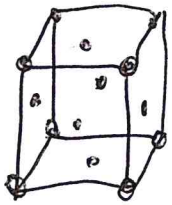
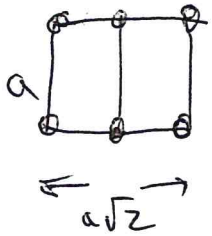
(1)

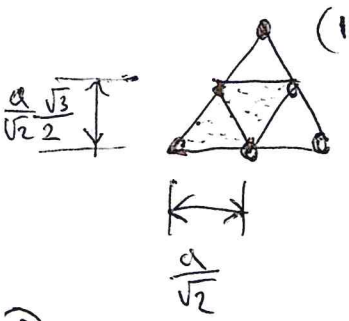


(110)



$$n_{110} = \frac{2}{a^2\sqrt{2}} = \frac{\sqrt{2}}{a^2} = 2.21\times10^{14}\ cm^{-2}$$

(111)



$$n_{111} = \frac{1}{\frac{a^2\sqrt{3}}{4}} = \frac{4}{a^2\sqrt{3}} = 3.61\times10^{14}\ cm^{-2}$$

(2) $\lambda = 1550\ nm$

$h\nu = \frac{hc}{\lambda} = 0.8\ eV$

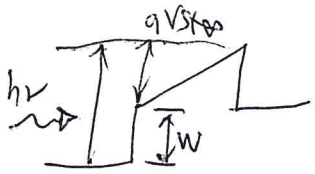
$$\langle E\rangle = \frac{h\nu}{e^{\frac{h\nu}{kT}}-1} = \frac{h\nu}{2} \longrightarrow e^{\frac{h\nu}{kT}} = 3$$

$$T = \frac{h\nu}{k\ln 3} = 8459\ K$$

$$n_{fotoni} = \frac{h\nu/2}{h\nu} = 0.5$$

(3) $\frac{hc}{\lambda} = h\nu > W \longrightarrow \lambda < \frac{hc}{W} = 287\ nm$

$\frac{hc}{\lambda} = 10.35\ eV$



$$V_{stop} = \frac{h\nu - W}{q} = 0.023\ V$$

$$\begin{cases} \frac{1}{2}mv^2 = h\nu - W \\ \frac{1}{2}m\left(\frac{v}{2}\right)^2 = h\nu - W - qV_{stop}\frac{x}{L} \end{cases}$$

$$\frac{1}{4} = 1 - \underbrace{\frac{qV_{stop}}{h\nu - W}}_{=1}\frac{x}{L} \Longrightarrow \frac{x}{L} = 1 - \frac{1}{4} = \frac{3}{4}$$

(4) PRIMA STIMA $E = \frac{h^2}{8ma^2} = 0.77\ eV$

DISTANZA DECADIMENTO $\frac{1}{\alpha} = \frac{\hbar}{\sqrt{2m(V-E)}} = 0.176\ nm$

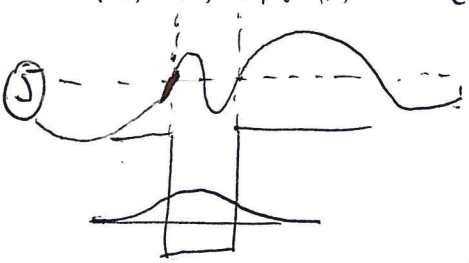
SECONDA STIMA $E' = \frac{h^2}{8m(a+2/\alpha)^2} = 0.34\ eV$ // $\frac{1}{\alpha} = 1.517\ \text{Å}$

TERZA STIMA $E'' = 0.374\ eV$ // $\frac{1}{\alpha} = 1.5327\ \text{Å}$

QUARTA STIMA $E''' = 0.372\ eV$ // $\frac{1}{\alpha} = 1.532\ \text{Å}$ // $\frac{\lambda}{2} = a + \frac{2}{\alpha} = 1.006\ nm$

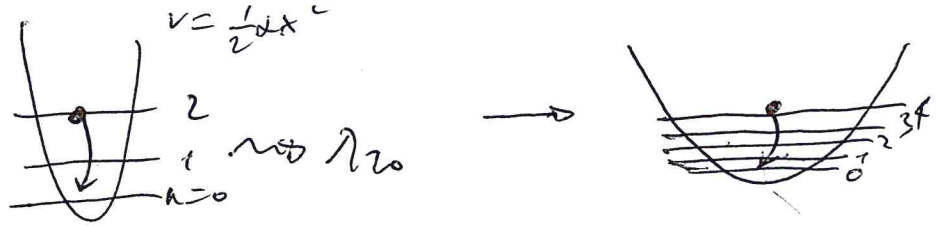
$\lambda = 2.012\ nm$

(5)



IL PRIMO LIVELLO RISONANTE CON $|T|^2 = 1$ È PER $a = \lambda$ QUINDI $n = 2 \rightarrow E = 3.077\ eV$ RISPETTO AL FONDO DELLA BUCA $\Rightarrow n \geq 2$

(6)



$$\lambda_{20} = \frac{c}{\nu} = \frac{hc}{2\hbar\omega} = \frac{2\pi c}{2}\sqrt{\frac{m}{\alpha}} = \lambda'_{40} = \frac{2\pi c}{4}\sqrt{\frac{m}{\alpha'}}$$

$$\lambda_{20} = \lambda'_{40} \Rightarrow \alpha' = \frac{\alpha}{4}$$

LA COSTANTE ELASTICA DEVE ESSERE MOLTIPLICATA PER UN FATTORE 4

(7) $V = \frac{1}{2}\alpha(x^2+y^2+z^2)$

$\alpha = 5\times10^{-3}\ N m^{-1}$

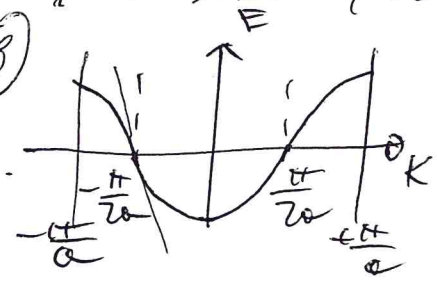
$E = \hbar\omega\left(\frac{3}{2}+n_x+n_y+n_z\right)$

$\hbar\omega = \hbar\sqrt{\frac{\alpha}{m}} = 48.8\ meV$

n_x	n_y	n_z	E
0	0	0	$\frac{3}{2}\hbar\omega = 73.28\ meV$
0	0	1	$\frac{5}{2}\hbar\omega = 122\ meV$
0	1	0	
1	0	0	
0	1	1	$\frac{7}{2}\hbar\omega = \cancel{171\ meV} > 125\ meV$ NON ACCETTABILE
1	0	1	
1	1	0	

4 AUTOSTATI (000, 001, 010 & 100) HANNO $E < 125\ meV$

(8)

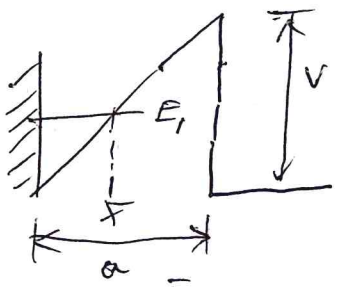


$$m^* = \frac{\hbar^2}{d^2E/dK^2} = \infty$$

$$v_g = \frac{1}{\hbar}\frac{dE}{dK} = \frac{\gamma a \sin Ka}{\hbar} = \frac{\gamma a}{\hbar} = 2.6\times10^7\ cm/s$$

$$\mu = \frac{1}{2\hbar}\frac{d^2E}{dK^2} = 0 \Rightarrow$$ NON C'È ALLARGAMENTO

(9)



$$\begin{cases} \Delta x = a\frac{E_1}{V} \\ \Delta p = \sqrt{2mE_1} \\ \Delta p\,\Delta x = \hbar \end{cases} \Rightarrow E_1^{\frac{3}{2}}\frac{a}{V}\sqrt{2m} = \hbar$$

$$E_1 = \left(\frac{\hbar V}{a\sqrt{2m}}\right)^{\frac{2}{3}} = 0.375\ eV$$

$$\bar{x} = a\frac{E_1}{V} = 0.16\ nm$$

$$t_{AR} = 2\int_0^{\bar{x}}\frac{dx}{v} = 2\sqrt{\frac{m}{2}}\int_0^{\bar{x}}\frac{dx}{\sqrt{E_1 - V\frac{x}{a}}} = \sqrt{2m}\frac{a}{V}\int_0^{E_1}\frac{dy}{\sqrt{y}} = \frac{a}{V}\sqrt{2m}\left[2\sqrt{y}\right]_0^{E_1} = \frac{2a}{V}\sqrt{2mE_1} \overset{*}{=} 1.75\ fs$$

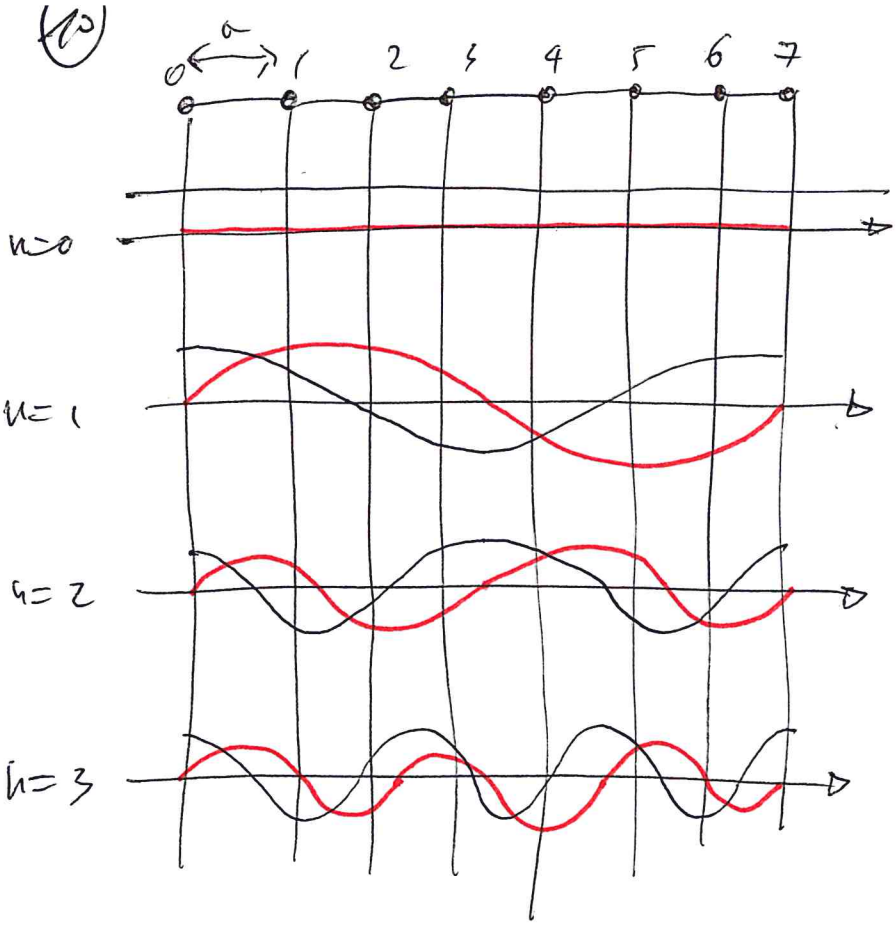
$$\frac{1}{2}mv^2 = E_1 - V\frac{x}{a}$$

$$|T|^2 = e^{-\frac{4\sqrt{2m}}{3\hbar q V a}(V-E_1)^{\frac{3}{2}}} = e^{-2.86} = 0.057 \quad (17.5\ \text{tentativi})$$

$$t_{TUN} = \frac{t_{AR}}{|T|^2} = 30.0\ fs$$

* DATO CHE $t_{AR} = \frac{2\bar{x}}{\bar{V}}$ DOVE $\bar{V}$ = VELOCITÀ MEDIA, SI OTTIENE $\bar{V} = \sqrt{\frac{E_1}{2m}} = 1.82\times10^7\ cm/s$

(10)



$K = \frac{2\pi}{a}\frac{n}{N}$ $\quad n = 0, \pm 1, \pm 2, \pm 3$

$N = 7$

$Re(e^{iKx})$

$Im(e^{iKx})$

$n =$	K	λ
0	0	∞
1	$\frac{2\pi}{7a}$	$7a$
2	$\frac{2\pi}{\frac{7}{2}a}$	$\frac{7}{2}a$
3	$\frac{2\pi}{\frac{7}{3}a}$	$\frac{7}{3}a$