Unit 9 - Bloch's theorem for wavefunction of a particle in a periodic potential, nearly free electron model, origin of energy band gaps, discussion of Bloch wavefunction

Assignment 8

The due date for submitting this assignment has passed.
As per our records you have not submitted this assignment.

Due on 2019-03-27, 23:59 IST.

1) *1 point*

Consider the wavefunction $\Psi(x) = C_0 e^{ikx} + C_1 e^{i(k+G)x} + C_{-1} e^{i(k-G)x}$ where $G = \frac{2\pi}{a}$ for a particl m moving in a periodic potential $V(x) = V_0 \cos(Gx)$ in a one-dimensional crystal of periodicity a. corresponding Hamiltonian is diagonalised, the resulting equation for the energy E is, (here, E_0 = $E_\pm = \frac{\hbar^2(k\pm G)^2}{2m}$)

- $(E_0 - E)(E_1 - E)(E_{-1} - E) - (E_1 - E)|V_G|^2 + (E_{-1} - E)|V_G|^2 = 0$
- $(E_0 - E)(E_1 - E)(E_{-1} - E) + (E_1 - E)|V_G|^2 - (E_{-1} - E)|V_G|^2 = 0$
- $(E_0 - E)(E_1 - E)(E_{-1} - E) + (E_1 - E)|V_G|^2 + (E_{-1} - E)|V_G|^2 = 0$
- $(E_0 - E)(E_1 - E)(E_{-1} - E) - (E_1 - E)|V_G|^2 - (E_{-1} - E)|V_G|^2 = 0$

No, the answer is incorrect.
Score: 0

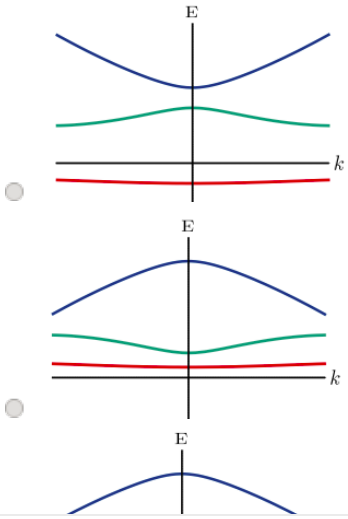
Accepted Answers:

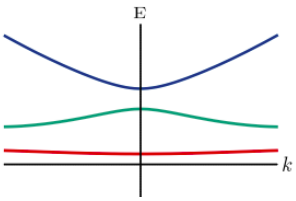
$(E_0 - E)(E_1 - E)(E_{-1} - E) - (E_1 - E)|V_G|^2 - (E_{-1} - E)|V_G|^2 = 0$

2) *1 point*

{Note :The equation above can be solved easily using a computer or a programmable calculator by over the energies E and finding those which satisfy the equation (for this value of zero is to be take small values; you would have to experiment a bit with your calculations for this). Answer up to qu based on this by taking $a = m = \hbar = 1, V_0 = \frac{G^2}{2}$.}

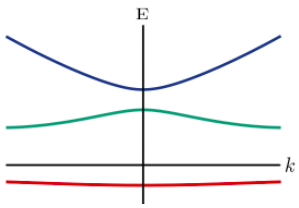
The band structure for question 1 is given as





No, the answer is incorrect.
Score: 0

Accepted Answers:



3) For question 1, the lowest value of energy in the first band is close to 1 point

- 12
- 7
- -7
- -12

No, the answer is incorrect.
Score: 0

Accepted Answers:
-7

4) The highest value of energy in the second band is close to 1 point

- 20
- 28
- 80
- 50

No, the answer is incorrect.
Score: 0

Accepted Answers:
20

5) The energy band gap between the first and the second band is close to 1 point

- 25
- 19
- 10
- 13

No, the answer is incorrect.
Score: 0

Accepted Answers:
19

6) The energy band gap between the second and the third band is close to 1 point

- 15
- 25
- 12
- 7

No, the answer is incorrect.
Score: 0

Accepted Answers:
7

7) When free electron energy is plotted in the reduced zone scheme, the ratio of the energy width of the third band to that of the second band is 1 point

- 5/3
- 3/2
- 5/4
- 3/4

No, the answer is incorrect.
Score: 0

Accepted Answers:
5/3

8) In a simple square lattice, the kinetic energy of a free electron at the corner of the first zone is higher than that of the midpoint of the side of the first zone by a factor of f. The value of f is close to 1 point

- 3
- 1.4
- 1
- 2

No, the answer is incorrect.
Score: 0

Accepted Answers:
2

9) 1 point

Consider a two dimensional square lattice with the crystal potential $V(x, y) = -4U\cos(2\pi x/a)\cos(2\pi y/$

$U > 0$. Take, $G_x = G_y = \frac{2\pi}{a}, G_{11} = G_x\hat{i} + G_y\hat{j}, G_{11'} = G_x\hat{i} - G_y\hat{j}, G_{1'1'} = -G_x\hat{i} - G_y\hat{j}$, and $G_{1',1} = -G$

Then

- $V_{G_x} = V_{G_y} = 0$ and $V_{G_{11}} = V_{G_{1'1}} = V_{G_{11'}} = V_{G_{1'1'}} = -U$
- $V_{G_x} = V_{G_y} = -4U$ and $V_{G_{11}} = V_{G_{1'1}} = V_{G_{11'}} = V_{G_{1'1'}} = 0$
- $V_{G_x} = V_{G_y} = 0$ and $V_{G_{11}} = V_{G_{1'1}} = V_{G_{11'}} = V_{G_{1'1'}} = 2U$
- $V_{G_x} = V_{G_y} = -U$ and $V_{G_{11}} = V_{G_{1'1}} = V_{G_{11'}} = V_{G_{1'1'}} = -U$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$V_{G_x} = V_{G_y} = 0$ and $V_{G_{11}} = V_{G_{1'1}} = V_{G_{11'}} = V_{G_{1'1'}} = -U$

10) The energy gap between the at the corner point of the Brillouin zone will be 1 point

- $2U$
- $4U$
- U
- 0

No, the answer is incorrect.
Score: 0

Accepted Answers:
2U

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