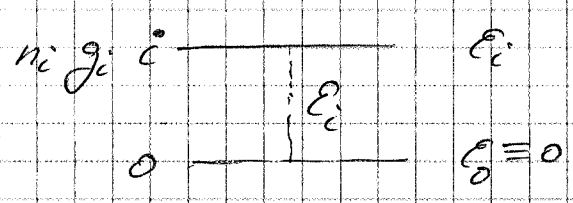


$$1) P_i = \frac{g_i e^{-\beta \epsilon_i}}{q} = \frac{n_i}{N} \text{ met } q = \sum_i g_i e^{-\beta \epsilon_i}$$



- 2) a)  $q$  is dimensieloos;  $q_0 \leq q \leq \infty$  als systeem niet begrensd is  
 b)  $q$  geeft globaal het totaal aantal niveaus dat bezet is aan.  
 c) als  $T \rightarrow 0$   $q \rightarrow g_0$

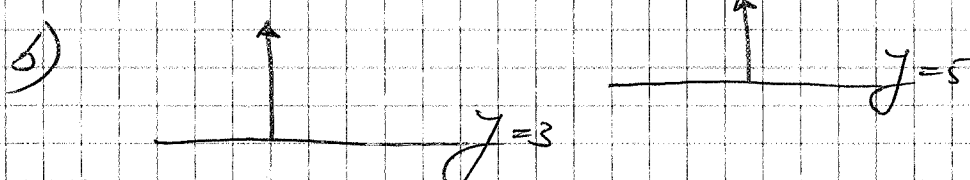
3)  $C_2H_5OH$  9 atome = 9\*3 = 27 vrijheidsgrade  
 -3 (translatie) -3 (rotatie) = 21 vibraties totaal  
 (niet-lineair moleculel)

a)  $\Theta_{vib}$  is de temperatuur waarvoor  $k\Theta_{vib} = h\nu$   
 dus geeft aan de vibratie energie

b) voor iedere vibratiemodus bijdrage  $R$ :  $2/R$   
 " translatie  $3/2 R$   
 " rotatie  $3/2 R$   
 totaal  $24 R$

4)  $OCS$   $B = 0.203 \text{ cm}^{-1}$

a)  $E(J) = B J(J+1)$   $E(J=3) = 12B$   
 $E(J=4) = 20B$   
 Dus  $h\nu = E(J=4) - E(J=3) = 8B$   
 $\nu = \frac{8B \cdot hc}{h} = 8 \cdot 0.203 \cdot 2.9979 \cdot 10^{10} = 4.87 \cdot 10^{10}$



$$\frac{I(J=3)}{I(J=5)} = \frac{n(J=3)}{n(J=5)} = \frac{g_3 e^{-\beta \epsilon_3}}{g_5 e^{-\beta \epsilon_5}} = \frac{g_3}{g_5} e^{-\beta(\epsilon_3 - \epsilon_5)}$$

$$g_3 = 2 \cdot 3 + 1 \Rightarrow g_5 = 2 \cdot 5 + 1 = 11; \quad E_5 = 30 \text{ B} \quad E_3 = 12 \text{ B}$$

$$\rightarrow \frac{1.0}{0.2} = \frac{7}{11} e^{-\beta(E_3 - E_5)}$$

$$\frac{7 \ln \frac{11.5}{7}}{E_3 - E_5} = \frac{-1}{kT} \rightarrow kT = \frac{-(E_3 - E_5)}{\ln \frac{11.5}{7}} = 8.73 \text{ B}$$

$$\rightarrow T = 2.6 \text{ K}$$

5)  $v_3 = 3100 \text{ cm}^{-1} \quad g_3 = 2 \quad T = 375 \text{ K} = 260 \text{ cm}^{-1}$

$v_2 = 190 \text{ cm}^{-1} \quad g_2 = 1$

$v_1 = 150 \text{ cm}^{-1} \quad g_1 = 2$

$$q_i = g_i \frac{1}{1 - e^{-\beta E_i}} \quad \begin{matrix} v_1 & v_2 & v_3 \\ 4.56 & 1.93 & 2 \end{matrix}$$

$$q_{\text{rot}} = 4.56 \cdot 1.93 \cdot 2 = 17.6$$

6)  $g=3 \quad E=450 \text{ cm}^{-1} \quad -E\beta$

$$\langle E \rangle = \frac{1 \cdot 0 + 3 \cdot e^{-E\beta}}{1 + 3 \cdot e^{-E\beta}} = \frac{0.712 \cdot 450}{1.712}$$

$g=1 \quad T=450 \text{ K} = 313 \text{ cm}^{-1} \quad q = 1 + 3e^{-E\beta} \quad \langle E \rangle = 187 \text{ cm}^{-1}$

$$\rightarrow E_{\text{mol}} = 2.24 \text{ kJ/mol}$$

7) a)  $E_{\text{kin}} = \frac{3}{2} kT$

b) zie PPT sheets

c) 1 mol Krypton  $T = 150 \text{ C} = 273 + 150 = 423 \text{ K}; \quad \lambda_{\text{th}} = 1.013 \cdot 10^5 \text{ Pa}$

$$\Delta = h \sqrt{\frac{\beta}{2\pi m}} = 6.62608 \cdot 10^{-34} \sqrt{\frac{1}{2\pi \cdot 13807 \cdot 10^{23} \cdot 423 \cdot 84 \cdot 1.6605 \cdot 10^{-27}}}$$

$$= 9.26 \cdot 10^{-12} \text{ m} = 926 \text{ pm}$$

$$\rightarrow S = 20.6 R = 171 \text{ J/(K mol)}$$

8) a) ando thermisch

b)  $K = \frac{q^R}{q^P} e^{-\Delta E/R T} \rightarrow \ln\left(\frac{q^R}{q^P} K\right) = -\Delta E/R T \rightarrow T = \frac{\Delta E}{R \ln\left(\frac{q^R}{q^P} K\right)}$

$$\rightarrow T = 1402 \text{ K}$$