Homework 2

Short questions

1. Apply the first law of the thermodynamics to (a) a closed system (b) an isolated system. Write an expression for the change of the internal energy of each system.

2. Which of the following are state functions? (1) Volume (2) Work (3) Density

3. The higher the internal energy a system has, in general, the more capacity it has to do work. True or false? Please briefly explain.

4. If you heat a copper bar and its temperature goes from T_1 to T_2 (assuming $T_2 > T_1$), the change of entropy of the copper bar is positive. True or false? Please use the second law of thermodynamics to briefly explain your answer.

5. How is it possible that one can boil water without changing the entropy of the universe?

6. The work that is performed by the expansion of a system composed of 1 mole of ideal gas is always numerically equal to the heat that is absorbed by the system. True or false?

7. The internal energy of a system and its surrounding is conserved during an irreversible process. True or false?

8. According to the second law of thermodynamics, one cannot realize a process adiabatically that results in a decrease in entropy. True or false?

9. For any closed system in a reversible isothermal process, it is always true that $q = T\Delta S$. True or False?

Exercise 1

One mole of an ideal gas is expanded from a volume of 1 L to a volume 2 L at a constant temperature of 20°C.

a. The gas is expanded **reversibly**.
b. The gas is expanded **irreversibly** against a constant external pressure equal to the final pressure of the gas.
c. The gas is expanded against zero external pressure (free expansion).

In all cases, calculate the work performed by the gas. For which case the work is the largest/smallest? Does your result obey the second law of thermodynamics? Please explain.

Exercise 2

An elastomer is a polymer that can stretch and contract.

In a perfect elastomer the force opposing extension is proportional to the displacement x from the resting state of the elastomer, so $|F| = k_f\, x$, where k_f is a constant. But suppose that the restoring force weakens as the elastomer is stretched, and $k_f(x) = a - bx^{1/2}$. Evaluate the work done on extending the polymer from x=0 to a final displacement l.