

Chem 131C—Physical Chemistry

Additional Problem Set 2

April 10, 2017

1. Consider a quantum system with an infinite number of states. The n^{th} state is occupied with a probability p_n , given by,

$$p_n = \left(\frac{1}{2}\right)^n$$

for $n = 1, 2, \dots$,

- a) Show that the probability distribution is normalized.
b) As we will see, the entropy is given in terms of the state probabilities p_n by

$$S = -k_B \sum_n p_n \ln p_n$$

Calculate the entropy of the system.

(Hint: To do part a) recall the geometric series $\sum_n x^n$. For part b) consider what happens if the geometric series is differentiated with respect to x .)

2. Consider an Ar atom at room temperature (298 K) confined to a tank with a volume of 1 liter.
- a) What is the thermal de Broglie wavelength of the atom?
- b) How many quantum states are effectively available to this atom, as counted by the translational canonical partition function $q_{\text{trans}}(T, V)$?
- c) A cylinder with a volume V of 1 liter is full of pure Ar, at a pressure of 10 atm. How many moles of Ar are present in the cylinder?
- d) Given your answer to c), comment on whether using Boltzmann statistics would be a good approximation for this system.