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Courses » Introduction to Solid State Physics

Announcements **Course** Ask a Question Progress FAQ

## Unit 13 - Superconductivity

Register for  
Certification exam

### 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

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.

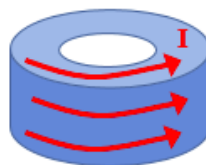
### Assignment 12

The due date for submitting this assignment has passed.

As per our records you have not submitted this assignment. **Due on 2019-04-24, 11:59 IST.**

1) 1 point

For a ring shown below, made of a metal of very low resistance  $R$  and the ring has an inductance is  $L$ . A current  $I_0$  is setup in the ring at time  $t = 0$  and subsequently no voltage is applied to the ring after  $t = 0$ . Then, which of the following statements is true for the current circulating in the ring.



- The current will decay down to zero
- The current will remain constant as Lenz law will prevent the current to die down
- The current will oscillate
- The current will decay down to a constant value.

No, the answer is incorrect.

Score: 0

Accepted Answers:

*The current will decay down to zero*

2) For the previous question the differential equation governing the decay of current in the low resistance ring is 1 point

$L \frac{dI}{dt} + RI = 0$

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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, and semi-classical dynamics of a particle in a band

Introductory Semiconductor Physics

Magnetism in materials

Superconductivity

- Introduction to Meissner state of superconductors and levitation
- Superconducting materials and Type-I and Type-II superconductors
- London's equation for superconductors
- Application of London's equation, behavior of specific heat and density of

ce De

$$R \frac{dI}{dt} + LI = \text{constant} \neq 0$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$L \frac{dI}{dt} + RI = 0$$

3) For the question 1, the time dependence of the current in the ring is **1 point**

$$I = I_0 \exp\left(-\frac{R}{L}t\right)$$

$$I = I_0(1 - \exp\left(-\frac{R}{L}t\right))$$

$$I = I_0 \exp\left(i\frac{R}{L}t\right) \text{ where } i = \sqrt{-1}$$

$$I(t) = I_0 \frac{Rt}{L}$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$I = I_0 \exp\left(-\frac{R}{L}t\right)$$

4) If the material in question 1 becomes superconducting, then the correct equations describing the situation **1 point**

Total current circulating in the ring  $I(t)$  is slightly greater than  $I_0$  because of Meissner effect

Total current circulating in the ring  $I(t)$  is slightly less than  $I_0$  because of Meissner effect

Total current circulating in the ring  $I(t)$  is equal to  $I_0$

Total current circulating in the ring  $I(t)$  will be zero

No, the answer is incorrect.

Score: 0

Accepted Answers:

*Total current circulating in the ring  $I(t)$  is slightly less than  $I_0$  because of Meissner effect*

5) A true test of superconductivity developing in a material is **1 point**

Only when resistance  $R \approx 0$

Magnetic susceptibility  $\chi = -1$

Magnetic susceptibility  $\chi = 1$

Only when conductivity becomes very high

No, the answer is incorrect.

Score: 0

Accepted Answers:

*Magnetic susceptibility  $\chi = -1$*

6) In the Kammeling Onnes experiment on superconductivity, the Hg on which he conducted his experiments had an atomic mass of 198 a.m.u. The superconducting transition temperature  $T_c$  was measured to be 4.18 K. If the same experiment was performed with using an isotope of Hg with **1 point**

states in  
superconductors

A qualitative  
introduction to  
BCS theory of  
superconductivity

Josephson's  
effect in  
superconductors  
and tunneling  
current across  
barriers

Quiz :  
Assignment 12

Introduction to  
Solid State  
Physics :  
Feedback For  
Week 12

Assignment 12  
Solutions

**Solutions of  
Assignments**

atomic mass of 203 a.m.u then what is the  $T_c$  you would expect to measure

- 4.23K
- 4.18K
- 4.13K
- 4.08K

**No, the answer is incorrect.**

**Score: 0**

**Accepted Answers:**

4.13K

7) For Hg with a superconducting transition temperature of 4.18 K, a **1 point** rough estimate of the superconducting energy gap associated with Cooper pairing of electrons in the solid is

- 3.6 Joules
- 4.18 meV
- 0.36 MeV
- 0.36 meV

**No, the answer is incorrect.**

**Score: 0**

**Accepted Answers:**

0.36 meV

8) For Hg with a superconducting transition temperature of 4.18 K, an **1 point** order of magnitude estimate of the Debye frequency of Hg (atomic mass 198) is

- $10^{14}$  Hz
- $10^{13}$  Hz
- $10^{12}$  Hz
- $10^{11}$  Hz

**No, the answer is incorrect.**

**Score: 0**

**Accepted Answers:**

$10^{14}$  Hz

9) In question 8, if we used Hg with increasing atomic mass, then the **1 point** Debye frequency of the material would

- Increase in proportion to the square of the atomic mass
- Decrease in proportion to the square of the atomic mass
- Decrease in proportion to the square root of the atomic mass
- Increase linearly with the atomic mass

No, the answer is incorrect.

Score: 0

Accepted Answers:

*Decrease in proportion to the square root of the atomic mass*

10) At the superconducting transition  $T_c$ , which of the following statement is correct 1 point

- It becomes relatively difficult to heat the electrons in the system with a very small amount of heat supplied to the material and the superconducting transition is a second order transition in zero applied magnetic field
- It becomes very easy to heat up the electrons system by supplying a very small amount of heat and the superconducting transition is a second order transition in zero applied magnetic field
- It becomes very easy to heat the system and the superconducting transition is a first order transition in zero applied magnetic field
- It becomes relatively difficult to heat the electrons in the system with a very small amount of heat supplied to the material and the superconducting transition is a first order transition in zero applied magnetic field

No, the answer is incorrect.

Score: 0

Accepted Answers:

*It becomes relatively difficult to heat the electrons in the system with a very small amount of heat supplied to the material and the superconducting transition is a second order transition in zero applied magnetic field*

11) Consider two identical superconductors of Niobium (Nb) are connected to each other with the help of a superconducting wire also of Nb having a cross-sectional area  $x^2$ , where  $x$  is the superconducting coherence length of Nb. The entire circuit is maintained at a temperature below the superconducting transition temperature of Nb. If a small finite voltage  $V$  is applied across the two superconductors then which of the following statements is true 1 point

- The phase difference across the superconducting wire connecting the two superconductors will change as a function of time and a dissipationless time dependent current will flow across the junction
- The phase different across the superconductors will remain constant and no current will flow across the junction
- The junction will become normal and a dissipative current will flow across the superconductor
- The phase difference across the junction will begin changing chaotically as a result the current across the junction will be very noisy

No, the answer is incorrect.

Score: 0

Accepted Answers:

*The phase difference across the superconducting wire connecting the two superconductors will change as a function of time and a dissipationless time dependent current will flow across the junction*

