CCK Special Topics Problem: Whack-a-Mol
2007-Jul-13

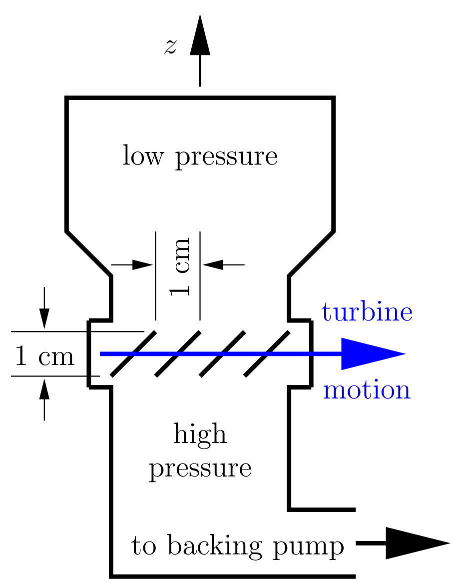
A turbomolecular pump is a turbine (rotary fan) used to evacuate a volume (the "low pressure" region in the sketch). If the mean free path of the gas is greater than the dimensions of the turbine blades, then collisions between molecules are unimportant, and molecules entering the turbine from any direction are swatted into the "high pressure" region. A separate backing pump keeps the high pressure region in the millitorr range. A turbomolecular pump with many stages of spinning turbines can bring the low pressure region to ultrahigh vacuum. In the following, use a simplified geometry: (1) There will be a single turbine, idealized as a series of diagonal 1 cm blades in linear motion (see sketch); (2) the *initial* velocities of molecules incident on the turbine will be assumed to be in the $\pm z$ direction; (3) molecular interactions with the blades will be modeled as an elastic collision of a point particle with an angled surface. Assume $T = 300\,\mathrm{K}$ everywhere, and the high pressure region is at 7.6×10^{-3} torr.[1]

A. Is the mean free path assumption correct?

B. If the turbine blades move at speed v_f, what is the slowest molecule that can backstream (cross from high to low pressure region)?

C. Assume that $v_f = 10^4\,\mathrm{m/s}$. Estimate the backstreaming rate (particles $\mathrm{m}^{-2}\,\mathrm{s}^{-1}$).

D. Estimate the pressure in the low pressure region.



[1] 7.6×10^{-3} torr $= 10^{-5}$ atm $= 1$ Pa