3.091 Fall Term 2002

Homework #3

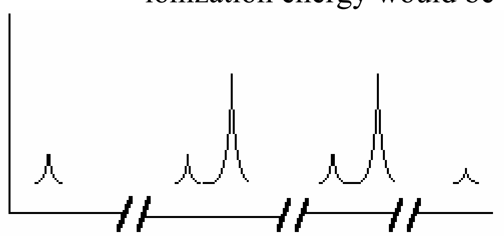
Solutions

From the text:

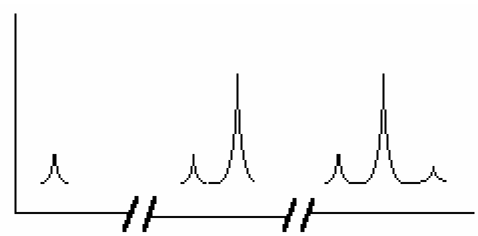
3-84. Mg. The energies are given in Table 3.5.

3-85. (a) The first 18 electrons for K are found in the $1s^2$, $2s^2$, $2p^6$, $3s^2$, and $3p^6$ shells. This is also the order of decreasing ionization energies. The relative intensities for the p electrons would be 3 times as large as the s electrons.

(b) Within a given shell, it is expected that the energies to remove electrons are quite similar. Therefore, if the 19th electron were in an n = 4 shell, the ionization energy would be substantially different because the electrons are further from the nucleus. This can be seen by comparing the relative ionization energies for the different shells in Na and Li. The ionization energy would be closest to 0.42 MJ/mol.



(c) Within a given shell, it is expected that the energies to remove electrons are quite similar. Therefore, if the 19th electron were in an n = 3 shell, the energy would be close to but slightly larger than the 1.52 MJ/mole found for Ar. The ionization energy would be closest to 2.0 MJ/mole.



(d) There is a drop in energy from a grouping of 3.93 MJ/mole and 2.38 MJ/mole to 0.42 MJ/mole. This suggests that this final peak represents electrons that are further from the nucleus and should be assigned to the n = 4 shell.

3-108. 5 unpaired electrons can be placed in a d subshell.

3-125. "e" is incorrect.

3-132. Element 119 should belong to group 1.

3-184. The AVEE of Be is 0.90 as compared to 1.91 for oxygen. Since the AVEE is a measure of how tightly an atom holds its valence electrons, it is more difficult to remove electrons from O as compared to Be.

3-185. B: AVEE $= \dfrac{2(1.36)+1(0.80)}{3} = 1.17$

F: AVEE $= \dfrac{2(3.88)+5(1.68)}{7} = 2.31$

These are the same values found in Figure 3.27.

3-206. When there are equal numbers of spin-up and spin-down electrons, the atom is said to be diamagnetic and repelled by a magnetic field. This is what is meant by "paired" electrons.

3-207. (a) C, 2 unpaired electrons (b) N, 3 unpaired electrons (c) O, 2 unpaired electrons (d) Ne, 0 unpaired electrons (e) F, 1 unpaired electron.

3-208. There are 3 pairs of electrons in a filled p shell.

3-209. In the Stern-Gerlach experiment beams of atoms will interact with a magnetic field and split into two separate beams if they possess unpaired electrons. The magnetic moment is related to the number of unpaired electrons. Since He and Ne do not have a magnetic moment, we would expect that beams of these atoms would not be split. Beams of the other atoms should split in two because they have magnetic moments.

3-210. The ion could be Cr^{2+} or Fe^{2+}.

3-211. Element Z is diamagnetic and typically forms +2 cations. This is consistent with Z having 2 electrons in its outermost shell. Group 2A matches this description. Since Z has the next to lowest ionization energy in its group and ionization decreases down a group, Z must be the next to last element in Group 2A: Ba. The compounds formed would be BaO and $BaCl_2$.

Additional questions:

1. How many of the following electron configurations are allowed?

(a) $1s^2 2s^2 2p^7$	NO [No p^7 occupation]
(b) $1s^2 2s^2 2p^6 2d^1$	NO [No 2d orbitals]
(c) [Ne] $4s^2 4p^4$	NO [3s and 3p orbital filling would precede 4s, 3d would precede 4p
(d) [Ar] $4s^2 3d^6$	YES
(e) $1s^2 2s^2 2p^8 3s^2 3p^4$	NO [No $2p^8$ configuration]

There are two conventions for writing electron configurations (see text p. 90 2nd edition, p. 106 1st edition): list subshells (1) in order of increasing energy or (2) following the arrangement of elements in the periodic table. The text favors the latter; the Permacharts periodic table favors the former. Prof. Sadoway is with the authors of the text but will accept both answers.

2. Determine which of the following five electronic states are forbidden:

	n	ℓ	m
(1)	**2**	**2**	**1**
(2)	**1**	**0**	**1**
(3)	**3**	**2**	**0**
(4)	**4**	**1**	**2**
(5)	**3**	**2**	**2**

Forbidden states are:

1, because $\ell = n$

2, because $m > \ell$

4, because $m > \ell$

3. (a) In box notation, give the complete ground-state electron configuration for each of the following chemical entities: Cr, Ca^{5+}, I^{-}, He^{2+}, Dy^{3+}.

Cr

1s	2s	2p	3s	3p	4s	3d
↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓	↑	↑ ↑ ↑ ↑ ↑

Ca^{5+}

1s	2s	2p	3s	3p	
↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑ ↑ ↑	

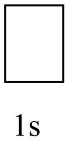
I^{-}

1s	2s	2p	3s	3p	4s
↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓

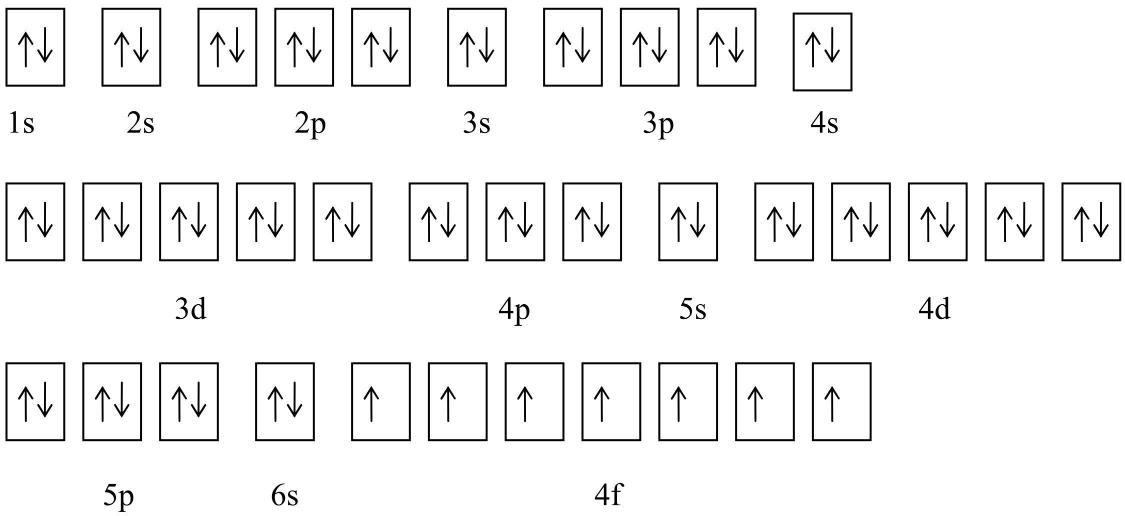
3d	4p	5s	4d
↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓

5p
↑↓ ↑↓ ↑↓

He^{2+}



Dy^{3+}



(b) Give the values of *n*, ℓ, and *m* for each orbital in the 5d subshell.

n	ℓ	m
5	**2**	**2**
5	**2**	**1**
5	**2**	**0**
5	**2**	**-1**
5	**2**	**-2**