

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Atoms of the same element with the same number of protons but different numbers of neutrons.

2.2 Let $x = \%$ of ^{11}B : $(10(100-x) + 11x)/100 = 10.8 \rightarrow x = 80$. So 20% ^{10}B , 80% ^{11}B .

2.3 $[\text{Ar}] 3\text{d}^3$ – the 4s electron is lost first, then two of the 3d.

3.1 The large jump is between the 3rd and 4th ionisation energies ($11577 \gg 2745$): three electrons in the outer shell, so Group 3; these seven values show the number of outer electrons but do not by themselves count all occupied shells, so the jump alone does not establish the period. These are aluminium values, but identifying a familiar dataset is additional knowledge.

3.2 Sulfur's fourth 3p electron is the first to pair in an orbital; the inter-electron repulsion of the pair makes that electron easier to remove; the removed electrons are in the same 3p subshell with similar shielding by inner electrons. The extra repulsion explains the dip despite sulfur's larger nuclear charge.

3.3 Combinations: $79+79 = 158$, $79+81 = 160$, $81+81 = 162$. With a 1:1 abundance, $P(158) = 1/4$, $P(160) = 1/2$, $P(162) = 1/4$; peaks at m/z 158, 160, 162 in the ratio 1 : 2 : 1.