

Chemguide – answers

FIRST IONISATION ENERGIES



The state symbols are *essential*. If you haven't included them, or got one of them wrong, then the answer is worthless.

- The electron is being removed from the same orbital as in hydrogen's case. In both cases, the electrons are close to the nucleus and unscreened. Helium's first ionisation energy is much higher than hydrogen's, because the nucleus now has 2 protons attracting the electrons instead of 1.
- Lithium's electronic structure is $1s^2 2s^1$. The 2s electron (which is the one which will be lost) is further from the nucleus, and screened from it by the 1s electrons. This more than offsets any extra attraction due to the extra proton.
- In Period 2, the outer electrons are all in 2-level orbitals, which are all at much the same sort of distance from the nucleus. They are all screened by the 1s electrons. As you go across the period, the number of protons in the nucleus increases, increasing the attraction on the 2-level electron which will be removed. In Period 3, the same thing is true, except that we are now talking about 3-level electrons, screened by 1s, 2s and 2p electrons. Because attractions increase, ionisation energy will also increase.
- Magnesium's electronic structure is $1s^2 2s^2 2p^6 3s^2$; beryllium's is $1s^2 2s^2$. Magnesium has 8 more protons in the nucleus than beryllium has, but the extra effect of these is screened by the 8 electrons in the complete 2-level in magnesium. The magnesium's first ionisation energy is less than beryllium's because the electron being removed is in the 3-level rather than the 2-level, and so is further from the attraction of the nucleus.
- Aluminium's electronic structure is $1s^2 2s^2 2p^6 3s^2 3p^1$; magnesium's is $1s^2 2s^2 2p^6 3s^2$. The electron being removed in aluminium is in a 3p orbital which has a slightly higher energy than a 3s orbital, and is slightly further, on average, from the nucleus. Being further away makes the attraction less, and the 3p electron is also screened slightly by the 3s electrons. The effect of this outweighs the effect of the extra proton.
- Sulphur's structure is $1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^1 3p_z^1$; phosphorus is $1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^1 3p_z^1$. The screening is identical in both atoms, and the electrons are being removed from the same 3p orbitals. The only difference is that in sulphur the electron is being removed from a pair of electrons in the $3p_x$ orbital. The repulsion between them makes that easier than it would be to remove an electron if it was on its own in the orbital. The effect of this outweighs the effect of the extra proton.
- The first electron to be lost from all of the d-block elements comes from the 4s orbital. The 3d orbitals lie slightly closer to the nucleus. As you add an extra proton to the nucleus, you also add an extra electron to the 3d orbitals. That more or less screens the effect of the extra proton.
- Copper is $[\text{Ar}] 3d^{10} 4s^1$; zinc is $[\text{Ar}] 3d^{10} 4s^2$. In both copper and zinc, the electron is coming from the 4s level with a complete $3d^{10}$ level inside it. The screening in both cases will be identical. The increase in first ionisation energy is due to the attraction of the extra proton in the nucleus.