Sample test.

Disclaimer: This does not cover every topic that may be tested, nor will everything here be guaranteed to be on the test.

1. Consider my favorite statistical mechanics/entropy example of 100 coins on a tray.

(a) Explain the difference between a microstate and a macrostate and give an example with my 100 coin system. Explain the meaning of the term multiplicity.

(b) What is the multiplicity of the macrostate in which the tray has all the coins heads up?

(c) What is the multiplicity of the macrostate in which the tray has 99 heads and 1 tail?

(d) Describe the macrostate with the largest multiplicity? What is the multiplicity of this macrostate?

(e) Determine the entropy for each of the macrostates from (b), (c), and (d).

2. Consider two Einstein solids A and B each with two oscillators (NA=NB=2). The system has 4 quanta of energy qA+qB=4. Initially all the energy is in system A (qA=4 initially). The two systems are brought into contact such that energy can be exchanged. Complete the table below to determine the most likely final state of the system. What is the probability that the state is found in the qA=4 condition long after the two solids have been in contact.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| qA | A | qB | B | total |
| 0 |  |  |  |  |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |

3. Everybody’s favorite equation the Sackur-Tetrode equation for the entropy of an ideal gas.

(a) Explain briefly how the equation is derived—in particular how does Planck’s constant end up in the equation?

(b) Find the value of the entropy of 1 mole of helium gas (atomic mass = 4) at 500K and 1 atm.

(c) I have a box of an ideal gas with N atoms. I now introduce N more atoms of the same gas at the same temperature into the box. Use the Sackur-Tetrode to determine the change in entropy due to the doubling of N.

4. Calculate the total entropy change to heat 1 kg of aluminum from room temperature (20oC) up to its melting point (660oC) and then to melt the metal. The latent heat of fusion of Aluminum is 321 kJ/kg. The heat capacity of Aluminum is 902 J/Kg. What is the change in multiplicity associated with this process?

5. The entropy of a system is given by S=2Nkln(VU0.5) where N is the number of particles, V is the volume and U is the internal energy.

(a) Determine an expression for the internal energy in terms of temperature.

(b) Determine an expression for the pressure of this system.