Review of Lecture 12.

Midterm : until today's lecture. open book (textbook)
spectral properties open notes

$\hbar\omega_{photon} = E_f - E_i$

$\hbar \vec{k} = \vec{P}_f - \vec{P}_i + \vec{G}$

(1) atom

$$\begin{cases} \text{translation} & E = \frac{mv^2}{2} \\ \text{electronic} & E_n = -\frac{13.6}{n^2}\,\text{eV} \end{cases}$$

ψ_{nlm_s}

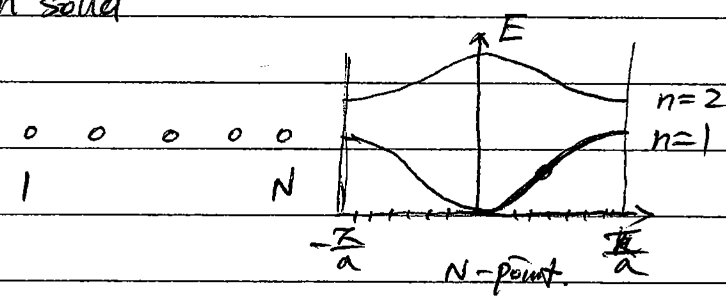
(2) molecules

$$\begin{cases} \text{translation} \\ \text{electronic : splitting} \quad n=1 \\ \text{rotational : } E_l = \frac{\hbar^2}{2I} l(l+1) \\ \text{Vibrational : } E_n = \hbar\omega(n+\frac{1}{2}) \end{cases}$$

$\underbrace{KE + PE}$

$\omega = \sqrt{\frac{K}{m}}$.

(3) electrons in solid

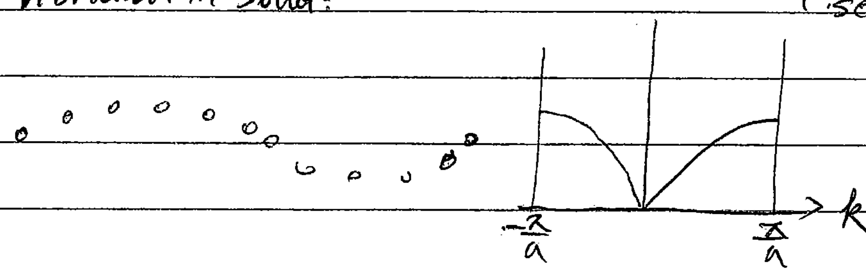


$k = \frac{2\pi n}{aN}$

$n = (\pm 1, \cdots, \frac{N}{2})$

$\begin{cases} \text{metal} \\ \text{insulator} \\ \text{semiconductor} \end{cases}$

(4) Vibration in solid:



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$h\nu_{photon} = E_f - E_i$, $\hbar \vec{k}_{phot} = \vec{P}_f - \vec{P}_i + \vec{G}$

discussion for solid.

Model dielectric constant

approaches $\begin{cases} \text{quantum mechanical} \\ \text{classical.} \end{cases}$

Recall $\vec{D} = \varepsilon_0 \vec{E} + \vec{P} = \varepsilon_0 (1+\chi)\vec{E}$

$\vec{P}$ — ~~displacement~~ polarization

dipole moment per unit volume.

also recall

$$\nabla \times \vec{B} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$$

$$= \frac{\partial \vec{D}}{\partial t} + \sigma \vec{E}$$

when $\vec{D} \sim e^{-i\omega t} \Rightarrow \vec{E} \sim e^{-i\omega t}$

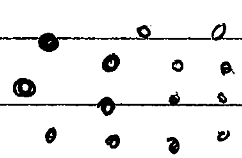
$$\nabla \times \vec{B} = \frac{\partial \vec{D}}{\partial t} + \frac{\partial}{\partial t}\left(\frac{\sigma \vec{E}}{-i\omega}\right)$$

$$= \frac{\partial}{\partial t}\left[\varepsilon_0 \underbrace{\left(1+\chi - \frac{\sigma}{i\omega}\right)}_{\hat{\varepsilon}_r} \vec{E}\right]$$

⇑ most time ~~those are~~ σ is grouped into ε_r

DONOT DOUBLE COUNT

Free electron in Solid: free — occational damping by collision.



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If no collision

$$m \frac{d^2x}{dt^2} = -\underbrace{e\vec{E}}_{\text{force}}$$

photon wave length so long, we can basic think local E uniform

$$m \frac{d^2x}{dt^2} = -eE_0 e^{-i\omega t}$$

$$x = A e^{-i\omega t}$$

$$m A(-\omega^2) = -eE_0$$

$$A = \frac{eE_0}{m}$$

If there is scatting. damping force $\gamma\vec{v}$

$$m\frac{d^2x}{dt^2} = -eE_0 e^{-i\omega t} - \gamma\vec{v}$$

$$mA(-\omega^2) + i\gamma\omega A = -eE_0$$

$$A = \frac{eE_0}{m\omega^2 + i\gamma\omega}$$

electric current

$$\vec{J} = -e\vec{v}n$$

$$= -e\frac{dx}{dt}n = ne(+i\omega)\overbrace{\frac{eE_0}{m\omega^2+i\gamma\omega}e^{-i\omega t}}^{E}$$

$$= \sigma E$$

$$\sigma = (+i\omega)\frac{+ne^2}{m\omega^2+i\gamma\omega}$$

$$\varepsilon_r = 1+\chi = \frac{ne^2}{m\omega^2 - i\gamma\omega} \underset{\uparrow}{=} 1 - \frac{\omega_p^2}{\omega^2 + i\omega/\tau}, \quad \tau = \frac{m}{\gamma}$$

if free electron only

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