SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF PHYSICS

QUESTION BANK

II SEMESTER

PH3222 - PHYSICS FOR INFORMATION SCIENCE

(Common to AI&DS, CSE, Cyber Security and IT)

Regulation – 2023

Academic Year 2024 – 25

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DEPARTMENT OF PHYSICS

SUBJECT: PH3222 - PHYSICS FOR INFORMATION SCIENCE
SEM/YEAR: II SEM / AY-2024-2025

UNIT I - CONDUCTING MATERIALS

Classical free electron theory –postulates- Expression for electrical and thermal conductivity - Wiedemann-Franz law – Success and failures – Quantum free electron theory(qualitative)- Fermi- Dirac distribution function – Density of energy states – Electron in periodic potential – Energy bands in solids-Low and high resistivity alloys.

PART – A

S.No	Questions	Level	Competence
1.	Write any two postulates of classical free electron theory.	BTL1	Remembering
2.	Define drift velocity.	BTL1	Remembering
3	What is meant by mobility of electrons?	BTL1	Remembering
4.	What is relaxation time?	BTL1	Remembering
5.	Calculate the drift velocity of the free electron with the mobility of 3.5×10^{-3} $m^2V^{-1}s^{-1}$ in copper for an electric field strength of 0.5 V/m.	BTL2	Understanding
6.	List any two merits of classical free electron theory of metals.	BTL1	Remembering
7.	Write any two drawbacks of the classical free electron theory of metals.	BTL2	Understanding
8..	Define electrical conductivity.	BTL1	Remembering
9.	Define thermal conductivity.	BTL1	Remembering
10.	Write the importance of the quantum free electron theory.	BTL2	Understanding
11.	What are the drawbacks of quantum free electron theory.	BTL1	Remembering
12.	State Wiedemann-Franz law.	BTL1	Remembering
13.	Define Lorentz number.	BTL1	Remembering
14.	The thermal conductivity of copper at 300 K is 470 W/m/K. Calculate the electrical conductivity. Given Lorentz number, L= 2.45×10^{-8} $W\Omega K^{-2}$.	BTL2	Understanding
15.	The thermal and electrical conductivities at 20°C are 390 W/m/K and 5.87×10^{7} Ω^{-1} m^{-1} respectively. Calculate the Lorentz number	BTL2	Understanding
16.	What is meant by Fermi energy level?	BTL1	Remembering
17.	Define Fermi distribution function.	BTL1	Remembering
18.	Define density of energy states.	BTL1	Remembering
19.	Define carrier concentration in metal.	BTL2	Understanding
20.	Interpret, how electrons move in a periodic potential.	BTL2	Understanding
21.	How solids are classified based on band theory?	BTL1	Remembering
22.	What are valence band and conduction band?	BTL1	Remembering

23.	Define forbidden energy gap.	BTL1	Remembering
24.	Name any two low and high resistive alloys with their resistivity.	BTL2	Understanding

PART –B

S.No	Questions	Level	Competence
1.	Derive an expression for the electrical conductivity of a conducting material using classical free electron theory and list its merits and demerits. (16)	BTL3	Applying
2.	Using classical free electron theory, obtain expressions for the electrical conductivity and thermal conductivity of a conducting material. (16)	BTL3	Applying
3.	(i) Derive an expression for the electrical conductivity of a metal. (12) (ii) Calculate the drift velocity of a copper wire having a cross-sectional area of 1 mm^2 which carries a current of 10 A. Given n = 8.5 x 10^{28} electrons per m^3. (4)	BTL3 BTL3	Applying Applying
4.	Derive an expression for the thermal conductivity of a conducting material. (16)	BTL3	Applying
5.	(i) Write the postulates of the classical free electron theory. (4) (ii) Derive an expression for the thermal conductivity of a metal. (12)	BTL4 BTL3	Analyzing Applying
6.	Obtain Wiedemann Franz law using the expressions of electrical and thermal conductivity. (16)	BTL4	Applying
7.	(i) Write the assumptions of classical free electron theory with its merits and demerits. Obtain the Wiedmann Franz law using the electrical and thermal conductivity expressions. (12) (ii) Calculate the electrical conductivity and Lorentz number for a metal which is having thermal conductivity 123.92 W/m/K and relaxation time 10^{-14} seconds at 300 K. (Density of electrons = 6 x10^{28} m^{-3}). (4)	BTL4 BTL 3	Analyzing Applying
8.	(i) Write an expression for Fermi Dirac distribution function F(E) and discuss the effect of temperature on the Fermi function with neat diagrams. (12) (ii) Calculate Fermi distribution function F(E) for an energy level lying 0.01 eV above the Fermi level at 270 K. (4)	BTL4 BTL 3	Analyzing Applying
9.	Discuss Fermi Dirac distribution function and also explain its variation with temperature using diagrams. (16)	BTL4	Analyzing
10	Define Fermi energy. Explain the Fermi Dirac distribution function for electrons in a metal and discuss the effect of temperature on Fermi function. (16)	BTL4	Analyzing
11.	Derive an expression for the density of energy states for a metal. (16)	BTL3	Applying
12.	Obtain an expression for the number of energy states per unit volume of metal. (16)	BTL3	Applying
13.	Derive the expression, $Z(E)dE = (4\pi/h^3)(2m)^{3/2}E^{1/2}dE$ from the number of energy states between E and E +dE. (16)	BTL3	Applying
14.	With clear mathematical expressions, deduce the density of energy states. (16)	BTL4	Analyzing
15.	Energy levels and bands are a convenient way of representing a solid material. With a neat sketch, explain the band theory. (16)	BTL4	Analyzing
16.	Explain energy bands in conductors, semiconductors and insulators, with examples. (16)	BTL4	Analyzing
17.	Discuss the classification of materials based on the band theory of solids. (16)	BTL4	Analyzing

UNIT II SEMICONDUCTOR PHYSICS

Properties - Intrinsic Semiconductors –Direct and Indirect band gap semiconductors- Carrier concentration in intrinsic semiconductors – Extrinsic semiconductors - Carrier concentration in N-type & P-type semiconductors – Variation of carrier concentration with temperature and impurity concentration-Variation of carrier concentration with temperature for extrinsic semiconductors-Hall effect- Theory and experiment and applications.

PART – A

S.No	Questions	Level	Competence
1.	List any two properties of a semiconductor.	BTL1	Remembering
2.	Why semiconductors are having negative temperature coefficient of resistance?	BTL2	Understanding
3.	What are the charge carriers in a semiconductor?	BTL1	Remembering
4.	What happens to the conductivity of a semiconductor when temperature increases?	BTL2	Understanding
5.	What are elemental semiconductors?	BTL1	Remembering
6.	What are compound semiconductors?	BTL1	Remembering
7.	Differentiate direct and indirect band gap semiconductors.	BTL1	Remembering
8.	Why elemental semiconductors are called an indirect band gap semi conductors?	BTL2	Understanding
9.	Why compound semiconductors are preferred for making LEDs?	BTL2	Understanding
10.	What are intrinsic semiconductors? Give an example.	BTL1	Remembering
11.	Draw an energy band diagram of an intrinsic semiconductor, at 0K.	BTL2	Understanding
12.	The intrinsic carrier density at room temperature in Ge is 2.37 x $10^{19}/m^3$. If the electron and hole mobility are 0.38 and 0.18 $m^2V^{-1}s^{-1}$. Calculate the electrical conductivity.	BTL2	Understanding
13.	Find the concentration of holes and electrons in n-type silicon at 300 K, if the conductivity is 3 x 10^4 ohm^{-1} m^{-1}. Given , n_i =1.5 x 10^{16} m^{-3}, μ_e =1300 x 10^{-4} $m^2V^{-1}s^{-1}$	BTL2	Understanding
14.	Define doping.	BTL1	Remembering
15.	What are extrinsic semiconductors? Give an example.	BTL1	Remembering
16.	Write expressions for the Fermi energy of an n-type and p-type semiconductor.	BTL1	Remembering
17.	How p-type semiconductors are obtained?	BTL2	Understanding
18.	Sketch the variation of carrier concentration with temperature in an extrinsic semiconductor.	BTL2	Understanding
19.	What is meant by exhaustion range in an n-type semiconductor?	BTL1	Remembering
20.	State Hall effect.	BTL1	Remembering
21.	How p-type and n-type semiconductors are identified using the Hall coefficient?	BTL1	Remembering
22.	Mention any two applications of the Hall Effect.	BTL1	Remembering
23.	An n-type semiconductor has a 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.	BTL2	Understanding
24.	A silicon plate of thickness 1mm, breadth 10mm, and length 100mm is placed magnetic field of 0.5 Wb/m^2 acting perpendicular to its thickness. If 10^{-2}A current flows along its length, calculate the Hall voltage developed if the Hall coefficient is 3.66 × 10^{-4} m^3 / coulomb.	BTL2	Understanding

PART B

S.No	Questions	Level	Competence
1.	Obtain an expression for density of electrons in a conduction band of anintrinsic semiconductor. (16)	BTL3	Applying
2.	Derive an expression for concentration of holes in valance band of anintrinsic semiconductor. (16)	BTL3	Applying
3.	Using density of energy states in the energy range E and E + dE, Show that, the density of hole in the valence band of an intrinsic semiconductor, $p = 2\left(\frac{2\pi m_h^* kT}{h^2}\right)^{3/2} e^{(E_v - E_F)/kT}$. (16)	BTL3	Applying
4	Show that, the electron concentration in the conduction band of an intrinsic semiconductor, $n = 2\left(\frac{2\pi m_e^* kT}{h^2}\right)^{3/2} e^{(E_F - E_C)/kT}$. (16)	BTL4	Analyzing
5.	Derive an expression for density of electrons in the conduction band and density of holes in the valence band of an intrinsic semiconductor. (16)	BTL3	Applying
6.	Obtain an expression for intrinsic carrier concentration. (16)	BTL3	Applying
7.	Obtain an expression for carrier concentration of electrons in conductionband of an n-type semiconductor. (16)	BTL3	Applying
8.	Derive an expression for density of electrons in conduction band of an n-type semiconductor. (16)	BTL3	Applying
9.	Show that for an n-type semiconductor, density of electron in the conduction band is proportional to the square root of the donor concentration at low temperatures. (16)	BTL4	Analyzing
10.	Obtain an expression for carrier concentration of holes in a valance band of a p-type semiconductor. (16)	BTL3	Applying
11.	Derive an expression for density of holes in a valance band of a p-type semiconductor. (16)	BTL3	Applying
12.	Show that for a p-type semiconductor, density of holes in the valence band is proportional to the square root of the acceptor concentration at low temperatures. (16)	BTL4	Analyzing
13.	Explain the variation of carrier concentration with temperature in an n -type semiconductor. (16)	BTL4	Analyzing
14.	With neat diagrams, explain the variation of Fermi level with temperature and impurity concentration in an n-type and p-type semiconductors. (16)	BTL4	Analyzing
15.	Obtain an expression for the Hall coefficient of n-type and p-type semiconductor. (16)	BTL3	Applying
16.	Show that the Hall Coefficient is negative for an n-type semiconductor and positive for p-type semiconductor. (16)	BTL4	Analyzing
17.	(i) State Hall effect. Derive an expression for the Hall coefficient of a sample in terms of Hall voltage. (12) (ii)Describe an experimental setup to measure the Hall voltage. (4)	BTL3 BTL4	Applying Analyzing

UNIT III MAGNETIC MATERIALS AND SUPERCONDUCTORS

Basic definitions of magnetism-Classification (based on spin): Diamagnetism, Paramagnetism, Ferrromagneitsm, antiferromagnetism and ferrimagnetism-Ferromagnetic Domain theory- Energy involved in domains- Hysteresis curve-Temporary and Permanent magnetic materials, examples and uses-Magnetic Principles in Computer data storage – Magnetic hard disc (GMR sensor).
Superconductors-Properties-Applications (Magnetic levitation, Cryotron and SQUID)

PART – A

S.No	Questions	Level	Competence
1.	Define magnetic dipole.	BTL1	Remembering
2.	Define the intensity of magnetization.	BTL1	Remembering
3.	What is meant by magnetic flux density?	BTL2	Understanding
4.	Define magnetic permeability.	BTL1	Remembering
5.	Define magnetic susceptibility.	BTL1	Remembering
6.	Iron has a relative permeability of 5000. Calculate its magnetic susceptibility.	BTL1	Remembering
7.	The magnetic field intensity and susceptibility of a piece of ferric oxide is 10^6 A/m and 1.5 x 10^{-3} respectively. Find the magnetization of the material.	BTL2	Understanding
8.	Classify the magnetic materials based on their spin arrangements.	BTL2	Understanding
9.	What happens to the magnetic flux, when a diamagnetic material is kept in a magnetic field?	BTL2	Understanding
10.	Write the properties of antiferromagnetic materials.	BTL2	Understanding
11.	List any two applications of ferrites.	BTL2	Understanding
12.	What are magnetic domains?	BTL1	Remembering
13.	Mention the four types of energies involved in the growth of magneticdomains.	BTL2	Understanding
14.	What is meant by hysteresis loop?	BTL2	Understanding
15.	What is meant by the term ‘retentivity’?	BTL1	Remembering
16.	What is meant by the term ‘coercivity’?	BTL2	Understanding
17.	Differentiate temporary and permanent magnetic materials.	BTL1	Remembering
18.	Why temporary magnetic materials are used in electromagnets?	BTL2	Understanding
19.	Mention the magnetic principles used in magnetic data storage.	BTL2	Understanding
20.	Define Giant Magneto-resistance.	BTL1	Remembering
21.	List any two advantages of magnetic disks.	BTL1	Remembering
22.	Write any two applications of magnetic hard disk drives.	BTL1	Remembering
23.	When do we call the material as superconducting material?	BTL2	Understanding
24.	List any two properties of superconducting materials.	BTL2	Understanding

PART –B

S.No	Questions	Level	Competence
1.	Explain the classification of magnetic materials based on their spins. (16)	BTL4	Analyzing
2.	Compare dia, para and ferromagnetic materials on the basis of spin. (16)	BTL4	Analyzing
3.	Write short notes on ferromagnetic, Antiferromagnetic and ferrimagnetic materials. (16)	BTL4	Analyzing
4.	Explain with neat diagrams, how the magnetization occurs in a ferromagnetic magnetic material, after the application of a magnetic field. (16)	BTL4	Analyzing

5.	Explain ferromagnetic domain theory. Describe the energy involved in domain theory. (16)	BTL4	Analyzing
6.	Explain different types of energy involved in domain growth. (16)	BTL4	Analyzing
7.	With a neat diagrammatic representation, describe ferromagnetic domain theory. Also write briefly about the energies involved in the growth of domain. (16)	BTL4	Analyzing
8.	Explain the different types of energies that are responsible for the growth of domains in a ferromagnetic material. (16)	BTL4	Analyzing
9.	(i) Draw the M-H curve (Hysteresis) for a ferromagnetic material. (4) (ii) Explain the hysteresis curve based on domain theory. (12)	BTL4 BTL4	Analyzing Analyzing
10.	(i) Define the term coercivity and retentivity. (4) (ii) Explain the lagging of magnetization behind the magnetizing field with the help of an M-H curve. (12)	BTL4	Analyzing
11.	(i)What are temporary and permanenet magnetic materials? (4) (ii)Write the differences between soft and hard magnetic materials. (12)	BTL4 BTL4	Analyzing Analyzing
12.	(i)Write a short note on hysteresis curve. (6) (ii)Differentiate soft and hard magnetic materials. (10)	BTL3 BTL3	Applying Applying
13.	Explain the magnetic data storage in computer hard disc. (16)	BTL4	Analyzing
14.	Explain the process of storing the information and the process ofretrieving the information with the help of a GMR sensor. (16)	BTL4	Analyzing
15.	Explain the writing and reading of data in magnetic hard disk using GMR sensors. (16)	BTL4	Analyzing
16.	Write short notes on different properties of superconductors. (16)	BTL4	Analyzing
17.	Give short notes on a) Cryotron. b) SQUID. c) Magnetic levitation. (16)	BTL4	Analyzing

UNIT IV OPTOELECTRONIC DEVICES

Classification of optical materials – Optical processes in semiconductors -Optical Absorption and Emission- Carrier injection and recombination – Photo diode- solar cell- Light Emitting Diode – Organic Light Emitting Diode – Quantum dot laser-Optical data storage devices-Plasmonics.

PART – A

S. No	Questions	Level	Competence
1.	What are optical materials?	BTL1	Remembering
2.	Classify the optical materials based on their interaction with visible light.	BTL2	Understanding
3.	What are translucent materials?	BTL2	Understanding
4.	What are transparent materials?	BTL1	Remembering
5.	Define carrier generation and recombination.	BTL2	Understanding
6.	What is meant by dark current?	BTL2	Understanding
7.	What is the principle behind the P-N junction diode?	BTL2	Understanding
8.	Write any two advantages of photodiode.	BTL1	Remembering
9.	Give any two applications of photodiode.	BTL1	Remembering
10.	What is the principle behind solar cell?	BTL2	Understanding
11.	Mention any two merits of solar cells.	BTL1	Remembering
12.	Give any two disadvantages of solar cells.	BTL1	Remembering
13.	List any two applications of solar cells.	BTL1	Remembering
14.	Write a note on Light Emitting Diode?	BTL2	Understanding

15.	What is minority charge carrier injection?	BTL2	Understanding
16.	List any two advantages of LED in electronic display.	BTL1	Remembering
17.	Justify, why LEDs are preferred to have a hemispherical shape.	BTL2	Understanding
18.	Calculate the wavelength of radiation emitted by an LED with a band gapenergy of 2.8 eV.	BTL2	Understanding
19.	The wavelength of light emission in an LED is 1.55μm. Calculate the band gap in eV.	BTL2	Understanding
20.	Write the principle of OLED.	BTL2	Understanding
21.	Mention any two advantages of OLED.	BTL1	Remembering
22.	Write the principle of quantum dot laser.	BTL2	Understanding
23.	Name any two optical data storage techniques.	BTL1	Remembering
24.	Define the term " Plasmonics"	BTL2	Understanding

PART-B

S. No	Questions	Level	Competence
1.	Describe about the absorption and emission of light in semiconductors with neat diagrammatic representation. (16)	BTL4	Analyzing
2.	Explain the principle, construction and working of a photodiode with necessary diagrams. (16)	BTL4	Analyzing
3.	With neat diagrams, explain the process that takes place when a reverse-biased P-N junction diode is exposed to light. Also, write down its merits and demerits. (16)	BTL4	Analyzing
4.	Describe the principle, construction and working of a solar cell with a neat diagram. Also, mention any four applications. (16)	BTL4	Analyzing
5.	Explain the principle and workings of a large-area photovoltaic device which converts sunlight directly into electricity. (16)	BTL4	Analyzing
6.	Explain the working of the photovoltaic device which uses a renewable energy source. (16)	BTL4	Analyzing
7.	What is meant by minority charge carrier injection? Explain how a P-N junction diode acts as a LED. (16)	BTL4	Analyzing
8.	Explain the principle and working of LED with a neat diagram and mention its advantages and disadvantages. (16)	BTL4	Analyzing
9.	Describe the construction and working of a light-emitting diode along with its merits and demerits. (16)	BTL4	Analyzing
10.	Explain the principle, construction and working of OLED with its applications. (16)	BTL4	Analyzing
11.	Explain the construction and working of an optoelectronic device made up of many layers with organic molecules of different conductivity levels. (16)	BTL4	Analyzing
12.	Describe the principle, construction and working of an Organic Light Emitting Diode. (16)	BTL4	Analyzing
13.	What are the layers used in an OLED? Explain the working of an OLED. (16)	BTL4	Analyzing
14.	Compare the working concept of LED and OLED with neat sketch. (16)	BTL4	Analyzing
15.	Discuss briefly the principle and working of quantum dot laser with necessary diagram. (16)	BTL4	Analyzing
16.	Explain how the quantum dot is used to achieve the laser action? (16)	BTL4	Analyzing
17.	Explain the process of storing and retrieving the data by optical storage techniques, with neat diagrams. (16)	BTL4	Analyzing

UNIT V NANODEVICES AND QUANTUM COMPUTING

Introduction – Quantum confinement – Quantum structures (Qualitative) – Band gap of nanomaterials – Single electron transistor (SET): Tunneling – Coulomb Blockade effect – Carbon nanotubes:Properties and applications.
Quantum cellular Automata (QCA)-Quantum system for information processing- Characteristics and working of Quantum computers- Advantages and disadvantages of quantum computing over classical computing.

PART – A

S.No	Questions	Level	Competence
1.	What are nanomaterials?	BTL2	Understanding
2.	The Fermi energy of a material varies with its size. Justify.	BTL2	Understanding
3.	What happens to the band gap when a solid material is reduced into a nanomaterial?	BTL2	Understanding
4.	What is meant by quantum confinement?	BTL1	Remembering
5.	What is meant by quantum confined structure?	BTL1	Remembering
6.	Define the term quantum dot.	BTL1	Remembering
7.	Define the term quantum wire.	BTL1	Remembering
8.	Define the term quantum well.	BTL1	Remembering
9.	List any two applications of the quantum dot.	BTL1	Remembering
10.	Mention any two applications of the quantum wire.	BTL1	Remembering
11.	Write any two applications of the quantum well.	BTL1	Remembering
12.	What is meant by quantum tunneling?	BTL1	Remembering
13.	Define coulomb blockade.	BTL1	Remembering
14.	How coulomb blockade prevents unwanted tunneling?	BTL2	Understanding
15.	What is meant by a single electron transistor (SET)?	BTL2	Understanding
16.	What are the limitations of single electron transistor?	BTL2	Understanding
17.	Mention the two conditions for the single electron phenomena to occur.	BTL1	Remembering
18.	What are carbon nano tubes (CNTs)?	BTL2	Understanding
19.	Based on the rolling of the graphene sheet, how carbon nano tubes areclassified?	BTL2	Understanding
20.	List any two properties of carbon nano tubes.	BTL2	Understanding
21.	Mention any two applications of CNT.	BTL2	Understanding
22.	What is quantum cellular automata?	BTL2	Understanding
23.	Write few advantages of quantum computing over classical computing.	BTL2	Understanding
24.	List the applications of quantum computing.	BTL2	Understanding

PART-B

S.No	Questions	Level	Competence
1.	Describe quantum confinement and quantum structures in nanomaterials. (16)	BTL4	Analyzing
2.	Explain the different quantum structures based on their confinement. Also brief the correlation between confinement and bandgap of the materials. (16)	BTL4	Analyzing
3.	Describe single electron phenomena and single electron transistors with necessary diagrams. (16)	BTL4	Analyzing
4.	Describe the construction and working of a single electron transistor. (16)	BTL4	Analyzing
5.	Using single electron phenomenon, explain the construction and working of single electron transistors with neat diagrammatic representations. (16)	BTL4	Analyzing
6.	Explain the tunnelling phenomenon. Mention the conditions necessary for the single electron phenomenon to occur. (16)	BTL4	Analyzing
7.	Explain carbon nanotubes with their properties and applications. (16)	BTL4	Analyzing
8.	Describe the CNT structures with their properties and applications. (16)	BTL4	Analyzing
	What is a carbon nano tube? Explain the properties and applications of carbon nano	BTL4	Analyzing

9.	tubes. (16)		
10.	Sketch and explain the structures of Carbon nanotubes. Mention the physical properties and applications of CNT. (16)	BTL3	Applying
11.	Describe Quantum Cellular Automata with its advantages and applications. (16)	BTL4	Analyzing
12.	Explain the concept of QCA to build future computers. Also write their advantages and applications. (16)	BTL4	Analyzing
13.	Brief the Quantum system for information processing (QIP). Write few applications based on QIP. (16)	BTL3	Applying
14.	What is QIP? Explain QIP with its procedure, steps and applications. (16)	BTL4	Analyzing
15.	How the quantum computers will work? Explain the theory based on Qubits.(16)	BTL4	Analyzing
16.	Describe the working of quantum computers based on Qubits. Write their applications. (16)	BTL4	Analyzing
17.	Summarize the concept of Qubits and write a note on working of quantum computers based on Qubits. (16)	BTL4	Analyzing