Übungen zur Oberflächenphysik
Blatt 1 – 6.3.2012

1) **Pressure**
   a) If a vacuum system contains gas at a pressure of 10^{-8} mbar at 120 ℃, what will be the pressure at room temperature?
   b) A vacuum system is filled with N_2 at room temperature. How many collisions will occur between the particles and the chamber wall per unit time and area if the pressure is i) p = 1 mbar, ii) $p=10^{-6}$ mbar and iii) $p=10^{-10}$ mbar?
   c) For a typical atom on the surface in b), how long will it take between 2 statistical collisions with a N_2 molecule.

2) **Ideal Pump**
   A cube with 10 cm size is being pumped by a pump which is assumed to be ideal (everything which enters it is removed), the size of the pump-opening is 1 cm^2.
   a) What is the pumping speed of this ideal pump?
   b) How long does it take to pump from ambient pressure down to 10^{-9} mbar?

3) **Absorption/desorption**
   a) A vacuum chamber contains a residual gas of $5x10^{-10}$ mbar. By measuring with a mass spectrometer you find that it is water. How can you remove it?
   b) Following from a), if you do not remove the water: how many monolayers accumulate on a sample surface after 20 h. Assume sticking coefficient of 0.7 and a sample temperature of 0 K.
   c) Discuss the relevance of the calculation in 2b if the sample is kept at room temperature. What do you expect to happen?
   d) If a surface is initially covered with a single monolayer of 10^{15} molecules/cm^2, having E_{des} = 30 kcal/mol, how long does it take to reduce the coverage to 10^{13} molecules/cm^2 at the temperature of 600 K. Assume $\tau_0 = 10^{-13}$ s and that re-adsorption can be neglected. (τ_0 is inverse of the attempt frequency).
   e) The average time for which an oxygen atom remains chemisorbed to a tungsten surface is 0.36 s at 2548 K and 3.49 s at 2362 K. Find the activation energy for desorption.

4) **Mean free path**

Derive a formula for the mean free path of molecules (diameter d) in a gas (pressure p, temperature T) ($\lambda = k_BT / \pi d^2 p$), e.g. the path between two collisions.

Use the following assumptions:

- molecular density: n = N / V, where N - number of molecules, V – volume
- all molecules are fixed except for one under consideration

5) **Pressure leaks**
   - An end-station at synchrotron is 20 meters far away from the valve which protects synchrotron ring against accidents. Estimate how fast the valve has to be closed to avoid that the vacuum in the ring is not affected if there is vacuum break at end-station. Tube which connects ring and end-station has 40 mm in diameter.