

## AP WORKSHEET 01GH: ANSWERS

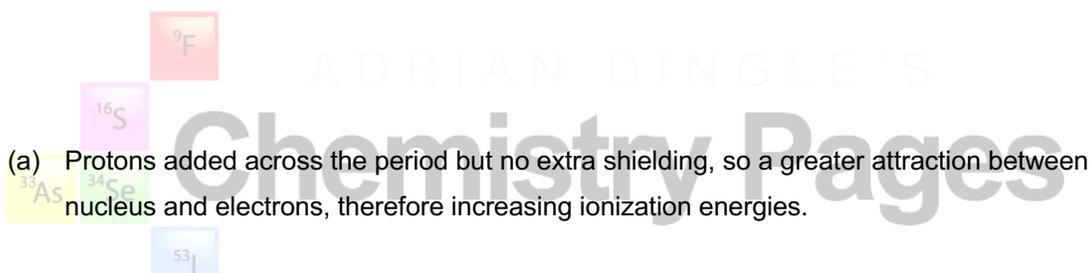
1.

- (a) Sodium has an extra quantum level (shell) of electrons and therefore greater shielding when compared to lithium. Despite the extra protons (greater nuclear charge) in sodium, shielding is the dominant factor.

In addition, sodium's outermost electron is further away from the nucleus and in a higher energy level than lithium outermost electron (3s as opposed to 2s). As a result, sodium's outermost electrons are more easily removed, i.e., Na has a lower ionization energy.

- (b) Oxygen's outermost electron is being removed from a pair in a 2p orbital ( $2p^4$ ), but from a singly occupied 2p orbital in nitrogen ( $2p^3$ ). There is repulsion between the pair of electrons in the full 2p orbital in the oxygen atom, therefore the electron is more easily removed and the ionization energy is lower than expected. No such repulsion exists in nitrogen.

2.

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- (a) Protons added across the period but no extra shielding, so a greater attraction between nucleus and electrons, therefore increasing ionization energies.

- (b) The 2p outer electron is in a slightly higher energy orbital than the 2s, slightly further away from the nucleus, and is being shielded by a full 2s orbital. All these factors make it easier to remove, giving it a lower ionization energy than expected.

- (c) On descending the group the outer electrons become increasingly shielded from the nuclear charge. Although the nuclear charge increases down the group (more protons) the effectiveness of the attraction is significantly diminished by the extra shielding and the electrons become easier to remove.

- (d) The electrons in a helium atom experience no shielding from the nuclear charge by inner shells of electrons and as a result are extremely difficult to remove.

3.

- (a) The large increase in ionization energy between the 7<sup>th</sup> and the 8<sup>th</sup> values suggests that the 8<sup>th</sup> electron is in an inner quantum shell, closer to the nucleus with less shielding and therefore experiences a greater attraction from the nucleus. This suggests that the first seven electrons are in an outer shell, i.e., group 17.
- (b) In each case, the corresponding ionization energy for element X is less than that of element Y. Since ionization energy increases across the period table from left to right, that would suggest that element X is to the left of element Y.
- (c) Each element has a minimum of nine electrons so they cannot be in period 1. The first, possible period is period 2.
- (d) Second electrons are being removed from a now, positive species. If the second electron is being removed from the same quantum shell as the first electron, then the electrons will now experience slightly less mutual repulsion and may be able to get slightly closer to the nucleus thus experiencing a greater attraction. If the second electron is being removed from an inner quantum shell, closer to the nucleus, then it will experience a significantly greater attraction from the nucleus and be significantly more difficult to remove.
- (e) Y must be a noble gas since group 18 elements have the highest ionization energies in any given period.
- (f) It only has four electrons.

4.

- (a) The energy required to remove one mole of electrons from one mole of gaseous atoms.
- (b)  $\text{Ca}^+_{(g)} \rightarrow \text{Ca}^{2+}_{(g)} + e^-$