Universität Stuttgart **Prof. Dr. Rudolf Hilfer**
Fakultät 8, Fachbereich Physik **Tillmann Kleiner**

Advanced Statistical Physics, SS 2017
Sheet 4

Problem 1: **(2 points)**

a) What is the change in an iceberg's entropy at 0° C when 25 kJ are added to it?

b) A graduate student is enclosed for 24 hours in a large, isolated physics building at 37° C. During this time, his body consumes 2000 kilocalories (physicist's), but he does absolutely no work. What is the change of entropy of the physics building?

Problem 2: **(4 points)**

Show that the entropy is concave. That means for any pair of states $X_i = (U_i, V_i, N_i)$, $i = 1, 2$ and $0 \leq \lambda \leq 1$:

$$S(\lambda X_1 + [1-\lambda]X_2) \geq \lambda S(X_1) + (1-\lambda)S(X_2) \tag{1}$$

The following steps may help you complete this problem.

a) Consider two isolated thermodynamic systems of the same substance. The systems are in equilibrium and are in the states X_1 and X_2. Then, bring the two systems together, and let them come to equilibrium. Call the equilibrium state X_*. Use the second law to derive an inequality involving $S_1(X_1)$, $S_2(X_2)$ and $S_*(X_*)$.

b) Calculate the equilibrium state X_* and explain why S_1, S_2 and S_* are all the same function.

c) Show that Eq. (1) holds for $\lambda = 1/2$. How would you show that Eq. (1) holds for $0 \leq \lambda \leq 1$?

Problem 3: **(4 points)**

Suppose a gas obeys Boyle's law:

$$pV = \phi(T), \tag{2}$$

and its internal energy depends only on T, i.e. $U(T, V) = \psi(T)$. Use the first and second laws (or Clausius' Theorem) to show that the gas must be an ideal gas. An ideal gas has an equation of state of the form $pV = cT$ where c is a positive constant.

Deliver your hand-written solutions at the beginning of the lecture on Friday, May 12th.