Hlutapróf 1, 25. september, 8:20-9:50

Leyfð hjálpargögn: Ein A4 blaðsíða sem hver nemandi hefur skrifað sjálfur og reiknivél.

Problem 1:

Consider a collection of N independent, distinguishable molecules with two accessible energy levels that differ in energy by $\Delta\epsilon$. The lower level corresponds to only one state but the upper level corresponds to three states (i.e. is threefold degenerate). Take the zero of energy to be at the higher energy level.

(a) Give an expression for the partition function of the collection of N molecules and simplify as much as possible.

(b) Calculate the population of the two energy levels as a function of temperature and discuss the two limits as the temperature approaches zero and infinity (explain the meaning of your results).

(c) Calculate the average energy of the system as a function of temperature and discuss the two limits as the temperature approaches zero and infinity (explain the meaning of your results).

(d) Sketch the heat capacity as a function of energy and state what the high and low temperature limits are. Explain the basic reason for the two limits.

Problem 2:

Consider a polymer that can form a dimer, that is each monomer in one of the polymer molecules can bind to a corresponding monomer in the other polymer. Each polymer consists of P monomers. Each bond formed between the two polymers has energy E_b and is much weaker than the bond connecting the monomers within a polymer. Also, there is an extra strong bond between the monomers at one of the ends. Due to thermal energy, the bond at the other end of the polymers can break as well as any bond adjacent to a broken bond, up to a total of $P-1$ bonds.

(a) What is the energy of the two polymers when 10 bonds have been broken?

(b) Give an expression for the partition function of the polymer dimer considering all the possible states of the $P-1$ bonds.

(c) Calculate the average bond energy in the polymer dimer, $< E >$, as a function of temperature.

(d) Give an expression for the probability that no bond between the two polymers has broken.

(e) Now consider a slightly different situation where the bond of either one of the two ends of the polymers can break, as well as the adjacent bonds. Give an expression for the partition function and simplify as much as possible.