# 4.E: UHV and Effects of Gas Pressure (Exercises)

This section provides a limited number of examples of the application of the formulae given in the previous section to determine the:

- Density of Molecules in the Gas Phase
- Mean Free Path of Molecules in the Gas Phase
- Flux of Molecules incident upon a Surface
- Rate of Adsorption of Molecules and Surface Coverages

If you have not already been through Section 4.2 then I would suggest that you stop now and return to this page only after you have done so **!**

*Within any one of the following sub-sections, it will be assumed that you have already done the previous questions and may make use of the answers from these questions - you are therefore advised to work through the questions in the order they are presented.*

### A. Molecular Gas Densities

Calculate the molecular gas density for an ideal gas at 300 K, under the following conditions (giving your answer in molecules $m^{-3}$ ):

| | |
|---|---|
| | At a pressure of $10^{-6}$ Torr |
| | At a pressure of $10^{-9}$ Torr |

## B. Mean Free Path of Molecules in the Gas Phase

Calculate the mean free path of CO molecules in a vessel at the indicated pressure and temperature, using a value for the collision cross section of CO of 0.42 $nm^2$.

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| | P = $10^{-4}$ Torr, at 300 K |
| | P = $10^{-9}$ Torr, at 300 K |

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**C. Fluxes of Molecules Incident upon a Surface**

Calculate the flux of molecules incident upon a solid surface under the following conditions:
[Note - 1 u = 1.66 x $10^{-27}$ kg: atomic masses ; $m$(O) =16.0 u, $m$(H) = 1.0 u]

| | |
|---|---|
| | Oxygen gas ( P = 1 Torr ) at 300 K |
| | Oxygen gas ( P = $10^{-6}$Torr ) at 300 K |
| | Hydrogen gas ( P = $10^{-6}$Torr ) at 300 K |
| | Hydrogen gas ( P = $10^{-6}$Torr ) at 1000 K |

## D. The Kinetically Limited Uptake of Molecules onto a Surface

The rate of adsorption of molecules onto a surface can be determined from the flux of molecules incident on the surface and the sticking probability pertaining at that instant in time (note that in general the sticking probability itself will be dependent upon a number of factors including the existing coverage of adsorbed species).

In the following examples we will assume that the surface is initially clean (i.e. the initial coverage is zero), and that there is no desorption of the molecules once they have adsorbed. You should determine coverages as the ratio of the adsorbate concentration to the density of surface substrate atoms (which you may assume to be $10^{19}$ $m^{-2}$ ). In the first two questions we will assume that the sticking probability is constant over the coverage range concerned.

| | |
|---|---|
| | Calculate the surface coverage obtained after exposure to a pressure of $10^{-8}$ Torr of CO for 20 s at 300 K - you may take the sticking probability of CO on this surface to have a constant value of 0.9 up to the coverage concerned. |
| | Calculate the surface coverage of atomic nitrogen obtained by dissociative adsorption after exposure to a pressure of $10^{-8}$ Torr of nitrogen gas for 20 s at 300 K - you may take the dissociative sticking probability of molecular nitrogen on this surface to be constant and equal to 0.1 |

In general, the sticking probability varies with coverage - most obviously, the sticking probability must tend to zero as the coverage approaches its saturation value. These calculations are not quite so easy **!**

| | |
|---|---|
| | Calculate the surface coverage obtained after exposure to a pressure of $10^{-8}$ Torr of CO for 200 s at 300 K - the sticking probability of CO in this case should be taken to vary linearly with coverage between a value of unity at zero coverage and a value of zero at saturation coverage (which you should take to be 6.5 x $10^{18}$ molecules $m^{-2}$ ). |