Exercise Classes 2, Physical Chemistry 1 2021/2022

Exercise 6

Consider 1.0 mol of a perfect gas of atoms at an initial temperature of 25 °C and a pressure of 5.0 bar.

a) Calculate the following values for an isothermal and reversible expansion to a final pressure of 1.0 bar.
- the final temperature of the gas,
- the work done on the gas,
- the increase in internal energy of the gas,
- the heat absorbed by the gas,
- the entropy change of the gas,
- the change in the Helmholtz free energy of the gas and
- the change in the Gibbs free energy of the gas.

b) Find out (without calculation) for all quantities considered in the previous part of the exercise whether you expect a different answer for an isothermal expansion from $P = 5$ bar to a final pressure of the gas of $P = 1$ bar, but now against a constant external pressure of 1.0 bar.
Note that this is an irreversible process.

c) Then calculate the values from the first part for the irreversible process.

Exercise 7

Consider an irreversible adiabatic expansion of n mol of a perfect gas in a cylinder sealed by a frictionless piston in vacuum. The piston is initially locked and when the lock is released, the piston can freely move. The initial pressure of the gas is P_1 and the temperature is T_1.

a) Determine the final temperature T_2.

b) We determine the entropy change in terms of V_1 and V_2.
Hint: Use the state function property of S and choose an alternative path consisting of a reversible isobaric and a reversible isochoric process.
First sketch the three processes in a $P - V$-diagram.
Then express ΔS in terms of C_V, C_P and the relevant temperatures using $\mathrm{d}Q = \mathrm{d}H|_P = C_P \mathrm{d}T$ and $\mathrm{d}Q = \mathrm{d}U|_V = C_V \mathrm{d}T$.
Finally you can use the perfect gas law to express ΔS in terms of V_1 and V_2.

c) Find the conditions for which the process proceeds spontaneously.

d) We conduct the experiment at $T = 300$ K for 0.04 mol of gas with an initial volume of 1 L (corresponding to an initial pressure of $P \approx 1$ bar) and a final volume of 2 L.
Calculate the change in the Helmholtz and Gibbs free energy.

Exercise 8

Consider the entropy change of a spontaneous process.
Two equal amounts of the same liquid are brought in contact with each other at constant pressure and without loss of heat (to the surroundings) via a heat permeable (thermal) wall, so without mixing the fluids. Note that we are not considering perfect gases, but liquids!
The initial temperatures of the liquids are T_1 and T_2 respectively, where $T_1 < T_2$. We assume that C_P of the liquids is constant between T_1 and T_2. The final temperature T of both liquids will be equal.
Determine the entropy change during this process in terms of C_P, T_1 and T_2.
Use the second law of thermodynamics to show that this process proceeds spontaneously, as one would expect.