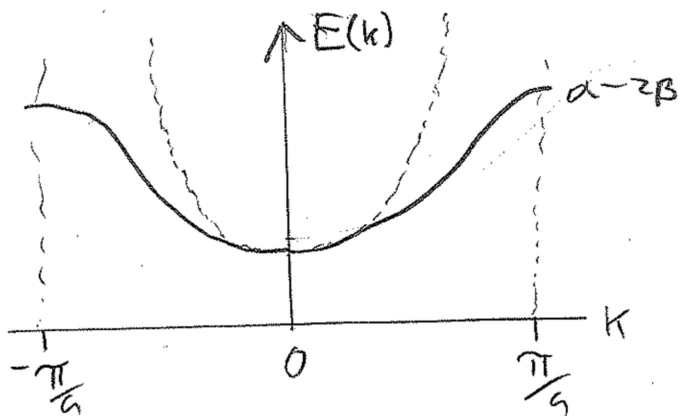
(HWRK see Fri. notes 3, read 15.6 in McIntyre)

Day 12 Recall the ground state of valence band energies are $E(k) = \alpha + 2\beta \cos ka$

$\simeq \alpha + 2\beta(1 - \frac{1}{2}(ka)^2)$, for small ka



Near $k=0$ the band looks parabolic, which reminds us of the free-electron dispersion, $E(k) = \frac{\hbar^2 k^2}{2m_e}$

Specifically for, $E(k) - E(k=0) \simeq \beta (ka)^2$

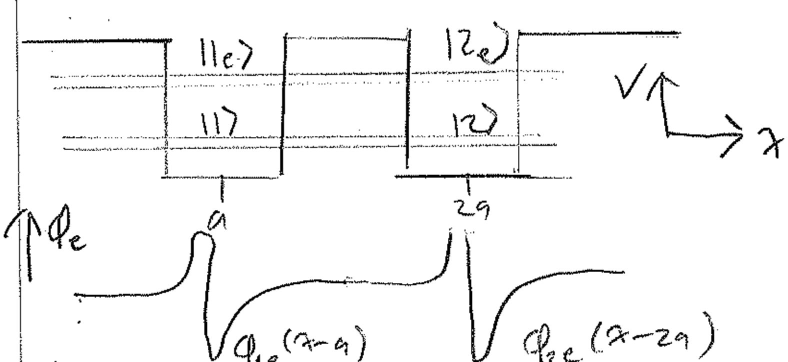
$$\simeq \frac{\hbar^2 k^2}{2m^*}$$

where m^* is the effective mass, $m^* \cong \frac{\hbar^2}{2|\beta|a^2}$

rigorously the effective mass is the free-electron mass "dressed" by the potential field of the crystal,

in general, $\boxed{m^* \equiv \hbar^2 \left[\frac{d^2 E}{dk^2}\Big|_{k=k_0} \right]^{-1}}$

What about the excited state w.f. $|1e\rangle, |2e\rangle, \ldots |Ne\rangle$ and the conduction band?



excited state w.f. is odd, $\varphi_e(-x) = -\varphi_e(x)$

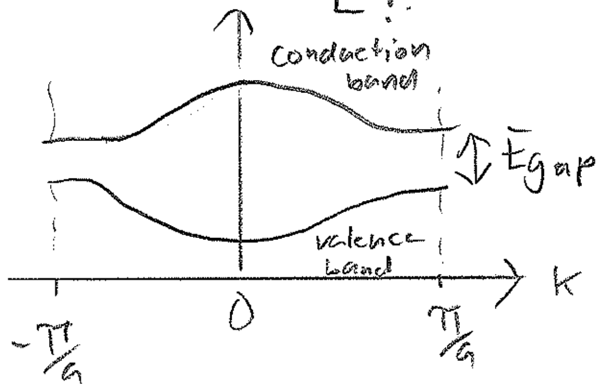
$\Rightarrow \beta_e = \langle 2e|\hat{H}|1e\rangle$

$= \langle 2e|\hat{V}(x-a)|1e\rangle$

$+ \langle 2e|\hat{V}(x-2a)|1e\rangle > 0$

Hence, $\beta_e > 0$ (recall $\beta < 0$)

Thus, $\hat{H} = \begin{bmatrix} \alpha_e & \beta_e & 0 & \cdots \\ \beta_e & \alpha_e & \beta_e & \\ \vdots & & & \ddots \end{bmatrix}$ or $E(k) = \alpha_e + 2\beta_e \cos ka$



Band-gap: min energy spacing between bands.

$$E_{gap} \cong (\alpha_e + 2\beta) - (\alpha - 2\beta)$$

Fermi Energy: the maximum occupied energy at T=0K

If E_F is in the band gap at T=0K, the material is a semiconductor or insulator. If E_F lies within a band it is a metal

Semiconductors are further classified as direct or indirect

it is a direct gap if the lowest point in the conduction band occurs at the same k-value as the highest energy in the valence band,

Band-width: the difference in the maximum and minimum energy allowed in each band.

e.g. $E_w = E(0) - E(\frac{\pi}{a}) = 4\beta$ for q-well valence band

$4\beta_e$ for conduction band

42-381 50 SHEETS EYE-EASE 5 SQUARES
42-382 100 SHEETS EYE-EASE 5 SQUARES
42-389 200 SHEETS EYE-EASE 5 SQUARES
National Brand