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# Advanced Statistical Physics, SS 2017
## Sheet 8

**Problem 1:** **(4 points)**

Consider the following reaction

$$2\,\mathrm{CO} + \mathrm{O_2} \rightarrow 2\,\mathrm{CO_2}, \tag{1}$$

where carbon monoxide (a poison) is converted into carbon dioxide (may be causing climate change, or not, but otherwise inoffensive). Assume that the reaction takes place in air, which can be considered as an ideal gas.

a) Suppose that the concentration of oxygen is much greater than that of carbon monoxide or carbon dioxide. In this case, use the law of mass action to show

$$\frac{x_{\mathrm{CO}}}{x_{\mathrm{CO_2}}} \propto p^{\alpha}, \tag{2}$$

and find $\alpha$. Here $x_{\mathrm{CO}}$ and $x_{\mathrm{CO_2}}$ denote the molar fractions of CO respectively $\mathrm{CO_2}$ with respect to the mixture of $\mathrm{O_2}$, CO and $\mathrm{CO_2}$.

b) For a single "turnover" of the reaction at $T = 25^\circ$ C and atmospheric pressure, the change in Gibbs potential is about 500 kJ/mole. Calculate the mass-action constant under these conditions (don't forget that $G = \mu N$). Evaluate the equilibrium value of $c_{\mathrm{CO}}$ assuming that $c_{\mathrm{O_2}} \approx 0.25$ mol/m$^3$ and $c_{\mathrm{CO_2}} \approx 0.005$ mol/m$^3$.

**Problem 2:** **(5 points)**

a) The pressure which a gas exerts on the walls of a vessel can be regarded as the time average of the impulses which the gas molecules impart on the wall when colliding with and recoiling from it. From this point of view, calculate the pressure $p$ and show that

$$p = \frac{2}{3} n \bar{\varepsilon}, \tag{3}$$

where $n$ is the number of atoms per unit volume and $\bar{\varepsilon}$ is the average kinetic energy per molecule.

b) Estimate the average velocity of a molecule at the Earth's surface.

*Deliver your hand-written solutions at the beginning of the lecture on Friday, June 16th.*