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Courses » Introduction to Solid State Physics

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Unit 2 - Introduction to Drude's free electron theory of metals, electrical conductivity Ohm's law and Hall effect

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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 Drude's theory of electrons in a metal- Part 1
- Introduction to Drude's theory of electrons in a metal- Part 2
- Postulates of Drude's theory
- Calculating electrical conductivity of metal using Drude's theory of electrons in metal Part- 1
- Calculating the electrical conductivity of metal using Drude's Model Part-2
- Introduction to Hall effect in Metals Part-1
- Introduction to Hall effect in metals Part-2
- Introduction to Hall effect in metals Part 3
- Quiz : Assignment 1
- Introduction to Solid State Physics : Feedback For Week 1
- Assignment 1 solutions

Introduction to Sommerfeld's model

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 wavefunction

Band theory of metals, insulators and semiconductors, Kronig-Penney model, tight binding method of calculating bands

Assignment 1

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
Take a straight metal wire that can be considered as one dimensional. Then the specific heat (C_V) due to conduction electron is (which will satisfy Drude's theory)

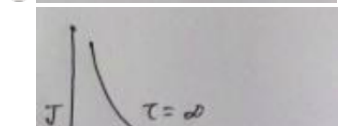
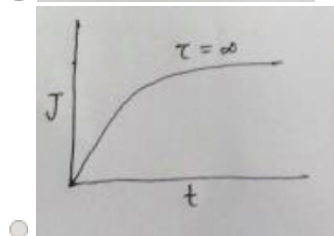
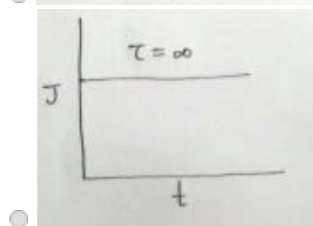
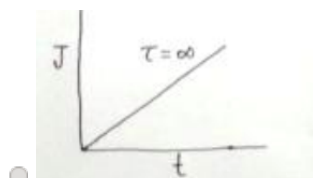
- $(3/2)R$
- $3R$
- R
- $R/2$

No, the answer is incorrect.
Score: 0

Accepted Answers:

 $R/2$

2) 1 point
A metal has very large scattering time (τ), which can be taken to be infinity. Then using Drude's model in the presence of DC electric field the behaviour of the current density (J) as a function of time will be



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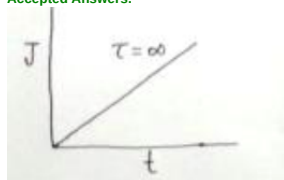
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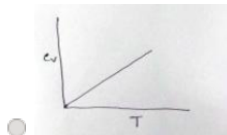
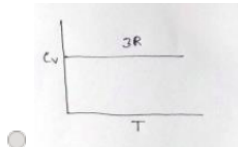
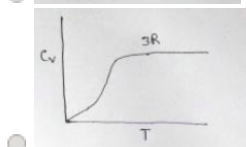
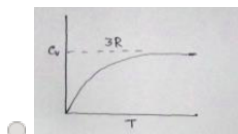
Solutions of Assignments

Score: 0

Accepted Answers:



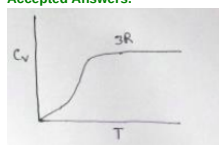
3) Sketch the behaviour of specific heat of a pure 3D metal as a function of temperature (T) 1 point



No, the answer is incorrect.

Score: 0

Accepted Answers:



4) 1 point
Electrons are drifting in a metal with an average velocity v_0 when an electric field \vec{E} is present. At $t = 0$ the electric field is switched off. Then the time dependence of the average velocity of the electron as a function of time will be

- $v = v_0 e^{-t/\tau}$
- $v = v_0 e^{t/\tau}$
- $v = v_0 e^{-2t/\tau}$
- $v = v_0 e^{\frac{t^2}{\tau}}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$v = v_0 e^{-t/\tau}$$

5) 1 point
Amongst the materials given below which one can have both $-ve$ and $+ve$ Hall coefficients:

- Metal
- Doped semiconductor
- Insulator

Intrinsic semiconductor

No, the answer is incorrect.

Score: 0

Accepted Answers:

 Doped semiconductor

6)

1 point

Aluminium has scattering time $\tau = 10^{-15}$ sec. Within Drude model if at time t the momentum is $\vec{P}(t)$ then what will be the momentum of the electron after time interval of 3×10^{-16} sec from ' t ' (consider $\vec{E} = 0$ and $\vec{B} = 0$)

$0.7 \vec{P}(t)$

$1.3 \vec{P}(t)$

0

$5 \vec{P}(t)$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$0.7 \vec{P}(t)$

7)

1 point

A metal is subjected to an electric field $\vec{E} = \vec{E}_0 e^{-i\omega t}$. Write the steady state velocity of the electron in the metal (assume velocity has the same time dependence as the applied electric field and take the collision time τ)

$v = -\frac{eE_0 e^{-i\omega t}}{m(i\omega + \frac{1}{\tau})}$

$v = \frac{eE_0 e^{-i\omega t}}{m(-i\omega + \frac{1}{\tau})}$

$v = -\frac{eE_0 e^{-i\omega t}}{m(-i\omega + \frac{1}{\tau})}$

$v = -\frac{eE_0 e^{-i\omega t}}{m(-i\omega - \frac{1}{\tau})}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$v = -\frac{eE_0 e^{-i\omega t}}{m(-i\omega + \frac{1}{\tau})}$

8)

1 point

Using the equation derived above the frequency dependent electrical conductivity (σ) of the metal is –

$\frac{\sigma_0}{1-i\omega\tau}$

$\frac{\sigma_0}{1+i\omega\tau}$

$\frac{\sigma_0\omega}{1+i\omega\tau}$

$\frac{1}{1+i\omega\tau}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$\frac{\sigma_0}{1-i\omega\tau}$

9)

1 point

The mobility of electron μ_e is an important quantity in a solid. It is defined as $\vec{v} = -\mu_e \vec{E}$, where \vec{v} is velocity of electron and \vec{E} is electric field applied to the metal. Using Drude theory the expression is,

$\frac{e\tau}{m_e}$

- $-\frac{e\tau}{m_e}$
 $\frac{e^2\tau}{m_e}$
 $\frac{\tau}{m_e}$

No, the answer is incorrect.
Score: 0

Accepted Answers:

$\frac{e\tau}{m_e}$

10)

1 point

Mean free path of an electron l_e of a one dimensional wire made of copper at temperature $T = 300\text{K}$ is of the order of (use $\tau = 4 \times 10^{-14}\text{sec}$),

- 24 Å
 100 Å
 1 Å
 1000 Å

No, the answer is incorrect.
Score: 0

Accepted Answers:

24 Å

11)

1 point

If density of copper is $n = 8.45 \times 10^{28}\text{m}^{-3}$ then the Hall coefficient of copper is expected to be

- $-0.074 \times 10^{-9}\frac{\text{m}^3}{\text{c}}$
 $0.074 \times 10^{-9}\frac{\text{m}^3}{\text{c}}$
 $-0.74 \times 10^{-9}\frac{\text{m}^3}{\text{c}}$
 $0.0074 \times 10^{-9}\frac{\text{m}^3}{\text{c}}$

No, the answer is incorrect.
Score: 0

Accepted Answers:

$-0.074 \times 10^{-9}\frac{\text{m}^3}{\text{c}}$

12)

1 point

R_H^s and R_H^m are magnitudes of Hall coefficients of an intrinsic semiconductor and a metal, respectively. Then which one of the following is true

- $R_H^s > R_H^m$
 $R_H^s < R_H^m$
 $R_H^s = R_H^m$
 $R_H^s = R_H^m = 0$

No, the answer is incorrect.
Score: 0

Accepted Answers:

$R_H^s > R_H^m$

13)

1 point

According to Drude' model, what is the change in the magnitude of the longitudinal resistance of a wire when a magnetic field (B) is applied perpendicular to it,

- $\Delta\rho = 0$
 $\Delta\rho \propto B$
 $\Delta\rho \propto 1/B$

$\Delta\rho \propto B^2$

No, the answer is incorrect.

Score: 0

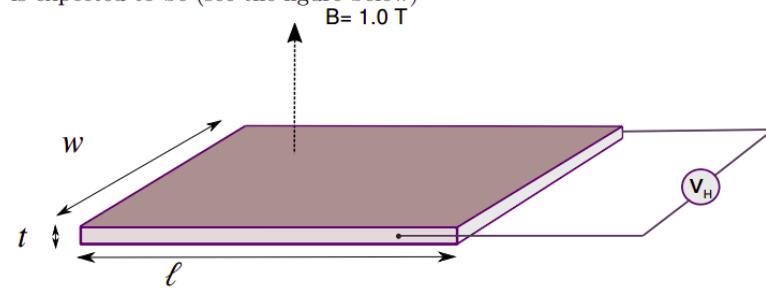
Accepted Answers:

$\Delta\rho = 0$

14)

1 point

A copper thin film of thickness(t) 1 nm, width(w) 1 mm, and length(ℓ) 2 mm is carrying current. If a magnetic field of strength 1 Tesla(T) is applied perpendicular to the film then the Hall voltage is expected to be (see the figure below)



$V_H = 0.5 \times 10^{-4} \text{ V}$

$V_H = 10^{-2} \text{ V}$

$V_H = 10^{-5} \text{ V}$

$V_H = 10^{-4} \text{ V}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$V_H = 10^{-4} \text{ V}$

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