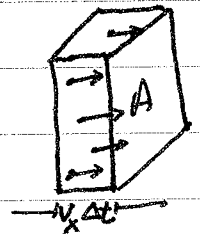
Phys 201 Problem Set 5 Solutions
F'09

3.4 $m_C \approx 12\, m_H$, so $\boxed{12g}$ of C are required to mix with 1g of H to form $C_2H_2$.

3.29 a)




All of the gas particles moving to the right within transverse distance $v_x\Delta t$ from the surface w/ area A pass through the surface in time $\Delta t$.

There are $nAv_x\Delta t$ particles in that volume, of which half move to the right.

Since $\frac{1}{2}m\langle v_x^2+v_y^2+v_z^2\rangle = \frac{1}{2}m\cdot 3\langle v_x^2\rangle = \frac{3}{2}k_BT$,

$v_x = \sqrt{\langle v_x^2\rangle} = \sqrt{\frac{k_BT}{m}}$. We assume all of the particles have this speed.

Hence, $\frac{1}{2}nAv_x\Delta t = \boxed{\frac{nA\Delta t}{2}\sqrt{\frac{k_BT}{m}}}$ particles strike the surface.

b) $A = 1\ cm^2$, $T = 273K$, $\Delta t = 1s$, $k_B = 1.38\times10^{-23}\ J/K$
$= 10^{-4}\ m^2$

$$m_{O_2} \approx 2m_O = 2\cdot(15.995\ u) = 2\cdot(15.995)(1.66\times10^{-27}\ kg)$$
$$= 5.31\times10^{-26}\ kg$$

To calculate n use the ideal gas law:

$$PV = Nk_BT \longrightarrow n = \frac{N}{V} = \frac{P}{k_BT} = \frac{1.01\times10^5\ N/m^2}{(1.38\times10^{-23}\ J/K)(273\ K)}$$
$$= 2.68\times10^{25}\ m^{-3}$$

$$\frac{nA\Delta t}{2}\sqrt{\frac{k_BT}{m_{O_2}}} = (2.68\times10^{25}\ m^{-3})(10^{-4}\ m^2)\frac{(1s)}{2}\sqrt{\frac{(1.38\times10^{-23}\ J/K)(273\ K)}{5.31\times10^{-26}\ kg}}$$

$$= \boxed{3.57\times10^{23}}$$ Oxygen molecules

3.39 $D_{rms} = \sqrt{\dfrac{k_B T}{3\pi \eta a}}\sqrt{t} \Rightarrow t \propto D_{rms}^2\, a$

$a$ = radius of object.

For $a = \frac{1}{2}\cdot(1\mu m)$, $D_{rms} = 5\mu m$, $t = 20s$.

For $a = \frac{1}{2}\cdot 100\mu m$, $D_{rms} = 500\mu m$,

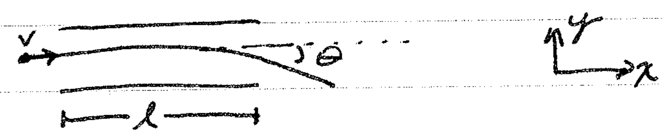
$$t = 20s \cdot \frac{(500\mu m)^2\left(\frac{1}{2}\cdot 100\mu m\right)}{(5\mu m)^2\left(\frac{1}{2}\cdot 1\mu m\right)}$$

$$= 20\,s \cdot 10^6$$

$$= \boxed{2\times 10^7\ s}$$

This is much too long to have been observed.

3.40




Time spent by electron between plates: $\Delta t = \frac{\ell}{v}$

Acceleration: $\vec{a} = \frac{\vec{F}}{m} = -\frac{eE}{m}\hat{y}$

Velocity after passing plates: $\vec{v} = v\hat{x} - \frac{eE}{m}\Delta t\,\hat{y}$

$= v\hat{x} - \frac{eE}{m}\cdot\frac{\ell}{v}$

$v_x = v$, $v_y = -\frac{eE\ell}{mv}$

$\tan\theta = \left|\frac{v_y}{v_x}\right| = \frac{eE\ell}{mv^2}$

For small angles $\tan\theta \approx$ $\boxed{\theta \approx \frac{eE\ell}{mv^2}}$

3.44 $K = \frac{1}{2} m v^2 = e V_0$

$R = \frac{mv}{eB} \Longrightarrow v = \frac{ReB}{m}$

$\frac{1}{2} m \left(\frac{ReB}{m}\right)^2 = e V_0$

$= \frac{1}{2} R^2 B^2 \frac{e}{m} \cdot e$

$\Longrightarrow \boxed{\frac{m}{e} = \frac{R^2 B^2}{2 V_0}}$