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NPTEL

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Courses » Introduction to Solid State Physics

Announcements

Course

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Unit 3 - Introduction to Sommerfeld's model

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Course outline

How to access the portal

Introduction to Drude's free electron theory of metals, electrical conductivity Ohm's law and Hall effect

Introduction to Sommerfeld's model

- Understanding thermal conductivity of a metal using Drude's model Part 1
- Understanding thermal conductivity of a metal using Drude's model Part 2
- Introduction to Sommerfeld's Theory of electrons in a metal Part-1
- Introduction to Sommerfeld's Theory of electrons in a metal Part-2
- Introduction to Sommerfeld's Theory of electrons in a metal Part-3
- Fermi energy and Fermi Sphere Part-1
- Fermi energy and Fermi Sphere Part-2
- Density of states Part-1
- Density of states Part-2
- Summary and Discussions of Sommerfeld's Model
- Quiz : Assignment 2
- Introduction to Solid State Physics : Feedback For Week 2
- Assignment 2 solutions

Specific heat of an electron gas and the behaviour of thermal conductivity of a solid and relationship with electrical conductivity

Introduction to crystal structure and their classifications

Direct Imaging of Atomic Structure, Diffraction of Waves by Crystals, Reciprocal lattice, Brillouin Zones

Vibrations of Crystals with Monatomic Basis, Acoustic modes

Two Atoms per Primitive Basis, Quantization of Elastic Waves, Phonon Momentum

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

Assignment 2

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

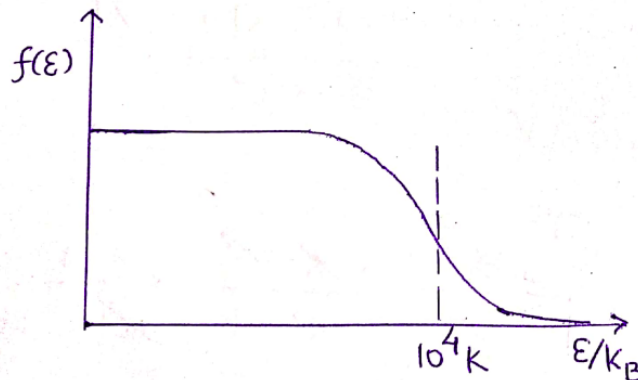
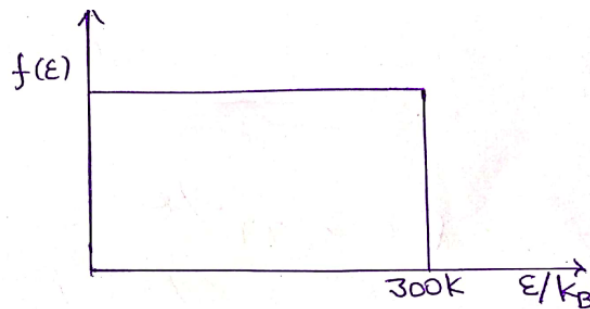
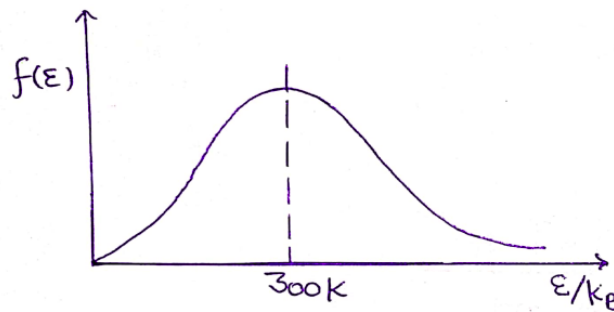
Due on 2019-02-13, 23:59 IST

1)

1 point

(Note: All across the paper the Boltzmann constant is k_B)

1. The probability distribution of electrons in a metal amongst the available energy states K is best described by the following graphs (graphs are schematic and not to scale):



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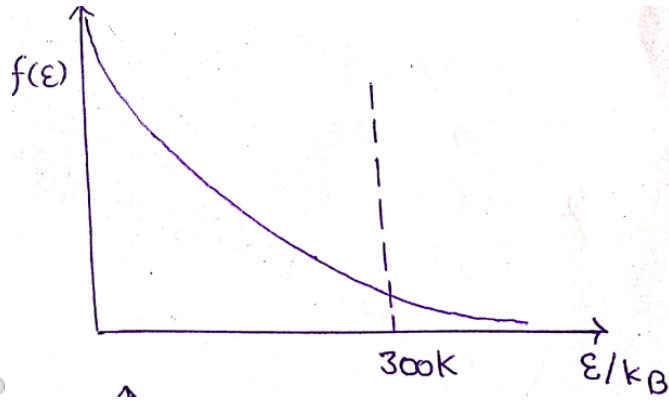
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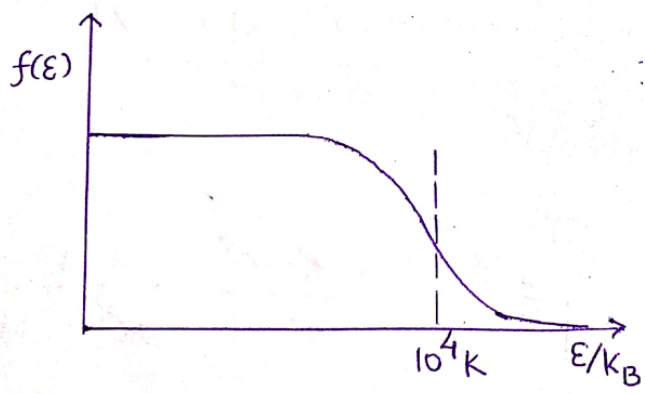
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- of a particle in a band
- Introductory Semiconductor Physics
- Magnetism in materials
- Superconductivity
- Solutions of Assignments



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

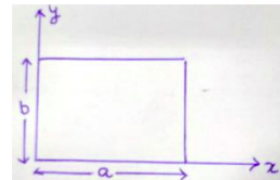


2) The probability of electrons at 300 K having energy $\epsilon_F + 1000 k_B$ is: 1 point

- 0
- 0.034
- 0.037
- ∞

No, the answer is incorrect.
Score: 0
Accepted Answers:
0.034

3) Using periodic boundary condition over a rectangle $a \times b$ ($a \neq b$) shown below, the Sommerf wave function is 1 point



where n_x and n_y are integers.

- $\psi(x, y) = A e^{i(\frac{2\pi n_x}{a}x)} e^{i(\frac{2\pi n_y}{a}y)}$
- $\psi(x, y) = A \sin(\frac{\pi n_x}{a}x) \sin(\frac{\pi n_y}{b}y)$
- $\psi(x, y) = A e^{i(\frac{2\pi n_x}{b}x)} e^{i(\frac{2\pi n_y}{b}y)}$
- $\psi(x, y) = A e^{i(\frac{2\pi n_x}{a}x)} e^{i(\frac{2\pi n_y}{b}y)}$

No, the answer is incorrect.
Score: 0

Accepted Answers:

$$\psi(x, y) = A e^{i\left(\frac{2\pi n_x}{a}x\right)} e^{i\left(\frac{2\pi n_y}{b}y\right)}$$

4)

1 point

The time dependent part of the wave function of the electron in the metal strip of previous question is

- $e^{-\frac{i}{\hbar}\left[\frac{\hbar^2}{2m}\left(\frac{n_x^2}{a^2} + \frac{n_y^2}{a^2}\right)\right]t}$
- $e^{\frac{i}{\hbar}\left[\frac{\hbar^2}{2m}\left(\frac{n_x^2}{a^2} + \frac{n_y^2}{b^2}\right)\right]t}$
- $e^{-\frac{i}{\hbar}\left[\frac{\hbar^2}{2m}\left(\frac{n_x^2}{a^2} + \frac{n_y^2}{b^2}\right)\right]t}$
- $e^{-\frac{i}{\hbar}\left[\frac{\hbar^2}{2m}\left(\frac{n_x^2}{b^2} + \frac{n_y^2}{b^2}\right)\right]t}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$e^{-\frac{i}{\hbar}\left[\frac{\hbar^2}{2m}\left(\frac{n_x^2}{a^2} + \frac{n_y^2}{b^2}\right)\right]t}$$

5)

1 point

In a 1D metal wire, taking periodic boundary condition over length L , the density of states g is

- $L/2\pi$
- $(L/2\pi)^2$
- $(2\pi/L)$
- (π/L)

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$L/2\pi$$

6)

1 point

The dependence of density of state $g(E)$ on energy in previous problem is

- $\propto E^{3/2}$
- $\propto E^{1/2}$
- $\propto E^0$
- $\propto E^{-1/2}$

No, the answer is incorrect.

Score: 0

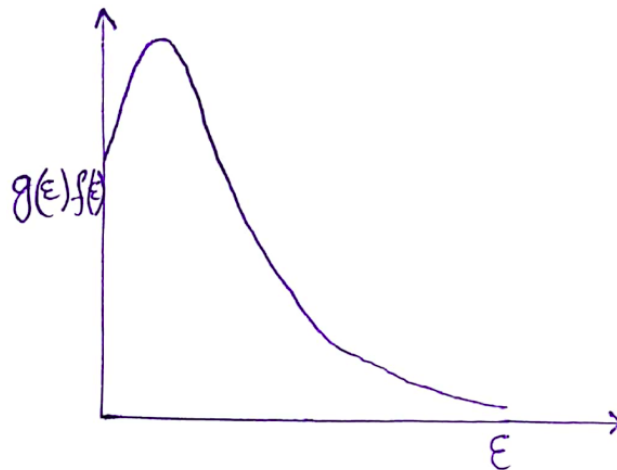
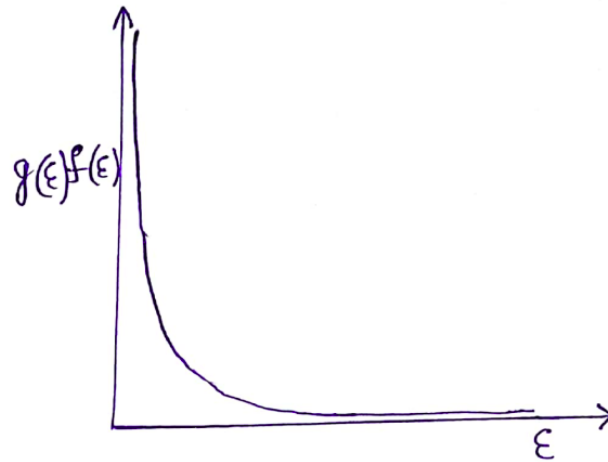
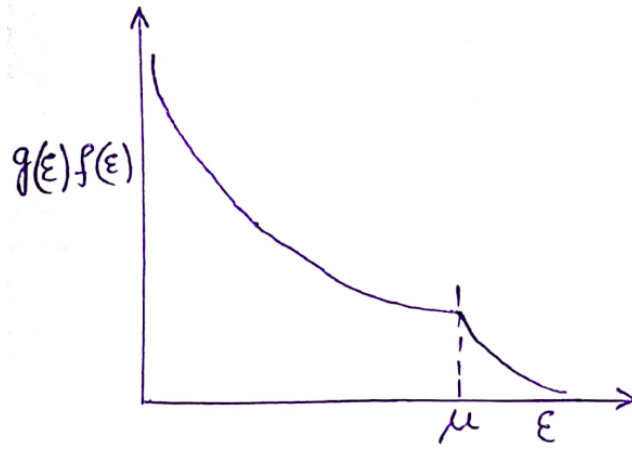
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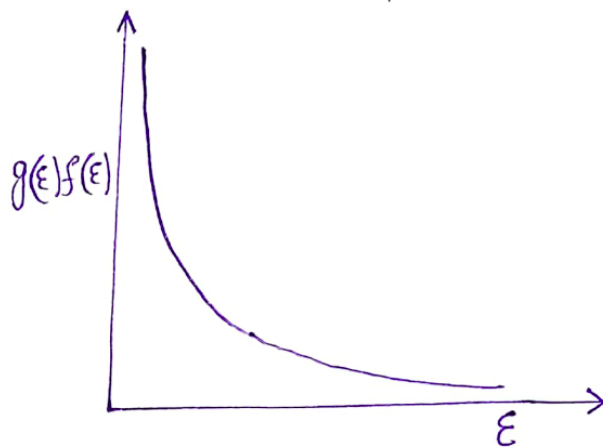
$$\propto E^{-1/2}$$

7)

1 point

At finite T in a 1D metal (wire of length L) the sketch of the density of occupied states is

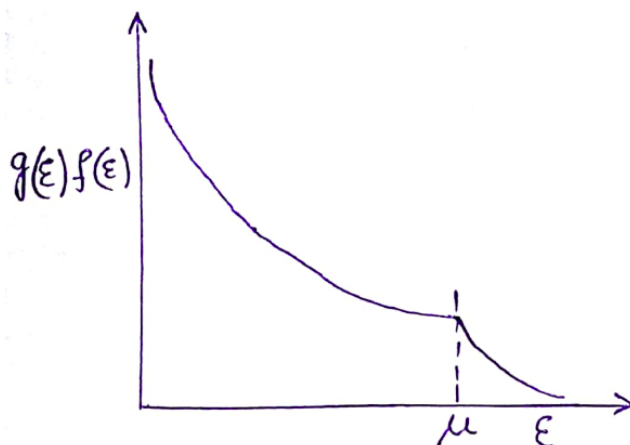




No, the answer is incorrect.

Score: 0

Accepted Answers:



8)

1 point

The fermi energy of the 1D metal wire of length L is (where N is the total number of electrons)

- $E_F = \frac{\hbar^2 \pi^2}{8m} \left(\frac{N}{L}\right)^2$
- $E_F = \frac{2\hbar^2 \pi^2}{m} \left(\frac{N}{L}\right)^2$
- $E_F = \frac{2\hbar^2 \pi^2}{m} \left(\frac{N}{L}\right)$
- $E_F = \frac{2\hbar^2 \pi^2}{m} \left(\frac{L}{N}\right)^2$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$E_F = \frac{\hbar^2 \pi^2}{8m} \left(\frac{N}{L}\right)^2$$

9) In a pure piece of Aluminium (Al) with $n = 18.06 \times 10^{22}$ e/c.c. the E_F is

1 point

- 1165 eV
- 116.5 eV
- 1.17 eV
- 11.65 eV

No, the answer is incorrect.

Score: 0

Accepted Answers:

11.65 eV

10)

1 point

Using Drude like approximation for the Sommerfeld model as was done in the lecture w charge (-e) in a 1D metal are subjected to an electric field \vec{E} in the +x direction and τ is the me collision time then the ratio of the energy gained by electron in the metal in steady state in 1 electric field w.r.t. the fermi energy E_f is

- $(eEv_F\tau/E_f)$
- $(eE\tau/E_f)$
- (eE/E_f)
- $(eE/\tau E_f)$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$(eEv_F\tau/E_f)$

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