Write the following information in the first page of Answer Script before starting answer

ODD SEMESTER EXAMINATION: 2020-21

Exam ID Number_____

Course_____ Semester_____

Paper Code _____Paper Title _____

Type of Exam: _____ (Regular/Back/Improvement)

Important Instruction for students:

1. Student should write objective and descriptive answer on plain white paper.
2. Give page number in each page starting from 1st page.
3. After completion of examination, Scan all pages, convert into a single PDF, rename the file with Class Roll No. **(2019MBA15)** and upload to the Google classroom as attachment.
4. Exam timing from 10am – 1pm (for morning shift).
5. Question Paper will be uploaded before 10 mins from the schedule time.
6. Additional 20 mins time will be given for scanning and uploading the single PDF file.
7. Student will be marked as ABSENT if failed to upload the PDF answer script due to any reason.

M.Sc. PHYSICS
THIRD SEMESTER
CONDENSED MATTER PHYSICS-I
MSP-304 A

Duration : 3 hrs. **Full Marks : 70**

(PART-A : Objective)

Time : 20 min. **Marks : 20**

Choose the correct answer from the following: ***1X20=20***

1. Electronic density of state at the Fermi level in a metal is:
a. Zero **b.** Finite
c. Infinite **d.** None

2. The effective mass of charge carriers in solids depends upon,
1. The topology of electronic band structure
2. Dispersion relation
3. Crystal size
4. Electronic density of states
a. Only 1 **b.** Only 2
c. 1,2 and 3 **d.** 1,2,3 and 4

3. Electronic band formation is due to the motion of electrons in a,
a. Constant potential **b.** Zero potential
c. Periodic potential **d.** None

4. In 1D lattice, the second Brillouin zone is defined in the region:
a. $-\pi/a$ to $+\pi/a$ **b.** $-2\pi/a$ to $+2\pi/a$
c. $-\pi/a$ to $-2\pi/a$ & $+\pi/a$ to $+2\pi/a$ **d.** $-3\pi/a$ to $-2\pi/a$ & $+2\pi/a$ to $+3\pi/a$

5. If E_H, j_x and B_z are the Hall field, current density and magnetic field strength, then the Hall constant(R_H) is given by:
a. $R_H = (E_H/J_x)/B_z$ **b.** $R_H = (J_x/E_H)/B_z$
c. $R_H = B_z/(E_H/J_x)$ **d.** None

6. Diamagnetic material possess:
a. Induced dipole moment **b.** Permanent dipole moment
c. No permanent magnetic dipoles **d.** None

7. Magnetic susceptibility (χ) of the magnetic material is given by: (symbols have their usual meaning)
a. $X = (\mu_r - 1)$ **b.** $X = M/H$
c. $X = (\mu - \mu_0)/\mu_0$ **d.** All are correct

8. The basic condition for cyclotron resonance is: (symbols have their usual meaning)
a. $\omega\tau << 1$ **b.** $\omega\tau = 1$
c. $\omega\tau >> 1$ **d.** None

9. For the Tight Binding model, consider the following,
1. The individual atomic wave functions are independent.
2. Method is appropriate to describe the band structure of diamond-like and inert gas type crystals.
3. Method is appropriate to describe metal-type crystals.
a. Only 1 **b.** Only 2
c. 1 and 2 **d.** 1,2 and 3

10. If the flatness of the electronic band increased then the effective mass will be:
a. Decreased **b.** Increased
c. Remains same **d.** None

11. A Josephson junction consists of a/an ……junction.
a. Insulator-superconductor-insulator **b.** Superconductor-insulator-superconductor
c. Normal-insulator-superconductor **d.** Normal- insulator-superconductor

12. At which of the following temperatures, transition from He II to He I phase happens?
a. 2.17 K **b.** 2.57 K
c. 5.17 K **d.** 4.2 K

13. Which one of the following is the value of quantum of magnetic flux?
a. 2.0 X 10^{-17} Webers **b.** 2.0 X 10^{-14} Webers
c. 2.0 X 10^{-16} Webers **d.** 2.0 X 10^{-15} Webers

14. Which of the following sets gives the correct values of exponential inequalities?
a. 1, 0, ½, 3 **b.** -1, 0, -1/2, 3
c. -1, 0, ½, 3 **d.** 1, 0, -1/2, 3

15. Latent heat is involved in ……phase transition.
a. He I to He II **b.** Water to ice
c. Ferromagnetic to paramagnetic **d.** Normal to superconductor

16. The temperature at which conductivity of a material becomes infinite is called:
a. Absolute temperature **b.** Crystallization temperature
c. Mean temperature **d.** Critical temperature

17. Cooper pairs are made of ……combination.
a. Electron- electron **b.** Electron- photon
c. Electron- proton **d.** Electron- phonon

18. Which one of the following is the correct expression for London penetration depth, with symbols having usual meaning?
a. $\lambda = \left(\frac{\mu_0 m}{n_s e^2}\right)^{\frac{1}{2}}$ **b.** $\lambda = \left(\frac{\mu_0 e^2}{n_s m}\right)^{\frac{1}{2}}$
c. $\lambda = \left(\frac{m}{\mu_0 n_s e^2}\right)^{\frac{1}{2}}$ **d.** $\lambda = \left(\frac{n_s e^2}{\mu_0 m}\right)^{\frac{1}{2}}$

19. The susceptibility of a superconductor is……..
a. Negative **b.** Positive
c. Zero **d.** Not predictable

20. If a photon does not lose energy on interaction with an electron, which kind of scattering is involved?

a. Compton
b. Rayleigh
c. Maxwell
d. Rutherford

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(PART-B : Descriptive)

Time : 2 hrs. 40 min. **Marks : 50**

[Answer question no.1 & any four (4) from the rest]

1. Obtain the dispersion relation of optical constants from Maxwell's equations. 10

2. **a.** Explain briefly DC and AC Josephson effects. 4+6=10
b. Discuss thermodynamics of superconductors with an appropriate figure.

3. **a.** Discuss Ising model of ferromagnetic to paramagnetic phase transition. 6+4=10
b. Explain superfluid phase transition with an appropriate figure.

4. **a.** Discuss isotope effect of superconductors. 2+8=10
b. Explain optical transitions in direct and indirect bandgap semiconductors with momentum and energy conservation principles.

5. **a.** Derive the expression for effective mass of electron in solid. 5+5=10
b. Write a short notes on the following:
1. Quantum Hall effective
2. de Haas-van Alphen effect

6. Explain Tight Binding method (TB)? Derive the dispersion relation using TB method (you may consider graphene case). 3+7=10

7. Derive the expression for energy versus wave vector relation by solving the Schrodinger equation using Kronig-Penney model. 10

8. **a.** What are first and second order phase transitions? Explain with examples. 3+7=10
b. Obtain expressions for Ehrenfest equations from thermodynamic considerations.

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