SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF PHYSICS

QUESTION BANK

SEMESTER - II

PH3223 - PHYSICS FOR ELECTRONICS ENGINEERING

(Common to ECE, EEE & EIE)

Regulation – 2023

Academic Year 2024 – 2025

Prepared by

Dr. S. GANDHIMATHI, Mrs. D. PRAVEENA, Mrs. S. SOWMIYA,

Dr. M. P. RAMYA RAJAN & Dr. R. RAJKUMAR

SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203.

DEPARTMENT OF PHYSICS

SUBJECT: PH3223 - PHYSICS FOR ELECTRONICS ENGINEERING

SEM/YEAR: II SEM / AY-2024-2025

UNIT I -CONDUCTING AND SUPERCONDUCTING MATERIALS

Classical free electron theory -Postulates - Expression for electrical conductivity and Thermal conductivity - Wiedemann-Franz law - Success and failures - Quantum free electron theory (qualitative) - Fermi Distribution function - Density of energy states - carrier concentration – Superconductors – Properties - Applications: Magnetic levitation, Cryotron and SQUID.

PART – A

S.No	Questions	Level	Competence
1.	Define drift velocity.	BTL1	Remembering
2.	What is meant by mobility of electrons?	BTL1	Remembering
3.	What is relaxation time?	BTL1	Remembering
4.	Define mean free path.	BTL1	Remembering
5.	Distinguish between relaxation time and collision time	BTL2	Understanding
6.	Calculate the drift velocity of the free electron with a mobility of 3.5×10^{-3} $m^2V^{-1}s^{-1}$ in copper for an electric field strength of 0.5 V/m.	BTL3	Applying
7.	A conducting rod contains 8.5×10^{28} electrons per m^3. Calculate the electrical conductivity at room temperature if the collision time for electron is 2×10^{-14} s.	BTL3	Applying
8.	List any two merits of classical free electron theory of metals.	BTL2	Understanding
9.	Define electrical conductivity.	BTL1	Remembering
10.	Define thermal conductivity.	BTL1	Remembering
11	Write any two postulates of quantum free electron theory.	BTL2	Understanding
12.	State Wiedemann-Franz law.	BTL1	Remembering
13.	What are the drawbacks of classical free electron theory?	BTL1	Remembering
14.	What is meant by Fermi energy level?	BTL1	Remembering
15.	Write a note on electron occupancy based on Fermi distribution function.	BTL2	Understanding
16.	Draw the Fermi distribution curve at any temperature $T > 0$ K.	BTL2	Understanding
17.	Evaluate the Fermi function for energy K_BT above the Fermi energy.	BTL3	Applying
18.	Define density of energy states.	BTL1	Remembering
19.	What do you mean carrier concentration?	BTL1	Remembering

20.	What is super conductor?	BTL1	Remembering
21.	Write any two properties of super conductor.	BTL1	Remembering
22.	What is transition temperature?	BTL2	Understanding
23.	Find the critical current which can pass through a long thin superconducting wire of aluminum of diameter 2 mm, the critical magnetic field for aluminum is 7.9×10^3 A m^{-1}.	BTL3	Applying
24.	Prove that susceptibility of superconductor is -1.	BTL3	Applying

	Questions	Marks	Level	Competence
1.	Write any three assumptions of classical free electron theory. Based on the assumptions derive an expression for electrical and thermal conductivity of metals.	16	BTL3	Applying
2.	Deduce an expression for electrical conductivity of a conducting material by using classical free electron theory and list out its merits and demerits.	16	BTL4	Analyzing
3.	**(i)** Derive an expression for electrical conductivity of a metal.	13	BTL3	Applying
	(ii) A copper wire having a cross-sectional area 1 mm^2 carries a current of 10 A. Find the drift velocity. Given n = 8.5 x 10^{28} electrons per m^3.	3	BTL3	Applying
4.	Derive an expression for thermal conductivity of a conducting material and write the success of classical free electron theory.	16	BTL3	Applying
5.	Write the postulates of classical free electron theory. Deduce an expression for thermal conductivity of a conducting material.	16	BTL4	Analyzing
6.	(i) Obtain the expression for thermal conductivity of a conducting material.	13	BTL3	Applying
	(ii) The thermal conductivity of copper at 300 K is 470.4 W/mK. Calculate the electrical conductivity of copper at 300 K. (Given L = 2.45 x $10^{-8.}$)	3	BTL3	Applying
7.	Obtain Wiedemann Franz law using the expressions of electrical and thermal conductivity.	16	BTL3	Applying
8.	Derive the mathematical expression for electrical conductivity and thermal conductivity of a conducting material and hence obtain Wiedemann-Franz law.	16	BTL3	Applying
9.	(i) Write an expression for Fermi Dirac distribution function F(E) and discuss the effect of temperature on Fermi function with neat diagrams.	12	BTL4	Analyzing
	(ii) Calculate Fermi distribution function F (E) for the energy level lying 0.01 eV above the Fermi level at 270 K.	4	BTL3	Applying
10.	Discuss Fermi Dirac distribution function and explain its variation for different temperature.	16	BTL3	Applying
11.	Derive an expression for the density of energy states for a metal.	16	BTL3	Applying
12.	Derive an expression for the number of energy states per unit volume of a cubic metal.	16	BTL3	Applying

13.	Derive an expression for the density of states and based on that calculate the carrier concentration in metals.	16	BTL3	Applying
14.	Discuss in detailed properties of super conductors.	16	BTL4	Analyzing
15.	Write short notes on different properties of superconductors.	16	BTL4	Analyzing
16.	Explain the working principles of (i) SQUID (ii) Cryotron (iii) Magnetic Levitation.	16	BTL3	Applying
17.	What is the effect of electric field, magnetic field and isotope on superconductors? Explain any two applications of superconductors in engineering.	16	BTL4	Analyzing

UNIT II-SEMICONDUCTOR AND TRANSPORT PHYSICS

Properties - Direct and indirect semiconductors - Intrinsic Semiconductors - Carrier concentration in intrinsic semiconductors - Extrinsic semiconductors - Carrier concentration in N - type & P- type semiconductors - Fermi energy - Variation of fermi level with temperature - Carrier transport - Drift and Diffusion transport - Hall Effect - Theory and Experiment - PN junction diode - Forward and reverse bias characteristics.

PART – A

S.No	Questions	Level	Competence
1.	List any two properties of a semiconductor.	BTL2	Understanding
2.	What are the charge carriers in a semiconductor?	BTL1	Remembering
3.	What happen to the conductivity of a semiconductor when temperature increases?	BTL1	Remembering
4.	Why there is negative temperature coefficient of resistance in semiconducting materials?	BTL2	Understanding
5.	What are elemental semiconductors?	BTL1	Remembering
6.	Differentiate direct and indirect band gap semiconductors.	BTL2	Understanding
7.	Why elemental semiconductors are called indirect band gap semiconductors?	BTL2	Understanding
8.	Why compound semiconductors are preferred for making LEDs?	BTL2	Understanding
9.	What are intrinsic semiconductors? Give an example.	BTL1	Remembering
10.	Draw an energy band diagram of an intrinsic semiconductor, at room temperature.	BTL2	Understanding
11.	The intrinsic carrier density at room temperature in Ge is $2.37\times10^{19}/m^3$. If the electron and hole mobilities are 0.38 and 0.18 $m^2V^{-1}s^{-1}$. Calculate the electrical conductivity.	BTL3	Applying
12.	Define doping.	BTL1	Remembering
13.	What are extrinsic semiconductors? Give an example.	BTL1	Remembering
14.	Write two differences between intrinsic and extrinsic semiconductors.	BTL1	Remembering
15.	How p-type semiconductors are obtained?	BTL2	Understanding

16.	What is Fermi energy?	BTL1	Remembering
17.	What will be the fermi level if temperature increases?	BTL1	Remembering
18.	Give your answer for carrier transport.	BTL1	Remembering
19.	Write ant two differences between drift and diffusion transport.	BTL1	Remembering
20.	State Hall effect.	BTL1	Remembering
21.	How P-type and N-type semiconductors are identified using Hall coefficient?	BTL2	Understanding
22.	Mention any two applications of Hall Effect.	BTL1	Remembering
23.	An n-type semiconductor has Hall coefficient, R_H = 4.16 x 10^{-14} m^3/C. The conductivity is 108 ohm^{-1} m^{-1}. Calculate the charge carrier density, n_e at room temperature.	BTL3	Applying
24.	What is forward bias and reverse bias in pn junction diode?	BTL1	Remembering

PART B				
1.	Derive an expression for density of electrons in conduction band of an intrinsic semiconductor.	16	BTL3	Applying
2.	Derive an expression for concentration of holes in valance band of an intrinsic semiconductor.	16	BTL3	Applying
3.	Assuming Fermi-Dirac statistics and Fermi function derive the expressions for electron and hole densities in an intrinsic semiconductor	16	BTL4	Analyzing
4.	Derive an expression for carrier concentration in intrinsic semiconductors.	16	BTL3	Applying
5.	Obtain the intrinsic carrier concentration using the expressions of density of electrons in conduction band and density of holes in valence band.	16	BTL4	Analyzing
6.	Obtain an expression for carrier concentration of electrons in conduction band of an N-type semiconductor.	16	BTL4	Analyzing
7.	Derive an expression for density of electrons in conduction band of an N-type semiconductor.	16	BTL3	Applying
8.	Show that for N-type semiconductor, density of electrons in the conduction band is proportional to the square root of the donor concentration.	16	BTL4	Analyzing
9.	Obtain an expression for carrier concentration of holes in a valance band of a P-type semiconductor.	16	BTL4	Analyzing
10.	Derive an expression for density of holes in a valance band of a P-type semiconductor.	16	BTL1	Remembering
11.	Show that for P-type semiconductor, density of holes in the valence band is proportional to the square root of the acceptor concentration.	16	BTL4	Analyzing
12.	What is carrier transport? Explain its types.	16	BTL1	Remembering
13.	Explain the following (i) Drift transport. (ii) Diffusion transport.	16	BTL3	Applying
14.	Obtain an expression for the Hall coefficient of N-type and P-type semiconductor. Discuss the experimental procedure for determining hall coefficient along with its applications.	16	BTL4	Analyzing

15.	Show that the Hall Coefficient is negative for an N-type semiconductor and positive for P-type semiconductor. How can hall coefficient be determined experimentally.	16	BTL4	Analyzing
16.	With necessary diagrams, explain the operation of forward biased and reverse biased PN junction Diode.	16	BTL4	Analyzing
17.	Explain the working of PN-junction diode in forward and reverse bias characteristics.	16	BTL3	Applying

UNIT III- MEMORY STORAGE MATERIALS AND DIELECTRIC MATERIALS

Magnetism in materials - Diamagnetic material, Paramagnetic material and Ferromagnetic material - Ferromagnetic domain theory - Hysteresis Curve - Hard and soft magnetic material - Bubble memory - Dielectric material : Electronic polarization, ionic polarization, orientational polarization and space - charge polarization - dielectric loss - dielectric breakdown - high – k dielectrics.

PART – A

S. No	Questions	Level	Competence
1.	Write a short note on diamagnetic material.	BTL1	Remembering
2.	Write a short note on paramagnetic material.	BTL1	Remembering
3.	Elucidate the spin arrangement of Para and Ferro magnetic materials.	BTL2	Understanding
4.	Why diamagnetism are called weak magnets?	BTL1	Remembering
5.	Define magnetic dipole moment.	BTL1	Remembering
6.	What is magnetic susceptibility?	BTL1	Remembering
7.	Give the relation between magnetic susceptibility and relative permeability.	BTL2	Understanding
8.	Magnetic field Intensity of a paramagnetic material is 10^4 A/m. At room temperature, its susceptibility is 3.7×10^{-3}. Calculate the magnetization in the material.	BTL3	Applying
9.	What are magnetic domains?	BTL1	Remembering
10.	Why ferromagnetic materials are called strong magnets?	BTL1	Remembering
11.	The magnetic susceptibility of a medium is 940×10^{-4}. Calculate its relative permeability.	BTL3	Applying
12.	What is hysteresis loss?	BTL2	Understanding
13.	State retentivity.	BTL2	Understanding
14.	What is coercivity?	BTL2	Understanding
15.	Mention the four types of energies involved in the growth of magnetic domains.	BTL2	Understanding
16.	Define electric susceptibility	BTL2	Understanding
17.	Define Ionic polarization.	BTL1	Remembering
18.	Define dielectric loss.	BTL1	Remembering
19.	Calculate the polarization produced in a dielectric medium of dielectric constant 6 and it is subjected to an electric field of 100 V/m. Given $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m.	BTL3	Applying
20.	Define dielectric strength.	BTL2	Understanding
21.	Distinguish Lorentz force and Coloumb force in dielectrics.	BTL1	Remembering

22.	Find out the average radius of the atom of an air molecule if the polarizability of atoms in the air molecules is 9×10^{-41} Fm^2.	BTL3	Applying
23.	Compare active and passive dielectrics.	BTL2	Understanding
24.	What is meant by high-k-dielectrics?	BTL1	Remembering

PART -B

S.No	Questions	Marks	Level	Competence
1.	(i) How magnetic materials are classified based on magnetic moments? (ii) Compare their properties and characteristic with examples.	4 12	BTL2 BTL4	Understanding Analyzing
2.	Briefly characterize the magnetic materials based on their spin and explain their properties.	16	BTL3	Applying
3.	With necessary diagrams, differentiate diamagnetic, paramagnetic and ferromagnetic materials based on their properties.	16	BTL3	Applying
4.	Discuss in detail about magnetic bubble memory.	16	BTL4	Analyzing
5.	Explain domain theory of Ferromagnetism. Using this theory explain the formation of hysteresis in ferromagnetic materials.	16	BTL2	Understanding
6.	Elaborate the hysteresis behavior of ferromagnetic materials and discuss it based on domain theory.	16	BTL4	Analyzing
7.	(i) Describe with diagrammatic representation of hysteresis loop formation in the ferromagnetic material. (ii) Compare soft and hard magnetic material with properties.	8 8	BTL3	Applying
8.	What is hard and soft magnetic materials? Explain it with characteristics and properties.	16	BTL2	Understanding
9.	Obtain an expression for electronic and ionic polarization in dielectrics.	16	BTL3	Applying
10.	Derive the expression for electronic and orientational polarization in the dielectric material.	16	BTL3	Applying
11.	Explain the different types of polarization mechanisms involved in a dielectric material. Derive an expression for total polarization.	16	BTL4	Analyzing
12.	(i) Write a short note on dielectric loss. (ii) With necessary theory derive an expression for dielectric power loss and summarize the factors affecting dielectric loss tangent.	2 14	BTL2 BTL4	Understanding Analyzing
13.	What is dielectric loss? Derive the expression for dielectric power loss.	16	BTL1	Remembering
14.	Explain in detail about different types of dielectric breakdown. Summarize the various factors contributing to breakdown in dielectrics.	16	BTL3	Applying
15.	Discuss in detail the different types of breakdown mechanism involving in solid dielectrics.	16	BTL4	Analyzing
16.	(i) What are the different types of dielectric break down in dielectric medium? (ii) Discuss in detail the various types of dielectric breakdown.	2 14	BTL1 BTL4	Remembering Analyzing
17.	Explain the theory of high-k-dielectrics and give a brief note on its Properties and applications.	16	BTL3	Applying

UNIT IV- OPTOELECTRONIC DEVICES

Classification of optical materials Optical processes in semiconductors: optical absorption and emission - carrier injection and recombination - photo diode - solar cell - photo detectors - Light Emitting Diode - Organic LED - Optical switching –Plasmonics

PART – A

S. No	Questions	Level	Competence
1.	What are optical materials?	BTL1	Remembering
2.	What are the types of optical material?	BTL1	Remembering
3.	Define carrier generation and recombination.	BTL2	Understanding
4.	What are transparent materials?	BTL1	Remembering
5.	What are translucent materials?	BTL1	Remembering
6.	Give your answer for optical absorption.	BTL1	Remembering
7.	Give your answer for optical emission.	BTL1	Remembering
8.	Mention the condition to identify the band gap of a semiconducting material to be transparent to visible light.	BTL3	Applying
9.	State “carrier injection”.	BTL1	Remembering
10.	What is recombination?	BTL2	Understanding
11.	What is dark current?	BTL1	Remembering
12.	What is the principle used in Photodiode?	BTL2	Understanding
13.	Give any two applications of photodiode.	BTL2	Understanding
14.	Write the working principle of solar cell.	BTL2	Understanding
15.	Mention any two merits and demerits of solar cell.	BTL3	Applying
16.	Write the principle of photo detectors.	BTL1	Remembering
17.	What is meant by LED? Give its principle.	BTL1	Remembering
18.	What are the main requirements for a suitable LED material?	BTL2	Understanding
19.	List any two advantages of LED in electronic display.	BTL3	Applying
20.	The wavelength of light emission in an LED is 1.55μm. Calculate the band gap in eV?	BTL3	Applying
21.	List the main two layers in an OLED.	BTL1	Remembering
22.	Calculate the wavelength of radiation emitted by an LED made up of a semiconducting material with band gap energy 2.8 eV.	BTL3	Applying
23.	What is the working principle of OLED?	BTL1	Remembering
24.	In what way OLED is advantageous than LED/LCD?	BTL2	Understanding

PART -B				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1.	What is the classification of optical material? Explain it with example in detail.	16	BTL2	Understanding
2.	Describe the absorption and emission process of light in semiconductors with necessary diagrams. .	16	BTL4	Analyzing
3.	Summarize the three types of carrier generations and recombination process in semiconductors.	16	BTL3	Applying
4.	(i) Explain carrier generations process in semiconductors. (ii) Write short notes on transparent and translucent materials.	8 8	BTL4	Analyzing
5.	Explain the principle, construction and working of a photo diode with necessary diagrams.	16	BTL4	Analyzing
6.	Discuss the response of photodiode to light along with the merits, demerits and applications.	16	BTL4	Analyzing
7.	(i) Describe the principle, construction and working of a solar cell with a neat diagram. (ii) Mention the advantages and disadvantages of a solar cell.	13 3	BTL3 BTL 2	Applying Understanding
8.	Elaborate the working of a photo-voltaic device which converts Sunlight directly into electricity.	16	BTL4	Analyzing
9.	Explain the principle, construction and the working of solar cell made of a semiconductor.	16	BTL3	Applying
10.	(i) What is meant by photodetector? (ii) With a neat diagram describe the construction and working of a photodetector.	3 13	BTL1 BTL3	Remembering Applying
11.	Explain the principle, construction and working of a photo detector with necessary diagrams.	16	BTL4	Analyzing
12.	(i) What is meant by minority charge carrier injection? (ii) Explain how a P-N junction diode acts as a LED along with its applications.	3 13	BTL1 BTL3	Remembering Applying
13.	Explain how a P-N junction diode acts as a Light Emitting Diode.	16	BTL4	Analyzing
14.	Explain the principle and working of LED with a neat diagram And mention its advantages and disadvantages.	16	BTL4	Analyzing
15.	Describe the construction and working of OLED and explain in what way itis more efficient than LED.	16	BTL4	Analyzing
16.	Explain the construction and working of optoelectronic device made up of many layers with organic molecules of different conductivity levels?	16	BTL4	Analyzing
17.	Write short notes on the following (i) Optical switching (ii) Plasmonics	7 8	BTL3	Applying

UNIIT V - MOLECULAR ELECTRONICS
Introduction to Nanotechnology - Size dependence of Fermi energy - quantum confinement – Excitons – HOMO - LUMO - Organic semiconductor (qualitative) - quantum structures - Quantum wire, Quantum Well, Quantum Dot laser - quantum interference effects – Tunneling : Resonant Tunnelling Diode (RTD) - Resonant Tunnelling Transistor (RTT) - Coulomb blockade effects - Single electron phenomena and Single electron Transistor - Nano Robotics.

PART – A			
S.No	**Questions**	**Level**	**Competence**
1.	What are nanomaterials?	BTL2	Understanding
2.	What do you understand the term "Nanotechnology"?	BTL1	Remembering
3.	Fermi energy of a material varies with its size. Justify.	BTL2	Understanding
4.	What happens to the band gap when a solid material is reduced into a nanomaterial?	BTL2	Understanding
5.	What will happen when we decrease the size of the particle to nano size?	BTL1	Remembering
6.	What is meant by quantum confinement?	BTL1	Remembering
7.	What is excitons?	BTL2	Understanding
8.	State the word "HOMO".	BTL2	Understanding
9.	State the word "LUMO".	BTL2	Understanding
10.	Give your answer for "Organic Semiconductor".	BTL1	Remembering
11.	Define the term quantum dot.	BTL2	Understanding
12.	Define the term quantum wire	BTL2	Understanding
13.	Define the term quantum well.	BTL2	Understanding
14.	Write the principle of Quantum Dot Laser.	BTL1	Remembering
15.	Write the principle of Quantum Interference Effect.	BTL1	Remembering
16.	What is meant by quantum tunneling?	BTL1	Remembering
17.	Write the principle of Resonant Tunneling Diode.	BTL2	Understanding
18.	Define coulomb blockade.	BTL2	Understanding
19.	How coulomb blockade prevent unwanted tunneling?	BTL1	Remembering
20.	State "Single Electron Phenomena".	BTL1	Remembering
21.	What is meant by single electron transistor (SET)?	BTL4	Analyzing
22.	What are the limitations of single electron transistor?	BTL2	Understanding
23.	Mention the two conditions for the single electron phenomena to occur.	BTL2	Understanding
24.	Write the principle of Nano Robotics.	BTL2	Understanding

PART-B				
S.No	**Questions**	**Marks**	**Level**	**Competence**
1.	Explain the electron density in bulk materials and its size dependence with Fermi energy.	16	BTL3	Applying
2.	Describe quantum confinement and quantum structures in nano materials.	16	BTL4	Applying

3.	(i) What is quantum confinement? (ii) Discuss quantum confinement in the quantum well, quantum wire and quantum dot.	3 13	BTL1 BTL4	Remembering Analyzing
4.	Derive the expression for density of states for different quantum confinements.	16	BTL3	Applying
5.	Derive an expression for density of states in zero-dimension, one dimension and two-dimension quantum confinement structures.	16	BTL3	Applying
6.	Write in detail (i) Excitons and its types (ii) HOMO (iii) LUMO	6 5 5	BTL3	Applying
7.	Explain in detail about quantum dot lasers with a neat diagram. What are the advantages and applications?	16	BTL4	Analyzing
8.	Discuss in detail the working of quantum dot laser and write its advantages.	16	BTL4	Analyzing
9.	Explain the working of Resonant Tunneling Diode (RTD).	16	BTL3	Applying
10	Discuss in detail the working of Resonant Tunneling Diode and give its advantages.	16	BTL4	Analyzing
11.	Explain the working of Resonant Tunneling Transistor (RTT).	16	BTL3	Applying
12.	(i) Explain coulomb blockade effect. (ii) Explain the phenomena of single electron which is used in single electron transistor.	4 12	BTL3	Applying
13	Explain single electron phenomena and the working of single electron transistor.	16	BTL3	Applying
14.	Describe single electron phenomena and single electron transistor.	16	BTL4	Analyzing
15.	Describe the construction and working of a single electron transistor	16	BTL4	Analyzing
16.	Explain the tunneling phenomenon. Mention the conditions necessary for the single electron phenomenon to occur.	16	BTL3	Applying
17.	Discuss in detail about Nano Robotics and its applications.	16	BTL4	Analyzing