Assignment –IV –November, 2019

1. For each of the atomic term symbols ^1S, ^2P, ^3P, ^3D, ^4D, write down:

a) The associated values of the total spin and orbital angular momentum quantum numbers, S and L;

b) the possible values of J, the total angular momentum quantum number; and

c) the number of states associated with each value of J.

2. a) How many fine-structure components would be observed in the emission line n = 4 → 3 of the H-atom if the effects of spin-orbit coupling were fully resolved in the spectrum? Illustrate these transitions on a diagram.

3. A line in the spectrum of potassium arises from the transition $4^2P \rightarrow 3^2D$. Upon closer examination it is found to consist of three lines at energies (in cm^{-1}) 8494.13, 8496.45 and 8554.17.

a) Draw a diagram representing these transitions given that the splitting is regular (i.e., energy increases with J) for the ^2P terms and inverted for the ^2D terms.

4. A number of possible transitions in the beryllium atom are listed below. Which are "fully allowed"? For those which are not allowed, which selection rule would have to be broken and what mechanisms which might lead to such a break-down? (n.b., one term symbol is invalid, which one and why?)

$2s5s\ (^1S_0) \rightarrow 2s5d\ (^1D_2)$

$2s5s\ (^3S_1) \rightarrow 2s2p\ (^1P_1)$

$2s5s\ (^1S_0) \rightarrow 2s^2\ (^1S_0)$

$2s5p\ (^3P_1) \rightarrow 2s3s\ (^3S_1)$

$2s5p\ (^3P_1) \rightarrow 3s4s\ (^3S_1)$

$2s3p\ (^3P_1) \rightarrow 3p^2\ (^3D_2)$

$2s3p\ (^3P_0) \rightarrow 3p4p\ (^3D_2)$

$2s3p\ (^3P_0) \rightarrow 3p4p\ (^3P_0)$

5. a) A transition from the 3s to a 3p level in Na is at 16 961cm−1. Transitions from this 3p level to the d levels form a series of lines of which the first three are at 8752, 16214 and 19386cm−1. Sketch the energy level diagram for the transitions involved and deduce the ionisation potential of Na in its ground state. (leave your answer in cm−1).

c) Explain the fact that the 3s → 3p transition referred to in part (a) is split into a doublet separated by 17cm−1 and under higher resolution the p to d transitions are each seen to consist of three lines. Explain these observations.