4. Periodicity: Physical and Chemical properties

Solutions to topic 6 Periodicity further problems:

1. (a) Ca(lcium) (b) Iodine
2. (a) Al (b) Be (c) 7(VII) (d) 4
3. (a) $[Xe]6s^2$ (b) $[Xe]6s^2 5d^{10} 6p^2$ (c) $[Kr]5s^2 4d^{10} 5p^5$ (d) $[Xe]6s^2 5d^9$ ($[Xe]6s^1 5d^{10}$)
4. i) the first one. A half filled subshell is more stable than more than half filled because of the repulsion between the paired electrons in the first orbital of the other *p* subshell.
   ii) The first one. There is stronger repulsion between the paired electrons in the second that between the unpaired electrons in the first.
   iii) The first one for the same reason as for i.
   iv) The second one because it is completely filled subshell.
   v) The second one for the same reason as iv.
5. i) Ionization energy increases from Li to Ne because the increasing nuclear charge increases the nuclear force of attraction experienced by the valence electrons requiring more and more energy to ionize it.
   ii) Ionization of oxygen involves removal of an electron from a *p* orbital which is shielded by the s electrons requiring less energy for removal.
   iii) The ionization of helium involves removal of an electron from the first energy while for the rest of the noble gases ionization involves removal of electron from successively higher energy level which are farther and farther away from the nucleus.
6. (a) $Na_{(g)} \longrightarrow Na^+_{(g)} + 1e^-_{(g)}$
   (b) $Pb^+_{(g)} \longrightarrow Pb^{2+}_{(g)} + 1e^-_{(g)}$
7. N, Be, Mg. Nitrogen has a higher ionization energy than Be because though it has the same number of shells nitrogen has a bigger nuclear charge in the nucleus, which exerts a stronger force of attraction on its valence electrons. Be has a higher ionization energy than Mg because Mg has one more shell than Be.
8. (a) Be, (b) N, (c) Ne, (d) Na^+
9. a) XCl_2
   b) 2nd ionization involves removal of an electron from a Mg^+ which not only has one less electron than Mg, but it also has a net positive charge both of which has the effect of increasing the nuclear attraction for the valence electrons in Mg^+ requiring more energy to remove the second electron.
   c) 3rd ionization involves removal of an electron from the second shell, a shell that is closer to the nucleus than the third shell, from which the electron originated in the 2nd ionization, requiring a much greater energy. Not only that, 3rd ionization involved removal of an electron from an ion with one less electron than when the ion underwent 2nd ionization.
10. It increases down a group because the number shells increases. It decreases across a period because the number of sheels remains the same but the nuclear charge increases.
11. i) Na. Everything is equal except nuclear charge. Na has smaller nuclear charge therefore it is bigger.
    ii) Si. One more energy level (shell) and therefore bigger.
    iii) Na. One more energy level (shell).
    iv) Mg. It has one more shell and not only that, the force of attraction experienced by the valence electrons in the Mg^{2+} is greater also because a fewer number of electrons are being attracted by the same nuclear charge.

v) F^-. Everything is equal except number of electrons. It has more electron then F and therefore stronger repulsion between electrons leading to a weaker nuclear attraction and therefore a bigger size.

vi) Cl^-. Everything else is equal except it has smaller nuclear charge.

vii) F-. It has one more shell.

viii) S^{2-}. Two reasons: Repulsion is stronger and also the nuclear charge is smaller.

ix) K^+. Everything is equal except nuclear charge. K^+ has smaller nuclear charge and therefore it is bigger.

x) Kr. Everything else is equal except nuclear charge. Kr has smaller nuclear charge and therefore it is bigger.

12. (a) Se because it has one more shell than S.

(b) C because though it has the same number of shells as N, it has one less proton in the nucleus.

(c) Fe^{2+} because though it has the same number of shells and the same number of protons as Fe^{3+}, it has a larger number of electrons and therefore smaller net positive charge.

(d) O^- because though it has the same number of shells and the same number of protons in the nucleus, it has more electrons than O^+.

(e) S^{2-} because though it has the same number of shells and the same number of protons in the nucleus, it has more electrons than S.

13. $Ca^{2+} < K^+ < Ar < Cl^- < S^{2-}$.

$Ca^{2+} < K^+$ because though they both have the same number of shells and electrongs Ca^{2+} has a bigger nuclear charge which attracts its valence electrons more strongly.

$K^+ < Ar$ because, though they both have the same number of shells and electrons (are isoelectronic) K^+ has a bigger nuclear charge than Ar.

$Ar < Cl^-$ because though they both have the same number of shells, not only does Ar have bigger nuclear charge, Cl^- has an overall negative charge which results in a stronger repulsion between its electrons resulting in it being larger.

$Cl^- < S^{2-}$ because even though they both have net negative charges, not only does Cl^- have a larger nuclear charge, S^{2-} has a larger net negative charge which results in a stronger repulsion between its electrons resulting in it being larger.

14. (a) $2Li + 2H_2O \longrightarrow 2LiOH + H_2$

(b) $2Na + Br_2 \longrightarrow 2NaBr$

(c) $Cl_2 + H_2O \longrightarrow HOCl + HCl$

(d) $Br_2 + 2I^- \longrightarrow I_2 + 2Br^-$

(e) $Cl^- + Ag^+ \longrightarrow AgCl$

15. (a) Cannot. (b) Can (c) can (d) cannot (e) cannot (f) cannot

16. (a) $Na_2O + H_2O \longrightarrow 2NaOH + H_2$

(b) $SO_2 + H_2O \longrightarrow H_2SO_3$

(c) cannot

(d) $MgO + 2HCl \longrightarrow MgCl_2 + H_2O$

(e) soluble (forms ions)

(f) $PCl_{3\,(l)} + H_2O_{(l)} \longrightarrow HCl_{(aq)} + H_3PO_{3\,(aq)}$