

1. The lowest energy level of atomic iodine has  $g_0 = 4$  and the first excited level,  $7603.15 \text{ cm}^{-1}$  higher, has  $g_1=2$ . At what temperature does  $\Delta_0 \tilde{U} = \tilde{U} - \tilde{U}(0) = 4.0 \text{ kJ/mol}$  for these electronic levels?
2. The third excited level of iodine (the 1<sup>st</sup> 2 levels are described in problem 1) has  $g_2=6$ ,  $\epsilon_2 = 54633.46 \text{ cm}^{-1}$ . For what range of temperatures will this level contribute less than 1% to the molecular partition function,  $q$ ?
3. Derive the expression for  $\Delta_0 \tilde{U} = \tilde{U} - \tilde{U}(0)$ , in terms of  $R$  and  $T$ , for an ideal gas.
4. The expression for the weights of the FD and BE distributions are as follows:

$$W_{FD} = \prod_i \frac{g_i!}{n_i!(g_i - n_i)!} \quad \text{and} \quad W_{BE} = \prod_i \frac{(n_i + g_i - 1)!}{n_i!(g_i - n_i)!}$$

- a. Use Stirling's approximation to show that

$$d \ln W = \sum_i \left( \ln \frac{g_i + cn_i}{n_i} \right) dn_i \quad \text{where } c=-1 \text{ for FD and } c=+1 \text{ for BE particles.}$$

- b. What expression results when we let  $c=0$ ?

5. Incorporate undetermined multipliers into the expression for  $d \ln W$  in problem 4 and show that FD and BE distributions can be written

$$n_i = \frac{g_i}{e^{\alpha} e^{\beta \epsilon_i} \pm 1} \quad \text{with the } + \text{ sign for FD and } - \text{ sign for BE statistics.}$$

6. Use the method of undetermined multipliers to show that

$$-\sum_{j=1}^N P_j \ln P_j \quad \text{subject to the condition} \quad \sum_{j=1}^N P_j = 1 \quad \text{is maximized when}$$

$P_j = \text{constant}$ . Determine the constant.

7. Maximize the function defined as "information" in information theory.

$$I = \sum_{j=1}^N P_j \ln P_j \quad \text{subject to the constraints} \quad \sum_{j=1}^N P_j = 1 \quad \text{and} \quad \sum_{j=1}^N E_j P_j = E. \quad \text{Compare with the result of problem \#6.}$$