

Problem set 5**Due April 18, 2024**

1. Assign the appropriate statistical ensemble to the systems listed below and justify your selection in each case.
 - (a) A bacterium cell.
 - (b) A mixture of nitrogen dioxide and dinitrogen tetraoxide (a dimer of nitrogen dioxide) in a sealed glass capsule insulated by a thick styrofoam layer.
 - (c) Gas in a cylinder sealed by a moveable piston under atmospheric pressure.
 - (d) A sealed jar of pickles.
2. For the equilibrium mixture of the two possible products of photochlorination of isobutane of Problem 1 from Problem Set 3, derive the formula for entropy as a function of temperature and determine how entropy changes with increasing temperature.

Hint: There are two ways to solve this problem. You can use the formula for the entropy in a canonical ensemble or determine the probability of each product as a function of temperature, then make use of the formula learned in today's lecture:

$$S = -k_B \sum_{i=1}^Z P_i \ln P_i$$

where P_i is the Boltzmann probability of microstate i , and recall the expression for entropy at $T = 0$ K. Note that a “microstate” literally means a “microstate” and not a group of degenerate states. Therefore, you need to transform this formula to obtain one for degenerate states. Also note that k_B becomes R when the “per mol” quantities are considered.