PROBLEMA 1

a) Li^{++} $Z = 3$

$$\nu_{23} = Z^2 R \left(\frac{1}{2^2} - \frac{1}{3^2} \right)$$

$$= 9 \cdot 109737 \cdot \left(\frac{1}{4} - \frac{1}{9} \right)$$

$$= 137171 \ cm^{-1}$$

b) $n = 3 \quad l = 0, 1, 2$

$n = 2 \quad l = 0, 1$

per $n = 3$ CONSIDERIAMO

$l = 0, 1$

$n = 3 \qquad l = 1 \begin{cases} j = 3/2 \\ j = 1/2 \end{cases}$

$l = 0 \qquad j = 1/2$

$n = 2 \qquad l = 1 \begin{cases} j = 3/2 \\ j = 1/2 \end{cases}$

$l = 0 \qquad j = 1/2$

$$\Delta E_{nj} = E_n \frac{(Z\alpha)^2}{n^2} \left[\frac{n}{j + 1/2} - \frac{3}{4} \right]$$

$$\alpha = \frac{1}{137} \qquad (Z\alpha)^2 \simeq 4.8\, 10^{-4}$$

$\Delta E_{3\,3/2} = -4.38 \text{ cm}^{-1}$

$\Delta E_{3\,1/2} = -13.16 \text{ cm}^{-1}$

$\Delta E_{2\,3/2} = -7.4 \text{ cm}^{-1}$

$\Delta E_{2,1/2} = -37.0 \text{ cm}^{-1}$

IN cm^{-1}

$E_3 = -109737$

$E_{3,3/2} \quad -109741.4$

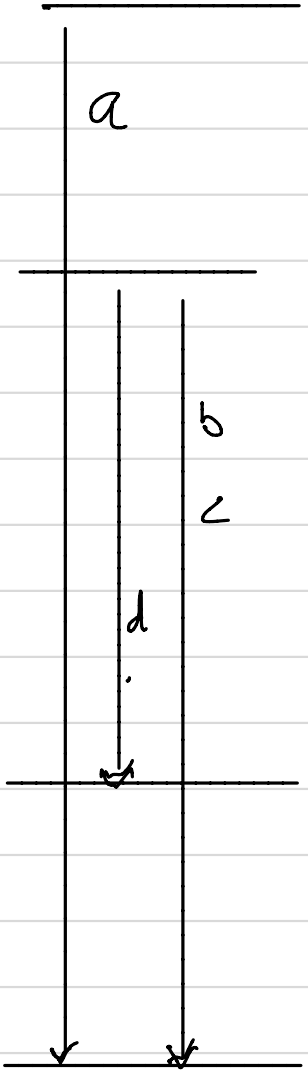
$\rightarrow 3,1/2 \quad -109750$

$E_2 = -246908$

$E_{2\,3/2} \quad -246915$

$\rightarrow 2\,1/2 \quad -246945$

c) $\Delta l = \pm 1 \qquad \Delta j = 0, \pm 1$



$3p\ 3/2 \qquad l = 1 \qquad j = 3/2$

$3p\ 1/2 \qquad l = 1 \qquad j = 1/2$

$3s\ 1/2 \qquad l = 0 \qquad j = 1/2$

$p\ 3/2 \qquad l = 1 \qquad j = 3/2$

$p\ 1/2 \qquad l = 1 \qquad j = 1/2$

$2s\ 1/2 \qquad l = 0 \qquad j = 1/2$

$3,1,3/2 \xrightarrow{a} 2,0,1/2 \qquad 3,1,1/2 \xrightarrow{b} 2,0,1/2$

$3,0,1/2 \xleftrightarrow{c} 2,1,1/2 \qquad 3,0,1/2 \xrightarrow{d} 2,1,3/2$

$$\nu_a = E_3 - E_2 + \Delta E_{3\,3/2} - \Delta E_{2\,1/2}$$

$$\nu_b = \nu_c = E_3 - E_2 + \Delta E_{3\,1/2} - \Delta E_{2\,1/2}$$

$$\nu_d = E_3 - E_2 + \Delta E_{3\,1/2} - \Delta E_{2\,3/2}$$

$$\nu_a = 137204 \text{ cm}^{-1}$$

$$\nu_b = 137195 \text{ cm}^{-1}$$

$$\nu_d = 137165 \text{ cm}^{-1}$$

d) $\mu_B \cdot B \simeq 23 \cdot 10^{-5}\ cm^{-1}$

$\Delta E^{SO} >> \mu_B B$

ANCHE $B \simeq 1 T \ll 2^4 T$

→ ZEEMAN ANOMALO

e) POSSIAMO CONSIDERARE LA TRANS. PIÙ BASSA IN ENERGIA

$3, 0, 1/2 \rightarrow 2, 1, 3/2$

B È PICCOLO QUINDI CI ASPETTIAMO UNA PICCOLA VARIAZIONE

REGOLE DI SELEZIONE LSN

$\vec{k} \perp \vec{B}$ e $\hat{\varepsilon} \parallel \vec{B}$ $\quad \Delta m_j = 0$

POSSIBILI

(1) $3, 0, 1/2, 1/2 \rightarrow 2, 1, 3/2, 1/2$

(2) $3, 0, 1/2, -1/2 \rightarrow 2, 1, 3/2, -1/2$

(1) $\nu_d + g_3 \mu_B B \frac{1}{2} - g_2 \mu_B B \frac{1}{2}$

(2) $\nu_d + g_3 \mu_B B\left(-\frac{1}{2}\right) - g_2 \mu_B B\left(-\frac{1}{2}\right)$

(1) $\Delta\nu_1 = \nu_d + \mu_B B\left(1 - \frac{2}{3}\right)$

(2) $\Delta\nu_2 = \nu_d + \mu_B B\left(-1 + \frac{2}{3}\right)$

$\Delta\nu_2$ PIÙ PICCOLA

$\left(g_3 = 2, \quad g_2 = 4/3\right)$

PROBLEMA 2

a) $$K = 2 D_e \alpha^2$$

$$K = 2 \cdot 4.62 \cdot \left(\frac{2.38}{1.27}\right)^2 \text{ eV/Å}^2$$

$$K = 32.45 \text{ eV/Å}^2$$

$$1/\mu = 1 + 1/35 \Rightarrow \mu = 0.9726 \text{ amu}$$

$$\mu = 1.6144\ 10^{-27} \text{ Kg}$$

$$K = 32.45 \cdot 1.602\ 10^{-19} \text{ J} \cdot 10^{20} \text{ m}^{-2}$$

$$K = 519.8 \text{ J/m}^2$$

$$\omega_0^2 = \frac{519.8}{16.14} 10^{28}$$

$$\omega_0 = 5.67\ 10^{14}\ s^{-1}$$

$$\nu_0 = \frac{1}{2\pi c}\omega_0 \simeq 3000\ cm^{-1}$$

$$B = \frac{\hbar^2}{4\pi c \mu R_0^2} = 10.74\ cm^{-1}$$

b)

$$\hbar\omega_0 = 5.98\ 10^{-20}\ J$$

$$\simeq 0.373\ eV$$

$$\beta = \frac{0.373}{4 \cdot 4.62} = 0.02018$$

c)

$k_B T \simeq 0.025$ eV

LE MOLECOLE SONO NELLO

STATO FONDAMENTALE

$$E_{nK} = \nu_0 \left(n+\frac{1}{2}\right)\left[1-\beta\left(n+\frac{1}{2}\right)\right] + B K(K+1)$$

$$E_{11} - E_{10} = \nu_0 \left[1-2\beta\right] + 2B$$

$$= (2878 + 2 \cdot 10.74)\ cm^{-1}$$

$$\simeq 2900\ cm^{-1}$$

RIGA a ν_0 + RICA $K=0 \to K=1$