

Total No. of printed pages = 10

63/2 (SEM-3) PHY 304, 305

2021

(held in 2022)

PHYSICS

Paper Code : PHY-304 (New)

(Advanced Condensed Matter Physics-I)

Full Marks – 80

Time – Three hours

The figures in the margin indicate full marks
for the questions.

1. Answer the following questions : 1×5=5

(a) The $n^+ - n$ heterojunction is a

(i) Rectifying contact

(ii) Ohmic contact

(iii) Near Ohmic contact

(iv) None of the above

[Turn over

(b) The drift current density under reverse bias is due to the

- (i) Minority carriers
- (ii) Majority carriers
- (iii) Both majority and minority carriers
- (iv) None of the above

(c) Which of the following geometry is representing the armchair structure of a carbon nanotube ?

- (i) $\theta = 30^\circ (n, n)$
- (ii) $\theta = 0^\circ (n, 0)$
- (iii) $\theta = 15^\circ (n, m)$
- (iv) $\theta = 15^\circ (0, m)$

(d) Chemical vapor deposition is a method which is used to obtain the

- (i) Semiconductors
- (ii) Crystalline semiconductors
- (iii) Conducting compounds
- (iv) Dielectric compounds

(e) The gel is a _____ mass.

- (i) Heavy molecular
- (ii) Semi rigid
- (iii) Rigid
- (iv) Gaseous.

2. Answer the following questions : 2×5=10

- (a) Explain the physical mechanism of sputtering with the help of schematic diagram. 2
- (b) Explain how the film thickness can be controlled in DC sputtering technique. 2
- (c) Discuss the pre nucleation theories of thin film growth. 2
- (d) What is band edge and defect state luminescence ? 2
- (e) What is localized surface plasmon resonance phenomena ? 2

3. Answer any *five* of the following questions : 5×5=25

- (a) Establish the Einstein relation of mobility and diffusion coefficient. 5

(b) Obtain the junction capacitance of a p-n junction device and also discuss for the p⁺-n system. 4+1=5

(c) What are the different classes of semiconductor heterojunctions? With equilibrium band diagram explain the Type I p-n heterojunction. 1+4=5

(d) Obtain the Brus equation and discuss the term red shift and blue shift in optical absorption. 5

(e) Explain the term phonon. What is the momentum of phonon? Discuss the Normal and Umklapp process of phonon scattering using relevant momentum vector diagram. 1+1+3=5

(f) Discuss the principle of spray pyrolysis process of thin film deposition. How to reduce the grain size of thin film in this technique? 4+1=5

4. Answer any *four* of the following questions: 10×4=40

(a) Discuss the rectifying and ohmic metal-semiconductor contacts with proper energy band diagrams. Explain the effect of interface states in the metal-semiconductor contacts. 8+2=10

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(b) Obtain the continuity equation for electron and holes, and derive the diffusion current density for excess holes or electrons. 5+5=10

(c) What is quantum confinement? Show that the dimension of the confinement must be of the order of the de Broglie wavelength. Obtain the density of states of one dimensionally confined system. 2+3+5=10

(d) (i) Explain the working mechanism of electron beam evaporation with the help of schematic diagram. Discuss the advantages and disadvantages of this technique. 3+2=5

(ii) What are nucleation and crystal growth? Discuss the three modes of thin film growth. 2+3=5

(e) (i) What do you mean by size effect of resistivity? Discuss the phenomenon of integral and fractional quantum Hall Effect. 1+4=5

(ii) How do you describe the optical properties of a solid? Explain the transition mechanism of direct and indirect band gap of a semiconductor with the help of band diagram and give example for each type of transition. 1+4=5

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(Theory Paper)
Paper Code : PHY-305 (Old)

(Condensed Matter Physics-II)
Full Marks - 80

Time - Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : $1 \times 5 = 5$

(a) Which of the following statement is not true ?
1

(i) In AC Josephson effect current persists for a short time
(ii) In AC Josephson effect the voltage drop across the superconductor is zero
(iii) In DC Josephson effect the superconductors are separated by a very small thickness
(iv) In AC Josephson effect a very high frequency of electromagnetic radiation emanates from the gap

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(b) The drift current density under reverse bias is due to the
1

(i) Minority carriers
(ii) Majority carriers
(iii) Both majority and minority carriers
(iv) None of the above

(c) The coherence length of a superconductor becomes zero
1

(i) The distance where the magnetic field becomes zero
(ii) The distance required to fall to $1/e$ times of the externally applied magnetic field
(iii) The distance up to superconducting electron density doesn't change drastically
(iv) Independent of the Fermi velocity and energy gap

(d) A phonon is emitted or absorbed in

(i) Elastic scattering of a photon by a crystal
(ii) Inelastic scattering of a photon by a crystal
(iii) Both the elastic and inelastic scattering of a photon by a crystal
(iv) None of the above

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- (e) In an indirect bandgap semiconductor, a transition between conduction band and valance band results in

- (i) Heat (ii) Light
(iii) Both (iv) None of the above.

2. Answer the following questions : $2 \times 5 = 10$

- (a) Discuss the Beers law for an absorbing medium. 2
(b) Explain the interband transition for direct band gap and indirect band gap semiconductors. 2
(c) What is de Haas van Alphen effect and for what purpose it is used ? 2
(d) What is isotope effect in superconductivity? Explain with examples. 2
(e) What is BCS ground state ? 2

3. Answer any *five* of the following questions : $5 \times 5 = 25$

- (a) Show that the depletion width of a p-n junction is given by 5

$$W = \left[\frac{2 \epsilon kT}{q^2} \left(\ln \frac{N_a N_d}{n_i^2} \right) \left(\frac{1}{N_a} + \frac{1}{N_d} \right) \right]^{\frac{1}{2}}$$

- (b) Deduce the flux quantization in superconducting ring. 5

- (c) What is Frohlich's electron-phonon interaction? Explain the BCS theory of superconductivity. 5

- (d) Explain the term phonon. What is the momentum of phonon ? Discuss the Normal and Umklapp process of phonon scattering using relevant momentum vector diagram. $1+1+3=5$

- (e) Obtain the dispersion relation of a linear dielectric medium using Maxwell's equations in the absence of free charge and current densities. 5

- (f) What is cyclotron resonance ? Obtain the expression for resonant frequencies of an electron in magnetic field. $1+4=5$

4. Answer any *four* of the following questions : $10 \times 4 = 40$

- (a) Discuss the rectifying and ohmic metal-semiconductor contacts with proper energy band diagrams. Explain the effect of interface states in the metal-semiconductor contacts. $8+2=10$

- (b) Obtain the continuity equation for electron and holes, and derive the diffusion current density for excess holes or electrons. $5+5=10$
- (c) What is London penetration depth? Derive the expression for London equations in superconductors and discuss their significance. $2+8=10$
- (d) (i) Explain the classical theory of the response of a solid to an oscillating electromagnetic field and obtain an expression for the real part of the dielectric function in terms of the plasma frequency. 5
- (ii) State and explain the Franck-Condon principle. $1+4=5$
- (e) (i) Explain the term excitons. How exciton absorption affects the absorption spectrum of a semiconductor? $1+4=5$
- (ii) How do you describe the optical properties of a solid? Explain the transition mechanism of direct and indirect band gap of a semiconductor with the help of band diagram and give example for each type of transition. $1+4=5$