Problem Set #1
Answer Key

S1.1 Neutron capture by an atom involves an increase in mass number, in this case from 80 to 81. The atomic number remains the same, however; the atom in question is a bromine atom before and after the neutron capture. Any excess energy will appear as a photon in the ?–ray region of the electromagnetic spectrum. The balanced reaction is:

$^{80}_{35}Br + ^{1}_{0}n$ ✍ $^{81}_{35}Br$ + ?

S1.5 When considering questions like these, it is always best to begin by writing down the electron configurations of the atoms or ions in question.

F [He]$2s^2 2p^2$
Cl [Ne]3s23p5

The electron removed during the ionization process is a 2p electron for F and a 3p for Cl. The principal quantum number, n, is lower for the electron removed from F, so this electron is bound more strongly by the F nucleus than a 3p electron in Cl is bound by its nucleus.

S1.6 The electron configurations of these two atoms are:

C [He]$2s^2 2p^2$ N [He] $2s^2 2p^3$

An additional electron can be added to the empty 2p orbital of C, and this is a favorable process. However all of the 2p orbitals of N are already half filled, so an additional electron would cause sufficiently strong repulsions that the electron-gain process for N is unfavorable.

E1.1 a) $^{14}_{7}N + ^{4}_{2}He$ ✍ $^{17}_{8}O$ + p + ?

b) $^{12}_{6}C$ + p ✍ $^{13}_{7}N$ + ?

c) $^{14}_{7}N + ^{1}_{0}n$ ✍ $^{3}_{1}H + ^{12}_{6}C$

E1.7 For the 1st shell (n=1) there is only one orbital, the 1s. For the 2nd shell (n=2), there are 4 orbitals, the 2s and the three 2p orbitals. For n=3 there are 9. The progression of the number of orbitals is 1, 4, 9, which is n^2.

E1.10 The first ionization energies of strontium, barium, and radium are 5.69, 5.21, 5.28 eV, respectively. Normally, atomic radius increases and ionization energy decreases down a group in the periodic table. However, in this case I(Ba) < I(Ra). Look at the alkaline earth metals on the periodic table, notice that Ba is eighteen elements pas Sr, but Ra is thirty-two elements past Ba. The difference between the two corresponds to the fourteen 4f elements between Ba and Lu. Z_{eff} rises with each successive element because of incomplete shielding. Therefore, even though radium would be expected to have a larger radius than barium, it has a higher first ionization energy because it has such a large Z_{eff}.

P1.3 The ionization energy of rubidium and silver correspond to removing the electron from the outer most shell. Looking at their electron configurations one sees that the outer most shell is the 5s orbital. Which tells us that the principal quantum number (n) is 5. Using this and the equation on page the 12 of the text, you can find the ionization energy for hydrogen with its electron in the 5s orbital.

Rb [Kr] $5s^2$
Ag [Kr] $5s^2$ $4d^9$

$$E = -\frac{hcZ^2 \mathcal{R}}{n^2} = -\frac{13.6\text{eV}}{25} = -0.544 \text{ eV}$$

P1.4 58.4 nm radiation emitted by helium has enough energy to remove the electron and cause it to move at a specific velocity. The energy to remove the electron is the ionization energy and the energy of movement is kinetic energy. With this in mind we know that the energy emitted by the helium is equal to the ionization energy plus the kinetic energy.

$$\text{I.E.} = E_{helium} - \text{K.E.} = hc/? \; -1/2mv^2$$

For krypton: I.E. = 21.2 eV - 7.2 eV = 14 eV

For rubidium: I.E. = 21.2 eV - 17.05 eV = 4.15 eV

P1.11 When comparing ionization energies it is a good idea to look at electron configurations. Since we want to look at 2^{nd} ionization energies we will need to look at the electron configurations for Cr^{+1} and Mn^{+1}. Keep in mind that chromium is one of the exceptions when writing its electron configuration because it fills both the 4s and 3d orbitals half full.

Cr [Ar] $4s^1$ $3d^5$ Cr^{+1} [Ar] $4s^0$ $3d^5$
Mn [Ar] $4s^2$ $3d^5$ Mn^{+1} [Ar] $4s^1$ $3d^5$

When chromium loses its first electron it comes out of the 4s orbital leaving it empty, but when manganese loses its first electron it still has one electron left in the 4s orbital. The 4s orbital being further away from the nucleus makes it easier to remove than an electron from the 3d orbital which is further stabled by being half filled.