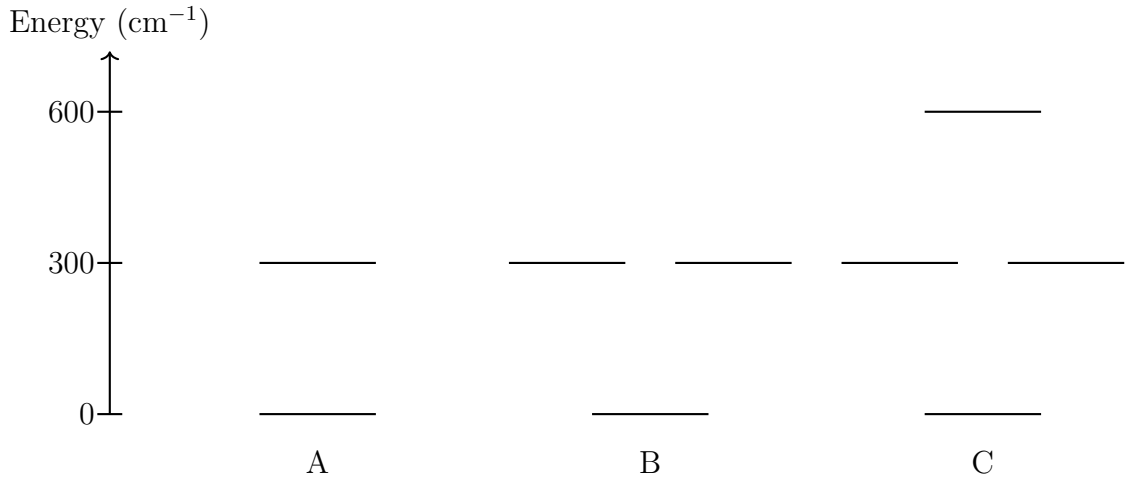
1. Consider the following three systems



(a) For energy level diagram A, if the probability of being in the $300\,cm^{-1}$ level is 0.15, what is the temperature of the system?

(b) For energy level diagram B, if the probability of being in the $300\,cm^{-1}$ level is 0.15, what is the temperature of the system? Explain in at most two sentences why this is the same, higher, or lower temperature as you found in part a.

(c) For energy level diagram C, if the probability of being in the $300\,\mathrm{cm}^{-1}$ is 0.15, how does its temperature compare (higher, lower, the same) to what you found in part b? You can approach this mathematically or conceptually.

(d) For diagram C, what temperature is required for the probability of being in the $300\,\mathrm{cm}^{-1}$ level to be 0.5?

2. Calculate the fraction of lithium atoms in the first excited state at 300 K, 1000 K, 2000 K. Does your answer match the trend you'd expect with increasing temperature?

Atom	Config	Term	$g = 2J + 1$	E / cm^{-1}
Li	$1s^2 2s$	$^2S_{1/2}$	2	0
	$1s^2 2p$	$^2P_{1/2}$	2	14 903.66
		$^2P_{3/2}$	4	14 904.00
	$1s^2 3s$	$^2S_{1/2}$	2	27 206.12

Homework Problem 7

1. In statistical mechanics, the exact value of energy E is not physically meaningful, only relative energy differences matter. This allows us to set the ground state energy at $\varepsilon_0 = 0$ for convenience. Show that pressure is independent of the choice of zero energy.
   Hint: Consider shifting all energy levels by a constant E_0, i.e., $E_i' = E_i + E_0$. How would this affect the expression for pressure?