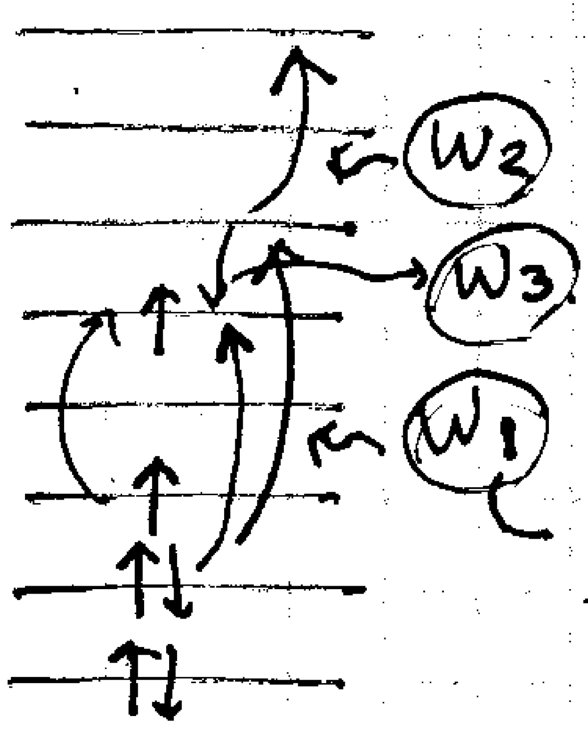
(출제) (제출).

Midterm : Wed → Mon Sheet ______ Date ______

1. 배운것 < H.F. CI 정리. / Perturbatrc theory.

2. Van der waals interaction in solid : vibration frequency 구할 줄 알아야 한

No class on Mon, Wed.



(electromagnetic field) $E_3 e^{-i\omega_3 t}$ (방출)

$\underbrace{E_1 e^{i\omega t}}_{\text{(time)}} \underbrace{e^{ik_1\cdot r}}_{\text{(space)}}$ (흡수)

$$H = H_0 + V(t) \Rightarrow i\hbar \frac{\partial \psi}{\partial t} = H\psi = E\psi$$

$$H \rightarrow (H_0 + V(t))$$

$$\Downarrow$$

$$i\hbar \frac{\partial \psi_0}{\partial t} = H_0 \psi_0 \Rightarrow i\hbar \frac{\partial u_0(t,t_a)\cancel{\psi_0(t)}}{\partial t} = H\, u(t,t_a)\psi_0(t_a)$$

sol). $\psi_0(t,t_a) = u_0(t,t_a)\psi_0(t_a)$

$$i\hbar \frac{\partial u_0(t,t_a)}{\partial t} = H_0 u_0(t,t_a) \Rightarrow u_0(t,t_a) = \exp\left(\frac{H}{i\hbar}(t-t_a)\right)$$

$$i\hbar \frac{\partial u(t,t_a)\cancel{\psi(t_a)}}{\partial t} = [H_0 + V(t)]\, u(t,t_a)\cancel{\psi_0(t_a)}$$

$$i\hbar \frac{\partial u(t,t_a)}{\partial t} = [H_0 + V(t)]\, u(t,t_a)$$

$$u(t,t_a) = u_0(t,t_a) + \left(\frac{1}{i\hbar}\right)\int_{t_a}^{t} dt_1 \,[u_0(t,t_1) \times V(t_1) \times u(t_1,t_a)]$$

$$i\hbar\left[\frac{\partial u_0}{\partial t} + \cancel{\frac{1}{i\hbar}\, u_0(t,t)}\, V(t)\, u(t,t_a)\right]$$

$$i\hbar \frac{\partial u_0}{\partial t} = H_0 u_0$$

$$i\hbar\left[\frac{H_0 u_0}{i\hbar} + \frac{V\cdot u(t,t_a)}{i\hbar}\right]$$

$$= [H_0 + V]\, u(t,t_a)$$

$$\left[\because\ i\hbar \frac{\partial u_0(t,t_a)}{\partial t} = H_0 u_0(t,t_a) \right.$$

$$\left. = i\hbar \frac{\partial u(t,t_a)}{\partial t} = H_0 u(t,t_a)\ \right]$$

$$i\hbar \frac{\partial u(t,t_a)}{dt} = [H_0 + V(t)]\, u(t,t_a).$$

$$\Rightarrow u(t,t_a) = \underbrace{u_0(t,t_a)}_{\exp\left(\frac{H_0}{i\hbar}(t-t_a)\right)} + \frac{1}{i\hbar}\int_{t_a}^{t} u_0(t,t_1)V(t_1)\underbrace{u(t,t_a)}_{u_0(t,t_a)+0}\, dt_1$$

$$u(t,t_a) = u_0(t,t_a) + \left(\frac{1}{i\hbar}\right)\int_{t_a}^{t} V_0(t,t_1)\,V(t_1)\,u_0(t_1,t_a)\,dt_1$$

$$+\left(\frac{1}{i\hbar}\right)^2\int_{t_a}^{t}\int_{t_a}^{t_1} dt_1\, dt_2 \left[u_0(t,t_2)V(t_2)\, u_0(t_2,t_1)\, V(t_1)\, u(t,t_a)\right]$$

$$+\left(\frac{1}{i\hbar}\right)^3\int_{t_a}^{t}\int_{t_a}^{t_1}\int_{t_a}^{t_2} dt_1\, dt_2\, dt_3 \left[u_0(t,t_3)\, V(t_3)\, u_0(t_3,t_2)\, V(t_2)\cdot u_0(t_2,t_1)\, V(t_1)\, u_0(t_1,t_a)\right]$$

$$u(t,t_a) = \underbrace{u_0(t,t_a)}_{\text{no transition}} + \overbrace{u_0^{(1)}(t,t_a)}^{\text{single}} + \underbrace{u_0^{(2)}(t,t_a)}_{\text{double transition}} + u_0^{(3)}(t,t_a) + \cdots$$

$$u_0^{(k)} = \left(\frac{1}{i\hbar}\right)^k \int_{t_a}^{t}\int_{t_a}^{t_1}\int_{t_a}^{t_2}\cdots\int_{t_a}^{t_k} dt_1\, dt_2\, dt_k \left[u_0(t,t_1)\, V(t_1)\, u_0(t_1,t_2)\cdot V(t_2)\, u_0(t_2,t_1)\, V u_0 \cdots\right]$$

$$t > t_1 > t_2 > t_k > t_a.$$

$$u_0(5)(t,t_a) = \left(\frac{1}{i\hbar}\right)^5 \int_{t_a}^{t}\int_{t_a}^{t_1}\int_{t_a}^{t_2}\int_{t_a}^{t_3}\int_{t_a}^{t_4} dt_5\, dt_4\, dt_3\, dt_2\, dt_1 \times$$

$$[u \quad V \quad u \quad V \quad u \quad V \quad u \quad V \quad u \quad V \quad u]$$

$$\psi(t,t_a) = u(t,t_a)\,|n\rangle.$$

$$= \sum_k |k\rangle\langle k|\, u(t,t_a)\,|n\rangle$$

$$H = H_0 - P\cdot E(t)$$

$$\hookrightarrow |E_1|\, e^{i(k\cdot r)}\, e^{i\omega_1 t}.$$

$E_1 e^{\mp i\omega_1 t}$

$$\psi(t,t_a) = \frac{1}{i\hbar}\int_{t_a}^{t} dt_1 \underbrace{\exp\frac{1}{i\hbar}(E_k)(t-t_1)}_{u_0(t,t_1)}\ |k\rangle\langle k|\,V(t_1)\, \underbrace{\exp\frac{1}{i\hbar}[E_n](t_1-t_a)}_{u_0(t_1,t_a)}\ |n\rangle.$$

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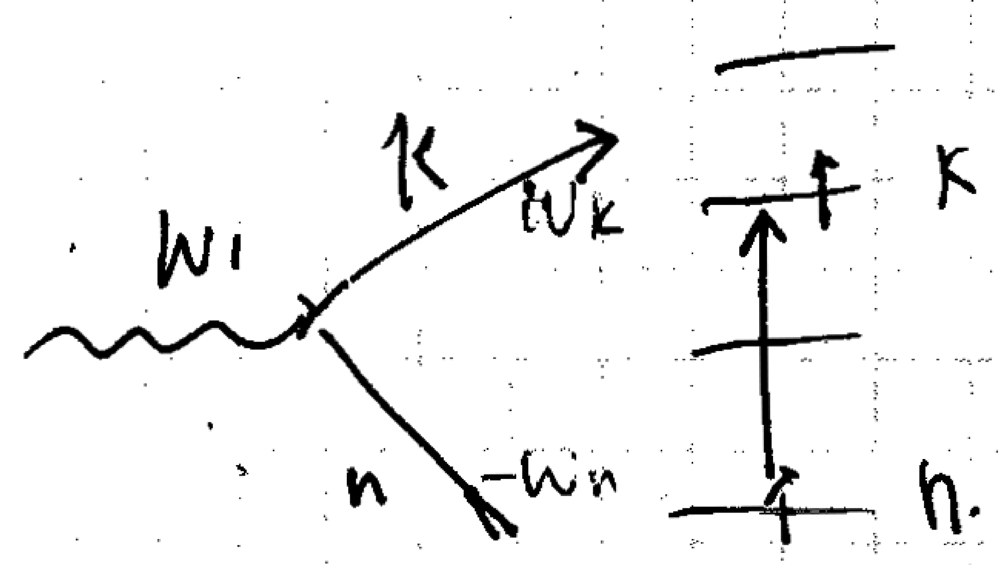
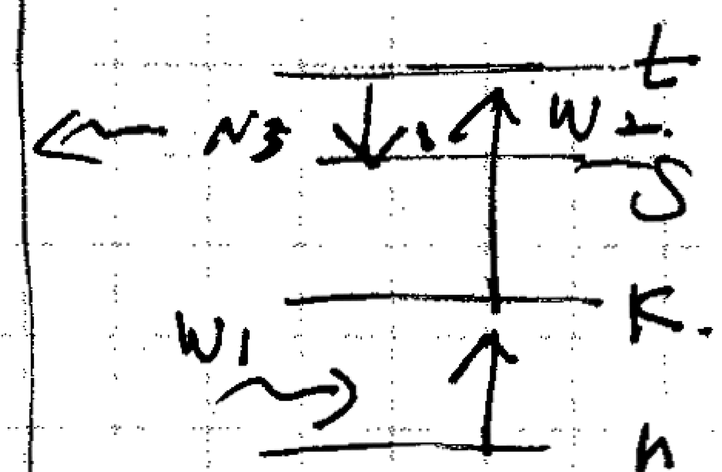
transition 확률.

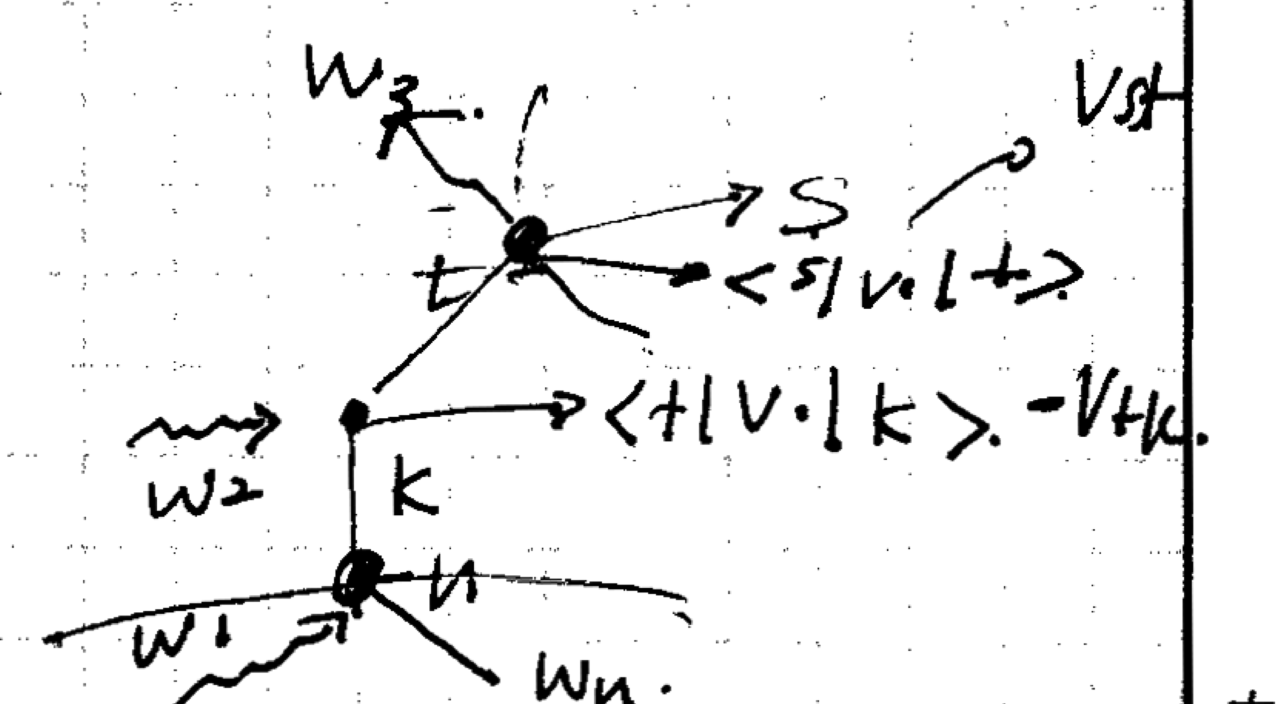
$$\psi^{k}(t+t_a) = \left(-\frac{\vec{E}}{i\hbar}\right)\int_0^t dt_1 \left[\exp^{t_1(\omega_k - \omega_n + \omega_1)t_1}\right] \exp^{-i[\omega_k]t} \cdot \exp^{t_1 \cdot \omega_n t_a}.$$

$$= E \cdot p = V_0 \, \frac{\exp^{i(-\omega_n+\omega_1)t} - \exp^{-i\omega_k t}}{\omega_k - \omega_n + \omega}$$

$$= \left(\frac{1}{i\hbar}\right) \langle k|V_0|k\rangle \frac{\left(\exp^{i(-\omega_n+\omega)t} + e^{-i\omega_k t}\right)}{\omega_k - \omega_n + \omega_1} |k\rangle .$$







$$\psi^3(t,0) - U^3(t,0)|n\rangle$$

$s\rangle\langle s|$

$$\left(\frac{1}{i\hbar}\right) \frac{V_{3t} V_{tk} V_{kn} |s\rangle \left(\exp^{i[\omega_n - \omega_1 + \omega_3]t} - e^{-i\omega_s t}\right)}{\hbar(-\omega_1 - \omega_n + \omega_k)(-\omega_1 - \omega_n - \omega_3 + \omega_s)}.$$

MPT.