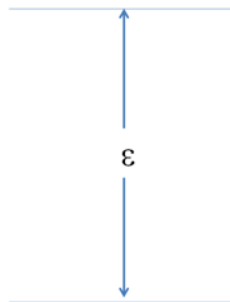
Given the energy levels in the two-level system shown in the diagram below.



a. Write an expression for the molecular partition function of a two level system

$$q = 1 + e^{-\beta\varepsilon}$$

b. What is the magnitude of the partition function at T = 0 K?

$$q = 1$$

c. What is the magnitude of the partition function at T = ∞ K?

$$q = 2$$

d. If $\varepsilon = 1000\ \text{cm}^{-1}$, at what temperature is the probability of the upper level equal to 0.25?

$P = e^{-\beta\varepsilon}/(1 + e^{-\beta\varepsilon}) = 0.25 \rightarrow e^{-\beta\varepsilon} = 0.25(1 + e^{-\beta\varepsilon}) = 0.25 + 0.25\, e^{-\beta\varepsilon} \rightarrow 0.75\, e^{-\beta\varepsilon} = 0.25$

$e^{-\beta\varepsilon} = 1/3 \rightarrow -\beta\varepsilon = \ln(1/3) \rightarrow -\beta\varepsilon = -\ln(3) \rightarrow \beta\varepsilon = 1.098 \rightarrow \varepsilon = 1.098{*}kT$

$T = \varepsilon/1.098{*}k = (1000\ \text{cm-1})/1.098/(0.695\ \text{cm}^{-1}\text{K}^{-1}) = 1310\ \text{K}$