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Courses » Introduction to Solid State Physics

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Unit 10 - Band theory of metals, insulators and semiconductors, Kronig-Penney model, tight binding method of calculating bands, and semi-classical dynamics of a particle in a band

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Assignment 9

The due date for submitting this assignment has passed. Due on 2019-04-03, 23:59 IST.
As per our records you have not submitted this assignment.

1) *1 point*

In free electron model energy $E(\vec{k})$, for an arbitrary wavevector $\vec{k}$ on the Bragg plane, mea $\vec{K}/2$, is given by $E(\vec{k}) = E_{\vec{K}/2} + E_{\vec{k}}$. In case of weak periodic potential, the expression c $E_{modified}(\vec{k}) = E_{\vec{K}/2} + E_{\vec{k}} \pm |U_{\vec{K}}|$. For $E_{modified}(\vec{k})$, Fermi surface intersects with the Bra radius r_1 and r_2. Difference between the area enclosed by the circles of radius r_1 and r_2 is

- $4m\pi U_K$
- $2m\pi U_K$
- $m\pi U_K$
- $8m\pi U_K$

No, the answer is incorrect.
Score: 0
Accepted Answers:
$4m\pi U_K$

2) *1 point*

In the potential model used in connection with Kronig-Penny calculation, if the potential is allowed to infinitely large i.e. $V_0 \to \infty$ and $b \to 0$ (delta function potential) in such a way that $V_0 b$ remains finite then allowed energy values are given by the equation

$$\frac{P\sin(\alpha a)}{\alpha a} + \cos(\alpha a) = \cos(ka) \quad \text{where } P = \frac{mV_0ab}{\hbar^2} \quad \ldots\ldots (1)$$

If P is large (but not infinite) then what happens?

- The allowed bands are narrower and the forbidden bands are wider
- The allowed bands are wider and the forbidden bands are narrower
- Band reduces to one single energy level
- Can't say anything

No, the answer is incorrect.
Score: 0
Accepted Answers:
The allowed bands are narrower and the forbidden bands are wider

3) *1 point*

In equation (1) if P is very small. Then it leads to

- Tight binding model
- Free electron model
- Intermediate case
- Can't say anything

No, the answer is incorrect.

The energy wave vector dispersion relation for a one-dimensional crystal of lattice constant a is given by

$E(k) = E_0 - \alpha - 2\beta\cos(ka)$, where E_0 α, β are constants

The effective mass m^* of the electron at the bottom and at the top of the band are-

- $\frac{\hbar^2}{2\beta a^2}$ and $\frac{\hbar^2}{2\beta a^2}$
- $\frac{\hbar^2}{2\beta a^2}$ and $-\frac{\hbar^2}{2\beta a^2}$
- $\frac{\hbar^2}{2a^2}$ and $-\frac{\hbar^2}{2\beta a^2}$
- $\frac{\hbar^2}{\beta a^2}$ and $-\frac{\hbar^2}{\beta a^2}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\frac{\hbar^2}{2\beta a^2}$ and $-\frac{\hbar^2}{2\beta a^2}$

5) *1 point*

For the Kronig–Penney model with P $(= \frac{mV_0ba}{\hbar^2})$ <<1, at K = 0, the energy of the lowest energy band is approximately

- $E_0 \approx P\frac{\hbar^2}{md^2}$
- $E_0 \approx P\frac{\hbar}{mb^2}$
- $E_0 \approx P\frac{\hbar^2}{md}$
- $E_0 \approx P\frac{\hbar^2}{ma^2}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$E_0 \approx P\frac{\hbar^2}{md^2}$

6) *1 point*

Imagine a 1D crystal with an energy band described by $E(K) = E_B + (E_T - E_B)sin^2\left(\frac{Kd}{2}\right)$; ($E_T$ and E_B are top and bottom of band) where that contains only a single electron. Effective mass depends on K as

- $\frac{\hbar^2}{d^2\cos(Kd)}$
- $\frac{\hbar^2}{d\cos(Kd)}$
- $\frac{\hbar^2}{d^2\cos(Kd/2)}$
- $\frac{2\hbar^2}{d^2\cos(Kd)}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\frac{2\hbar^2}{d^2\cos(Kd)}$

7) *1 point*

In Problem 6, effective mass depends on K. Which graph best describe dependence of effective mass on K (in the range -π/2 to π/2):

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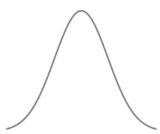
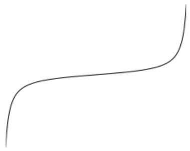
- 

- 
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No, the answer is incorrect.
Score: 0

Accepted Answers:

8) *1 point*

If the lattice spacing is 2 Å and the field strength is 200 N/C, what is the period of oscillation:

- 97 MHz
- 61 MHz
- 55 MHz
- 10 MHz

No, the answer is incorrect.
Score: 0

Accepted Answers:

61 MHz

9) *1 point*

If force F is applied, what will be amplitude of oscillation if the band width is Δ

- Δ/2F
- Δ/F
- Δ/4F
- 2ΔF

No, the answer is incorrect.
Score: 0

Accepted Answers:

Δ/2F

10) *1 point*

In a cubic lattice the nearest neighbour lattice sites are (±a,0,0), (0, ±a,0) and (0,0, ±a). The dispersion relation is given by

$$E(k) = E_0 - 2t(\cos(k_x a) + \cos(k_y a) + \cos(k_z a))$$

Considering hopping parameters are the same in all directions: $t_a = t$, the width of the band is given by

- 12t
- 0
- -12t
- 6t

No, the answer is incorrect.
Score: 0

Accepted Answers:

12t

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