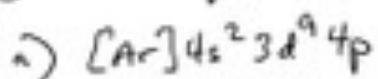


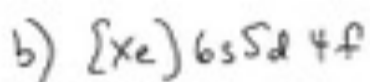
(10) ① Term symbols



$$l_1 = 2 \quad \left. \begin{array}{l} l_2 = 1 \\ l_3 = 0 \end{array} \right\} L = 3, 2, 1 \quad {}^3F, {}^3D, {}^3P$$

$$s_1 = \frac{1}{2} \quad \left. \begin{array}{l} s_2 = \frac{1}{2} \end{array} \right\} S = 1, 0 \quad {}^1F, {}^1D, {}^1P$$

$$J = L + S : \quad \begin{array}{l} {}^3F_4, {}^3F_3, {}^3F_2, {}^1F_3 \\ {}^3D_3, {}^3D_2, {}^3D_1, {}^3D_2 \\ {}^3P_2, {}^3P_1, {}^3P_0, {}^1P_1 \end{array}$$



$$l_1 = 0 \quad \left. \begin{array}{l} l_2 = 2 \\ l_3 = 3 \end{array} \right\} L = 2 \quad \text{couple w/ } l_3 = 3 \rightarrow L = 5, 4, 3, 2, 1$$

$$s_1 = \frac{1}{2} \quad \left. \begin{array}{l} s_2 = \frac{1}{2} \\ s_3 = \frac{1}{2} \end{array} \right\} S = 1, 0 \quad \text{couple w/ } s_3 = \frac{1}{2} \rightarrow \frac{3}{2}, \frac{1}{2}, \frac{1}{2}$$

$$J = L + S \quad (\text{lots of them})$$

$${}^4H_{13/2}, {}^4H_{11/2}, {}^4H_{9/2}, {}^4H_{7/2}$$

$$({}^2H_{11/2}, {}^2H_{9/2}) \times 2$$

$${}^4G_{11/2}, {}^4G_{9/2}, {}^4G_{7/2}, {}^4G_{5/2}$$

$$({}^2G_{9/2}, {}^2G_{7/2}) \times 2$$

$${}^4F_{7/2}, {}^4F_{5/2}, {}^4F_{3/2}, {}^4F_{1/2}$$

$$({}^2F_{5/2}, {}^2F_{3/2}) \times 2$$

$${}^4D_{3/2}, {}^4D_{5/2}, {}^4D_{7/2}, {}^4D_{9/2}$$

$$({}^2D_{5/2}, {}^2D_{3/2}) \times 2$$

$${}^4P_{5/2}, {}^4P_{3/2}, {}^4P_{1/2}$$

$$({}^2P_{3/2}, {}^2P_{1/2}) \times 2$$

(2) # of states

(8)

a) $4F$ $J = \frac{9}{2}, \frac{7}{2}, \frac{5}{2}, \frac{3}{2}$

$$\text{states} = 2J+1 = 10 + 8 + 6 + 4 = \textcircled{28}$$

b) $1s$ $J = 0 \rightarrow \textcircled{1}$ state

c) $3p$ $J = 2, 1, 0$

$$\text{states} = 5 + 3 + 1 = \textcircled{9} \text{ states}$$

d) $2D$ $J = \frac{5}{2}, \frac{3}{2}$

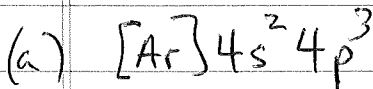
$$\text{states} = 6 + 4 = \textcircled{10} \text{ states}$$

(3)

~~(2)~~

(10)

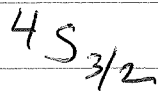
ground states via Hund's rules

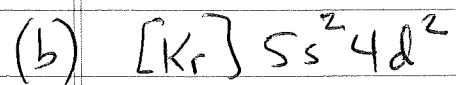


max S : $S = 3/2$

for this S , max $L = 0$

($\sum m_{li} = 0$)





$\max S = 1$ (triplet)

$\max L = 3$

from $m_{l1} = 2$ $m_{l2} = 1 \rightarrow m_l = 3$

3F w/ $J = 4, 3, 2$

since less than $1/2$ filled shell \rightarrow $\boxed{^3F_2}$

(3) [Xe]4f5d6s

(4)

a)
$$\left. \begin{array}{l} l_1 = 3 \\ l_2 = 2 \\ l_3 = 0 \end{array} \right\} 2 \left. \right\} L = 5, 4, 3, 2, 1$$

(5)
$$\left. \begin{array}{l} s_1 = s_2 = s_3 = 1/2 \\ s_1 + s_2 = 1, 0 \\ s_3 = 1/2 \end{array} \right\} S = \frac{3}{2}, \frac{1}{2}, \frac{1}{2}$$

Terms: ${}^4H, {}^2H, {}^2H, {}^4G, {}^2G, {}^2G, {}^4F, {}^2F, {}^2F, {}^4D, {}^2D, {}^2D,$
 ${}^4P, {}^2P, {}^2P$

Levels for highest L & S :

$${}^4H_{13/2}, {}^4H_{11/2}, {}^4H_{9/2}, {}^4H_{7/2}$$

b) for the ${}^4H_{13/2}$ level

$$L^2 \psi = \hbar^2 L(L+1) \psi = \hbar^2 (5)(5+1) \psi$$

(5)
$$\langle L^2 \rangle = 30 \hbar^2$$

$$\langle S^2 \rangle = \hbar^2 S(S+1) = \hbar^2 \left(\frac{3}{2}\right) \left(\frac{3}{2} + 1\right) = \frac{15}{4} \hbar^2$$

$$\langle J^2 \rangle = \hbar^2 \left(\frac{13}{2}\right) \left(\frac{13}{2} + 1\right) = \frac{195}{4} \hbar^2$$

(c) For $m_J = 13/2$, $m_S = 3/2$ and $m_L = \frac{10}{2} = 5$

therefore the possible spin-orbitals are

$$5d_2 \alpha \leftarrow m_L = 2$$

$$4f_3 \alpha \leftarrow m_L = 3$$

$$6s \alpha \leftarrow m_L = 0$$

↑

$$M_S = 3\left(\frac{1}{2}\right) = \frac{3}{2}$$

$$M_L = 5$$

$$\psi = \frac{1}{\sqrt{3!}} \begin{vmatrix} 4f_3(1)\alpha(1) & 5d_2(1)\alpha(1) & 6s(1)\alpha(1) \\ 4f_3(2)\alpha(2) & 5d_2(2)\alpha(2) & 6s(2)\alpha(2) \\ 4f_3(3)\alpha(3) & 5d_2(3)\alpha(3) & 6s(3)\alpha(3) \end{vmatrix}$$

(d) $S_- |s = 3/2, m_S = 3/2\rangle = \hbar \sqrt{\frac{3}{2}\left(\frac{3}{2}+1\right) - \frac{3}{2}\left(\frac{3}{2}-1\right)} |s = 3/2, m_S = 1/2\rangle$
 $= \hbar \sqrt{3} |3/2, 1/2\rangle$

$$(a_{1-} + a_{2-} + a_{3-}) \left| \frac{1}{2}, \frac{1}{2}, \frac{1}{2} \right\rangle = \hbar \left| -\frac{1}{2}, \frac{1}{2}, \frac{1}{2} \right\rangle + \hbar \left| \frac{1}{2}, -\frac{1}{2}, \frac{1}{2} \right\rangle + \hbar \left| \frac{1}{2}, \frac{1}{2}, -\frac{1}{2} \right\rangle$$

$$\text{so } \left| \frac{3}{2}, \frac{1}{2} \right\rangle = \frac{1}{\sqrt{3}} \left[\left| -\frac{1}{2}, \frac{1}{2}, \frac{1}{2} \right\rangle + \left| \frac{1}{2}, -\frac{1}{2}, \frac{1}{2} \right\rangle + \left| \frac{1}{2}, \frac{1}{2}, -\frac{1}{2} \right\rangle \right]$$

$$= \frac{1}{\sqrt{3}} \left[\beta(1)\alpha(2)\alpha(3) + \alpha(1)\beta(2)\alpha(3) + \alpha(1)\alpha(2)\beta(3) \right]$$