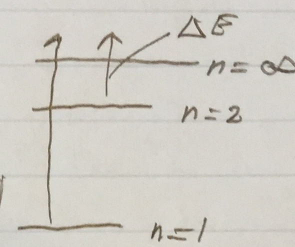
PHYS 1311 Chapter 8 EOC Problems

Problems P9, P11, P18, P23, P24, & P26 4-20-2016

Problem P9 $E_n = \dfrac{-13.6\text{ eV}}{n^2}$



$n=2 \rightarrow n=\infty$

$\Delta E = |E_\infty - E_2| = \left| -\dfrac{13.6}{\infty^2} - \left(\dfrac{-13.6}{2^2}\right)\right|$

$= \left| 0 + \dfrac{13.6}{4}\right| = \boxed{3.4\text{ eV}}$

Problem P11 $N_0 = 10{,}000$ atoms

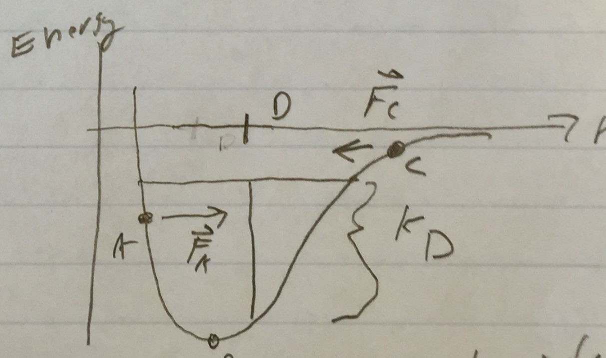
$\tau \equiv$ lifetime $= 25\times10^{-9}$ s

$t_i = 0$, $t_f = 12\times10^{-9}$ s $= t$

$N(t) = N_0 \exp(-t/\tau) = 10{,}000 \exp(-12/25)$

$= \boxed{6190 \text{ atoms}}$

Problem P18



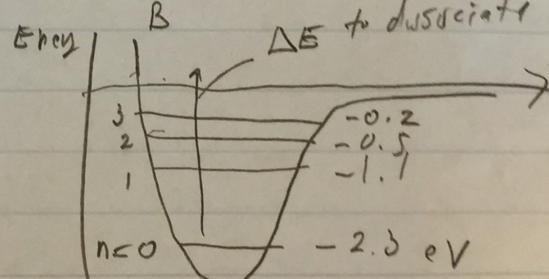
a) $\vec{F}_A \rightarrow \hat{r}$ direction

$\vec{F}_C \rightarrow -\hat{r}$ direction

$\vec{F}_B = 0$

since $F_r = -\dfrac{dU}{dr}$

$|\vec{F}_A| > |\vec{F}_C| > |\vec{F}_B|$



b) To dissociate

$\boxed{\Delta E > 2.3\text{ eV}}$

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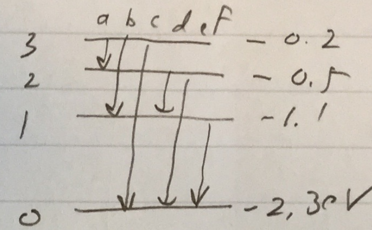
Problem P18 (cont'd)



c) Photon energies are:

$E_{Ph_a} = 0.3\,eV$, $E_{Ph_b} = 0.9\,eV$

$E_{Ph_c} = 2.1\,eV$, $E_{Ph_d} = 0.6\,eV$, $E_{Ph_e} = 1.8\,eV$, $E_{Ph_f} = 1.2\,eV$

d) Total energy $= E = E_{rest} + K + U = Mc^2$

M ← inertial mass

say $n=0$, and $n=1$

$E_0 = mc^2 + K_0 + U_0 = M_1 c^2$, $E_1 = mc^2 + K_1 + U_1 = M_2 c^2$

$$\Delta E = E_1 - E_0 = K_1 - K_0 + U_1 - U_0 = \Delta M c^2$$

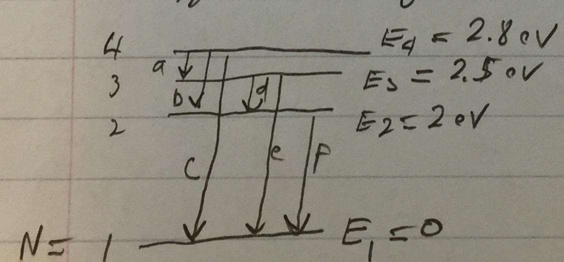
or $\Delta M = \dfrac{\Delta K + \Delta U}{c^2} > 0$ [here $1.2\,eV/c^2$]

- The higher excited state has more internal energy and therefore more inertial mass

Problem P23

observed $E_{ph} = \underset{= E_a}{0.3}, \underset{= E_d}{0.5}, \underset{= E_b}{0.8}, \underset{= E_f}{2}, \underset{= E_e}{2.5}, \underset{= E_c}{2.8}\,eV$

a) Try the following energy level diagram



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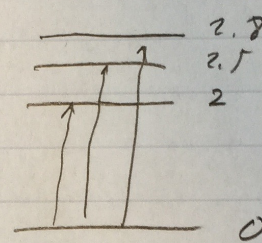
b) Since the energy intervals are not equally-spaced, the harmonic oscillator would not be a good model for this system

c) Absorption photons



$E = 2, 2.5, 2.8$ eV

→ Other energy diagrams possible

Problem P26 HCl molecules

$m = m_H + m_{Cl}$
$\simeq 1u + 36u$
$= 37u$
$= 37(1.7\times10^{-27}kg)$

a) For harmonic oscillator,

$E_n = n\hbar\omega_0 + E_0$

$\omega_0 = \sqrt{\frac{k_s}{m}}$, estimate $k_s \sim 10\,N/m$

$= \sqrt{\frac{10\,N/m}{37(1.7\times10^{-27}kg)}} = 1.3\times10^{13}\,rad/s$

$\hbar\omega_0 = \left(\frac{6.6\times10^{-34}\,J.s}{2\pi}\right) \times \frac{1\,eV}{1.602\times10^{-19}J}\left(1.3\times10^{13}\,rad/s\right)$

$\simeq \boxed{0.01\,eV}$

b) $\Delta E_{1\to0} = 0.01\,eV$

$\Delta E_{2\to0} = 0.02\,eV$, etc.

$\lambda = \frac{hc}{\Delta E} = \frac{12398\,eV\,Å}{0.01\,eV}$

$= 1.2\times10^{6}\,Å \simeq 100\,\mu m$

$\Rightarrow$ $\boxed{\text{infrared}}$