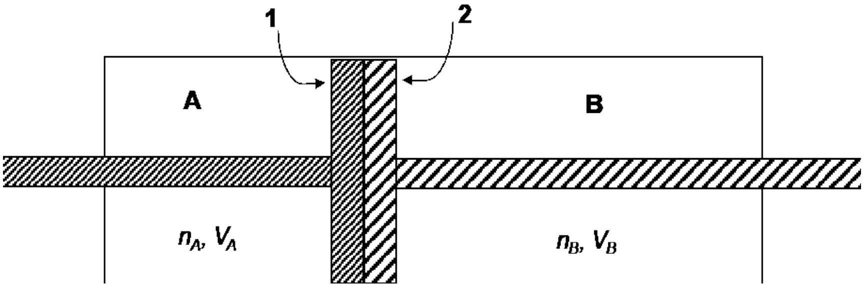
Homework 6

Exercise 1.

Derive the equation for the entropy of mixing ($\Delta_{mix}S = -R\sum n_i \ln x_i$) and the Gibbs free energy of mixing ($\Delta_{mix}G = RT\sum n_i \ln x_i$) as applied to two ideal gases only, by carrying out a reversible and isothermal mixing process in the apparatus shown below. Piston 1 is permeable only to gas A and piston 2 is permeable only to gas B. Initially, the two pistons are in contact, so that gas A is entirely in the left chamber and gas B is entirely to the right as shown, and the pressure in the two chambers is the same $p_A = p_B = p$. Finally, the two pistons are at the ends of the cylinder, thus gases have been mixed by passage through the pistons into the space between them.



Exercise 2.

You are responsible for the purchase of a gas cylinder which, before use, is stored at pressure of 200 atm and temperature 300 K in a cylindrical vessel of diameter $d = 0.2$ m and height $h = 2$ m. Would you prefer the gas behaved as an ideal gas or a real gas obeying the Van der Waals equation of state? For oxygen, the van der Waals constants are $a = 1.36 \frac{\text{atm liter}^2}{\text{mol}^2}$ and $b = 0.0318 \frac{\text{liter}}{\text{mol}}$). Hint – how much gas can be stored in each case?

Exercise 3.

One hundred moles of hydrogen gas at 298 K are reversibly and isothermally compressed from 30 to 10 litres. Let's explore this process with three different approximations: Van der Waals, Virial and ideal gas case.

The Van der Waals constants for hydrogen are

$$a = 0.2461 \frac{\text{atm liter}^2}{\text{mol}^2} \text{ and } b = 0.02668 \frac{\text{liter}}{\text{mol}}.$$

In the range of pressures from 0 to 1500 atm, the virial equation for hydrogen is

$$pv = RT(1 + Bp)$$

where $B = 6.4 * 10^{-4} \left(\frac{1}{atm}\right)$

Calculate the work that must be done on the system to produce the required change in the volume by assuming (a) that hydrogen is described by the Virial equation of state, (b) that hydrogen is behaving like a Van der Waals gas and (c) that hydrogen is assumed to behave as an ideal gas. Compare the different results.