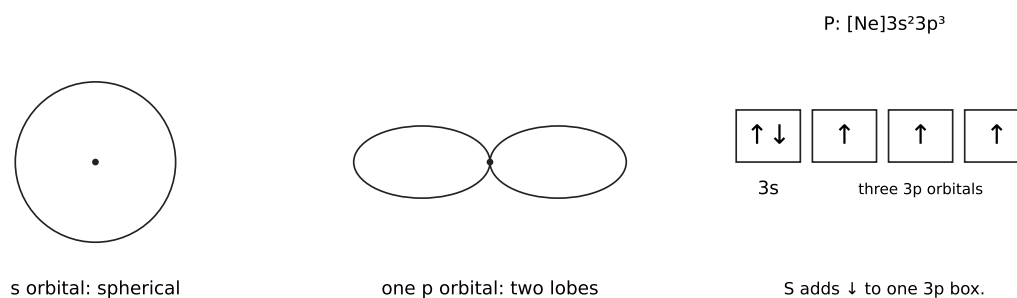
2.3 s: one orbital/two electrons; p: three/six; d: five/ten. Shell $n = 3$ contains 3s, 3p and 3d, with maximum $2 + 6 + 10 = 18$ electrons. A single d orbital holds two, not ten.

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

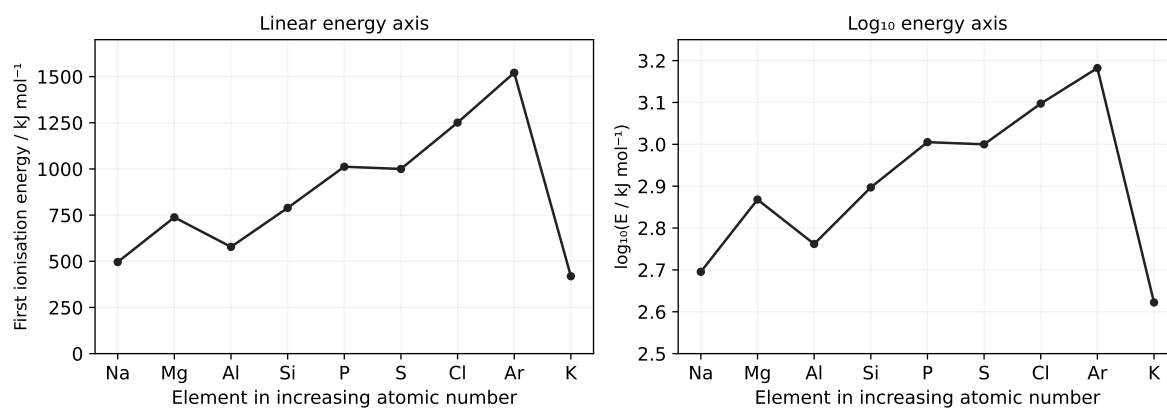


Spherical s region; two-lobed p region about the nucleus; either orbital holds up to two electrons with opposite spins. The electron-box panel is additional occupancy teaching, not a third spatial orbital.

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.