Hd 6

1. Ground state configuration

(a) The columns reveal the last shell being filled, the row the numbers of electrons in that shell,

Therefore

^{12}Mg : $1s^2 2s^2 2p^6 3s^2$

^{13}Al : $1s^2 2s^2 2p^6 3s^2 3p^1$

^{14}Si : $1s^2 2s^2 2p^6 3s^2 3p^2$

(b) ^{12}Mg : the configuration represents a filled shell, and thus all the angular momenta are zero, $^1S_0$

^{13}Al : there is a single valence electron ($s = s^1 = 1/2$), thus $2s^1 + 1 = 2$, $\ell = 1$ giving a P state $J = 3/2, 1/2$ with the smaller J lying lower, $^2P_{1/2}$

^{14}Si : here there are two $\ell = 1$ electrons $S = 0, 1$ and $L = 2, 1, 0$. For the lower energy pick the larger S. This gives the possibilities

$L = 2$, $J = 3, 2, 1$, $^3D_{3,2,1}$

$L = 1$, $J = 2, 1, 0$, $^3P_{2,1,0}$

$L = 0$, $J = 1$ $^3S_1$

The $^3D_1$ and $^3S_1$ states are however, prohibited by the exclusion principle. Of the $^3P_{2,1,0}$ states, the smallest J lies lowest, hence the ground state configuration should be $^3P_0$.

2.

Segulvægi $^3P_0$

þetta ástand hefur heildar hverfiþunga $J=0$ þess vegna er segul-vægið

$$M = g\mu_B\sqrt{J(J+1)} = 0$$

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3. Hverfiþungi ${}^3F_4$

Stafurinn F segir að heildar brautar hverfi-þunga skammtatala L sé 3.

Hástöfunin 3 er margfeldni liðarins 2S+1, sem kemur til vegna spuna skammta-tölunnar S=1, og á skör eru 4 sem er heildar hverfiþunga-skammtatalan J.

② Assign quantum numbers.

multiplet 1:2:3:4

For a single multiplet S and L have the same value for each level.

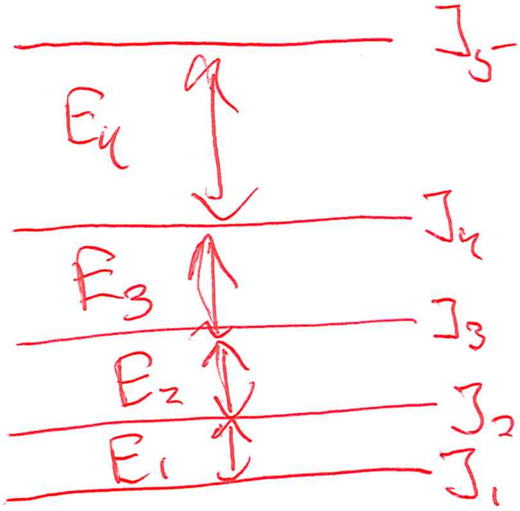
By the interval rule

$E_4 = 2KJ_5$

$E_3 = 2KJ_4$

$E_2 = 2KJ_3$

$E_1 = 2KJ_2$



Therefore

$$\frac{E_4}{E_3} = \frac{4}{3} = \frac{J_5}{J_4} = \frac{J_4+1}{J_4} \Rightarrow J_4 = 3$$

Since

$$J = 1, \quad J_5 = 4, \quad J_4 = 3, \quad J_2 = 1$$

and $J_1 = 0$

But

$$J = L + S, \ L + S + 1, \ \dots, \ |L - S|$$

so that

$$L + S = 4, \quad L - S = 0$$

and

$$L = S = 2$$

and hence

$$L = S = 2$$

$$J = 4, 3, 2, 1, 0$$

3. The Zeeman effect

In the absence of magnetic field, the 3d to 2p energy difference is

$$E = (-13.6057\,\text{eV})\left(\frac{1}{3^2} - \frac{1}{2^2}\right) = 1.88968\,\text{eV}$$

and the wavelength is

$$\lambda = \frac{hc}{E} = \frac{1239.842\,\text{eV nm}}{1.88968\,\text{eV}} = 656.112\,\text{nm}$$

The magnetic field gives a change in wavelength of

$$\Delta\lambda = \frac{\lambda^2}{hc}\Delta E = \frac{(656.112\,\text{nm})^2}{1239.842\,\text{eV nm}}\left(5.79\times10^{-5}\,\frac{\text{eV}}{\text{T}}\right)$$

$$\times (3.5\,\text{T}) = 0.0703\,\text{nm}$$

The wavelengths of the three normal Zeeman components are 656.112 nm, $656.112 + 0.070\,\text{nm} = 656.182\,\text{nm}$ and $656.112 - 0.07\,\text{nm} = 656.042\,\text{nm}$.

$\boxed{\diagup\!\!\diagup}$

4. Fine structure

The energy of the 2p to 1s Lyman transition is

$$E = (-13.60570\,eV)\left(\frac{1}{2^2} - \frac{1}{1^2}\right)$$

$$= 10.20428\ eV$$

and the wavelength (in the absence of fine structure

$$\lambda = \frac{hc}{E} = \frac{1239.842\ eV\,nm}{10.20428} = 121.5022\,nm$$

With the fine splitting of 4.5×10^{-5} eV, the wavelength splitting is

$$\Delta\lambda = \frac{\lambda^2}{hc}\Delta E = \frac{(121.5nm)^2}{1240\ eV\,nm} \times 4.5 \times 10^{-5}\ eV = 0.00054\ nm$$

so

$$\lambda + \tfrac{1}{2}\Delta\lambda = 121.5024\,nm\ ,\quad \lambda - \tfrac{1}{2}\Delta\lambda = 121.5019\,nm$$

The fine structure splits one level up by $0.5\Delta E$ and the other down by the same amount, so the wavelengths are

$$\lambda + \frac{1}{2}\Delta\lambda = 121.5024 \text{ nm}$$

and

$$\lambda - \frac{1}{2}\Delta\lambda = 121.5019 \text{ nm}$$