1 Problem 1

For the atomic term ^3P, what are the energy differences between the levels arising due to spin-orbit coupling.

1.1 Solution

For the atomic term ^3P, show the energy differences between the levels arising due to spin-orbit coupling.

Answer For this term, the values of J that arise are 0,1,2 and these correspond to $L = 1, S = 1$. Thus,

$$\begin{aligned} E_{0,1,1} &= \frac{hA}{2}[0 - 2 - 2] = -4\frac{hA}{2} \\ E_{1,1,1} &= \frac{hA}{2}[2 - 2 - 2] = -2\frac{hA}{2} \\ E_{2,1,1} &= \frac{hA}{2}[6 - 2 - 2] = 2\frac{hA}{2} \end{aligned} \tag{1}$$

The energies between levels can be determined by simple subtraction of the values between the $J = 0 and J = 1$ states and the $J = 1 and J = 2$ states.

The results are hA and $2hA$.

2 Problem 2

For the oxygen atom in the ground state, what terms are possible? What is the degeneracy of each term? If spin-orbit coupling is taken into account, what levels arise? What is the degeneracy of each level?

2.1 Solution

For the oxygen atom in the ground state, what terms are possible? What is the degeneracy of each term? If spin-orbit coupling is taken into account, what levels arise? What is the degeneracy of each level?

Answer Atomic electronic configuration of oxygen atom is: $1s^2, 2s^2, 2p^4$; thus, it's an np^4 configuration. From Handbook, the possible terms are ^1S,^1D,^3P.

The degeneracy of each **term** is determined by $g = (2S + 1)(2L + 1)$. Thus, for the 3 terms just mentioned, the degeneracies are $(1)(1) = 1, (1)(5) = 5$, and $(3)(3) = 9$.

In order to determine the levels arising from spin-orbit coupling, we have to determine the possible values of J for each term. For the ${}^1S$ there is only one value of $J = L + S = 0 + 0 = 0$, so the level is ${}^1S_0$. In like manner, the levels for the ${}^1D$ are ${}^1D_2$, and for the ${}^3P$ term the levels are ${}^3P_0$,${}^3P_1$,${}^3P_2$. The degeneracies for levels are determined by the J values by $g_J = 2J + 1$:

$$\begin{aligned} g_{J=0} &= 1 \\ g_{J=1} &= 3 \\ g_{J=2} &= 5 \end{aligned} \tag{2}$$