Unit 5 - Week 4

Week 4 Assignment 1

The due date for submitting this assignment has passed. Due on 2017-08-28, 23:55 IST.

Submitted assignment

Note: More than one option can be correct.

1) Debye approximation for Acoustic Phonons is _____ and is given by _____.

   - Linear, \( \omega = \sqrt{\frac{K}{m}} \kappa a \)
   - Constant, \( \omega = constant \)
   - linear, \( \omega = v_{debye} \kappa \)
   - parabolic, \( \omega = v_{debye} \kappa^2 \)

No, the answer is incorrect.
Score: 0
Accepted Answers:

   Linear, \( \omega = \sqrt{\frac{K}{m}} \kappa a \)
   linear, \( \omega = v_{debye} \kappa \)

2) Einstein’s Optical phonons consider dispersion curve to be _______.

   - Linear
   - Constant
   - Parabolic
   - None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers:

   Constant

3) For Polyatomic lattice in phase dispersion curve is given by

   \[ \omega^2 = K \left\{ \left( \frac{1}{M} + \frac{1}{m} \right) + \left[ \left( \frac{1}{M} + \frac{1}{m} \right)^2 - \frac{4 \left( \sin \frac{k_0}{2} \right)^2}{Mm} \right]^2 \right\} \]

   - \( \omega^2 = K \left\{ \left( \frac{1}{M} + \frac{1}{m} \right) + \left[ \left( \frac{1}{M} + \frac{1}{m} \right)^2 - \frac{4 \left( \sin \frac{k_0}{2} \right)^2}{Mm} \right]^2 \right\} \)
   - \( \omega^2 = K \left\{ \left( \frac{1}{M} + \frac{1}{m} \right) - \left[ \left( \frac{1}{M} + \frac{1}{m} \right)^2 - \frac{4 \left( \sin \frac{k_0}{2} \right)^2}{Mm} \right]^\frac{1}{2} \right\} \)
   - None of the above

Score: 0
Accepted Answers:
No, the answer is incorrect.
Score: 0
Accepted Answers:

$$\omega^2 = K \left\{ \frac{1}{m} + \frac{1}{m} - \left[ \frac{1}{m} + \frac{1}{m} \right]^2 - 4 \left( \frac{\sin \frac{K \alpha}{2}}{K m} \right)^2 \right\}$$

4) If ‘m’ atoms are in basis then no. of acoustic and optical modes are

- 3, 2(m-1)
- 3, 3(m-1)
- 2, 3(m-1)
- None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers: 3, 3(m-1)

5) Model used to solve Schrodinger equation for an electron inside crystal is called

- Kronig Penny Model
- Thomson Plum-Pudding Model
- Einstein’s wave model
- None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers: Kronig Penny Model

6) Statement of Bloch Theorem states

- None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers:

$$\psi(x + (a + b)) = \psi(x)e^{i\kappa(a+b)}$$
$$\psi(x + (a + b)) = \psi(x)e^{i\kappa a}$$
$$\psi(x + (a + b)) = \psi(x)e^{i\kappa(1+b/a)}$$
- None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers:

$$\psi(x + (a + b)) = \psi(x)e^{i\kappa(a+b)}$$

7) Solution to Schrodinger wave equation of electron in crystal is given by

where $K$ is electron wave vector, $P = \frac{baQ^2}{2}$ and $\kappa$ is crystal wave vector

- $\frac{p}{K_a} \sin K_a + \cos K_a = \cos K_a$
- $\frac{p}{K_a} \sin K_a + \cos K_a = \cos K_a$
- $\frac{p}{K_a} \sin K_a + \frac{p^2}{K_a^2} \cos K_a = \cos K_a$
- None of the above.

No, the answer is incorrect.
Score: 0
Accepted Answers:
\[ \frac{P}{K_a} \sin K_a + \cos K_a = \cos K_a \]

8) The relationship between energy of electron and wave vector for crystals and metallic crystal is given by

\[ E(k) = E(k_m) + \frac{5 \hbar^2 (k-k_m)^2}{m^*}, \quad E(k) = E(k_m) + \frac{5 \hbar^2 (k)^2}{m^*} \]

\[ E(k) = E(k_m) + \frac{2 \hbar^2 (k-k_m)^2}{m^*}, \quad E(k) = E(k_m) + \frac{5 \hbar^2 (k)^2}{m^*} \]

None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers:

9) For 1D monoatomic crystal dispersion relation is given by

\[ \omega = 2 \sqrt{\frac{k}{m}} \left| \sin \frac{\kappa a}{2} \right| \]

\[ \omega = 2 \sqrt{\frac{k}{m}} \sin \frac{\kappa a}{2} \]

\[ \omega = \sqrt{\frac{k}{m}} \sin \frac{\kappa a}{2} \]

None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers:

10) What is Brillouin zone?

- The unit cell of crystal about which wave vector keeps on repeating.
- The unit cell of crystal about which energy keeps on repeating.
- The unit cell of crystal about which dispersion relation keeps on repeating.
- None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers: The unit cell of crystal about which dispersion relation keeps on repeating.

11) What is the minimum wavelength/wave vector for phonon vibration in monoatomic 1D crystal?

- \( \lambda \leq 2a \)
- \( \lambda \geq 2a \)
- \( \kappa \leq \frac{\pi}{a} \)
- \( \kappa \geq \frac{\pi}{a} \)

No, the answer is incorrect.
Score: 0
Accepted Answers:
\[ \lambda \geq 2a \]
\[ \kappa \leq \frac{\pi}{a} \]

12) If there are \( N \) no. of atoms in a lattice, then no. of allowable quantum states in a Brillouin zone is given by?

- \( N \)
- \( N/2 \)
- \( 2N \)
- None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers: \( N \)

13) Electron density of states in a crystal with spherical parabolic band approximation is given by

\[ D(E) = \frac{2}{2\pi^2} \left( \frac{2m^*}{\hbar^2} \right)^{3/2} (E - E_c)^{3/2} \]

- \[ D(E) = \frac{2}{2\pi^2} \left( \frac{2m^*}{\hbar^2} \right)^{3/2} (E)^{1/2} \]
- \[ D(E) = \frac{2}{2\pi^2} \left( \frac{2m^*}{\hbar^2} \right)^{3/2} (E - E_c)^{1/2} \]
- None of the above

No, the answer is incorrect.
Score: 0
Accepted Answers:

\[ D(E) = \frac{2}{2\pi^2} \left( \frac{2m^*}{\hbar^2} \right)^{3/2} (E - E_c)^{1/2} \]

(Q14-15 linked question)
(Application of Density of state)
A Gold crystal has a FCC lattice with one Gold atom per lattice point and a lattice constant of 4.08 Ångstrom. Every gold has one valence electron.
(Hint-assume electron effective mass to be same as electron mass)

14) No. of Electrons per unit volume?

- \( 5.89 \times 10^{21} \) cm\(^{-3} \)
- \( 5.89 \times 10^{22} \) cm\(^{-3} \)
- \( 5.89 \times 10^{20} \) cm\(^{-3} \)
- \( 5.89 \times 10^{23} \) cm\(^{-3} \)

No, the answer is incorrect.
Score: 0
Accepted Answers:

\( 5.89 \times 10^{22} \) cm\(^{-3} \)

15) Estimate the electron Fermi level in a gold crystal?

- \( 5.4 \) eV
- \( 2.7 \) eV
- \( 10.8 \) eV
- \( 7.1 \) eV

No, the answer is incorrect.
Score: 0
16. Phonon Density of state in a 3D lattice, using Debye approximation is given by

\[ D(\omega) = \frac{3\omega^2}{2\pi^2 v^3_{\text{debye}}} \]

- \[ D(\omega) = \frac{\omega^2}{2\pi^2 v^{3}_{\text{debye}}} \]
- \[ D(\omega) = \frac{3\omega^2}{2\pi^2 v^{3}_{\text{debye}}} \]
- None of the above

No, the answer is incorrect.
Score: 0

Accepted Answers:

\[ D(\omega) = \frac{3\omega^2}{2\pi^2 v^3_{\text{debye}}} \]