Assignment Sheet #2 APQ answers

201
a. For a ground state arsenic atom: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^3$
(Technically, you group all principal quantum numbers in the electron configuration; they are not listed according to the aufbau fill sequence)

b. Assume the outermost electrons are in n = 4. Therefore, the quantum numbers are:

$n = 4, l = 0, m_l = 0, m_s = 1/2$
$n = 4, l = 0, m_l = 0, m_s = -1/2$
$n = 4, l = 1, m_l = -1, m_s = 1/2$
$n = 4, l = 1, m_l = 0, m_s = 1/2$
$n = 4, l = 1, m_l = 1, m_s = 1/2$

c. Paramagnetic; 3 unpaired electrons.

2
a. The Be atom has an additional proton in its nucleus, thus its effective nuclear pull on its outermost electrons is greater than the effective nuclear pull on the outermost electrons caused by the Li nucleus.

b. Once one electron is removed from a neutral K atom, the resulting +1 ion has a much smaller radius; it is isoelectronic with an argon atom. The K^{+1} ion's outermost electrons are in n = 3. The Ca^{+1} ion is isoelectronic with a neutral K atom; it still has an electron in n = 4, so its ionic radius is larger than the K^{+1} ion. In order to remove a second electron, you need to consider how far away from the nucleus the new outermost electron is. It is easier to remove the 4s electron in the calcium ion than the 3p electron in the potassium ion. Therefore, the 2nd ionization energy of K is greater than the 2nd ionization energy of Ca.

19
a. The six isotopes of selenium have the same atomic number and number of electrons, but they have different numbers of neutrons, and, hence, different mass numbers.

b. Selenium is #34 on the periodic table, so show 34 electrons in the configuration.
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^4$
There are two unpaired electrons in the 4p orbitals of a ground-state Se atom.

4p ↑↓ ↑ ↑

c-i. Bromine, with one additional proton in its nucleus, has a greater nuclear pull on its electrons; therefore it is a smaller atom, and the outermost electron requires more energy to remove than that of selenium.
c-ii. The outermost p orbital electron in a tellurium atom is in n = 5, which is further from the Te nucleus than selenium's outermost electron, which is in n = 4, is from the Se nucleus. Both atoms are in the same family, meaning that the outermost electron is in the same specific orbital ($m_l = -1$). Selenium's smaller radius, therefore, results in selenium requiring more energy to remove an outermost electron.

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a-i 495 nm = 4.95×10^{-7} m and $c = \lambda \times f$
therefore $f = (3 \times 10^{8}$ m/s$) \div (4.95 \times 10^{-7}$ m$) = 6.06 \times 10^{14}\ s^{-1}$

a-ii $E = h \times f$; therefore $E = (6.63 \times 10^{-34}$ J-s$)\ (6.06 \times 10^{14}\ s^{-1}) = 4.02 \times 10^{-19}$ J

a-iii It took 4.02×10^{-19} J to break one Cl-Cl bond; therefore, it will require 6.02×10^{23} times as much energy to break one mole of the bonds. 242,004 J = 242 kJ per mole.

b-i As the electron transits from n = 6 to n = 2, the atom emits energy. The atom had to gain energy when the electron initially moved to n = 6 from the ground state (n = 1).

$\Delta E = R_H\ (1/n_i^2 - 1/n_f^2) = 2.18 \times 10^{-18}\ (1/6^2 - 1/2^2) = -4.84 \times 10^{-19}$ J

(negative value due to exothermic change); the resulting photon will have this energy in positive terms.

$E = ch/\lambda$; therefore, $\lambda = ch/E = (3 \times 10^{8}$ m/s$)\ (6.63 \times 10^{-34}$ J-s$) \div (4.84 \times 10^{-19}$ J$) =$
4.11×10^{-7} m = 411 nm

b-iii The energy is greater in He^{+1} due to the 2^{nd} proton in the nucleus. The energies of the electron will be greater in all of the energy levels, so greater transition energies should be observed.

43

a. Potassium is a larger atom than lithium: potassium's outermost electron is in a 4s orbital, whereas lithium's is in a 2s orbital. The outermost lithium electron is closer to its nucleus, so the energy required to remove the electron is greater.

b. The N^{-3} ion has fewer protons pulling on its electrons than the 0^{-2} ion, therefore the N^{-3} electrons can expand over a larger area.

c. Both atoms are found in the same period of the periodic table, and the zinc atom has more protons than the calcium atom, so the effective nuclear pull of Zn is greater than that of Ca.

d. Boron has a single electron in its 2p orbital, which is slightly further from the nucleus than the 2s electrons of beryllium. The 2p electron is thus easier to remove, so boron's IE is lower than beryllium's..
From another perspective, the 2p electron is slightly less stable configuration than the 2 electrons that fill beryllium's 2s orbital. The filled 2s orbital is a relatively stable electron configuration in terms of potential energy (recall that having filled s or d orbitals is *almost* as cool as having filled valence s and p orbitals like the nobles)

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a. The smaller radius of the Ca^{+2} cation is due to two facts:
1, the calcium atom's outermost 4s electrons have been removed, leaving it with only n=3 electrons as its new "outermost" electrons, which are closer to the nucleus.
2, there are now 2 more protons than electrons in the resulting +2 cation, so the effective nuclear pull is greater, also reducing the ionic size.

c. Calcium's first I.E. is greater than potassium's first I.E. due to calcium's smaller atomic radius. Calcium's 2^{nd} I.E is less than potassium's 2^{nd} I.E. because the calcium +1 ion will next lose a 4s electron, whereas the potassium +1 ion will next lose a 3p electron, which is closer to the nucleus.

d. Aluminum loses its 1^{st} electron from the 3p orbital, which is further away from its nucleus than magnesium's outermost electron (the electron that will be lost first), which is a 3s electron. The 3s electron is closer to the nucleus than the 3p electron.