Exercise Set – TD 1: Thermodynamics

Some useful quantities:

- $R = 8.31\ \mathrm{J \cdot mol^{-1} K^{-1}}$
- $1\ \mathrm{bar} = 10^5\ \mathrm{Pa}$ $1\ \mathrm{bar} = 10^5\ \mathrm{Pa}$
- Specific enthalpy of fusion of water: $\Delta h_{fus} = 3.3 \cdot 10^2\ k\mathrm{J \cdot kg^{-1}}$
- Specific heat capacity water: $c_w = 4.2\ k\mathrm{J \cdot K^{-1} kg^{-1}}$

Exercise 1: Study of a car tire

The recommended pressure on the front wheels of a Kona is 2.2 bar. I adjusted my tire pressure on a cold day this winter, when the outside temperature was $-5\ °\mathrm{C}$.

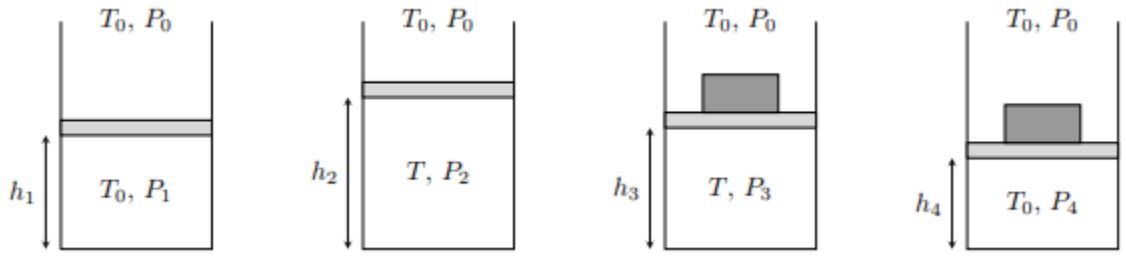
1. Assuming that the volume of the tires does not change, and that there are no air leaks, what will the manometer read on a hot day this summer with an outside temperature of $30\ °\mathrm{C}$?
2. Calculate the relative change in pressure due to the change in temperature. What would you advise me?

Exercise 2: Ideal gas in an container

A quantity of n moles of an ideal gas is enclosed in a container with a base surface S. The container is closed by a piston of mass m, which can slide without friction and allows heat transfer, so that when we wait long enough, the gas in the container will reach thermal equilibrium with the air outside. The external environment is at constant temperature and pressure T_0 and P_0. The gas is subjected to the following series of transformations:

- Initially, in state (1), the system has been at rest for long enough to have reached thermal and mechanical equilibrium.
- The gas is heated until it reaches temperature $T > T_0$ (State (2)).
- An additional mass M is suddenly placed on top of the piston: before any heat transfer can take place, the system is in state (3).
- Finally, thermal equilibrium is reached, and the system is therefore in state (4).

Determine the four positions of the piston h_1 to h_4.



Exercise 3: Melting ice

We put a mass $m_{wat} = 1$ kg of (liquid) water, initially at temperature $T_1 = 20\,°C$ in a calorimeter with heat-insulated walls and negligible thermal capacity. We then add a $m_{ice} = 0.5$ kg of ice at temperature $T_2 = 0\,°C$. We assume that the process takes place at constant pressure $P_{atm} = 1$ bar.

1. If we assume that in the final state the water is entirely in liquid form, determine its final temperature T_f. What is your conclusion?
2. We now assume that in the final state there is a mixture of water in liquid and solid form. What can we say without any calculation about the temperature in the final state? Determine the composition of the mixture, i.e., the mass of each phase, by defining a variable x for the fraction of water in solid form (i.e. ice).

Exercise 4: How many ice cubes in fruit juice?

On a hot summer day, you forgot to put the fruit juice for the aperitif in the fridge. How many ice cubes should you add to it to make it as refreshing as if it were in the fridge? Make whatever assumptions you think are necessary.