A. MODEL PAPER – I

a. Name the experiment which supports concept of dual nature of light?
b. Draw E-K diagram?
c. Explain the working principle of a Solar cell?
d. What is zener break down voltage?
e. Define Electric dipole,Electric Susceptibility and polarizability?
f. What is magneto resistance and magneto striction?
g. What is Nano scale?
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i. Give the basic principle of optical fiber?
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B. MODEL PAPER – II

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b. Write Fermi –Dirac distribution function?
c. Write any two characteristics of PIN diode
d. W hat is intrinsic semiconductor give one example?
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f. Give any two applications of multiferroics?
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j. what is the material numerical aperture of an optical fiber cable with a clad index of 1.378 and core index of 1.546?

C. MODEL PAPER – III

a. What are the properties of matter waves?
b. What are the examples of conductors,semi conductors and insulators?
c. Give the difference between PIN diode and APD (Avalanche photo Diode)?
d. What is the principle of Solar cell?
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f. Give the difference between Solid and Liquid electrolytes?
g. What is of Nano Technology?
h. What are the examples of 1-D,2-D and 3-D nano materials?
i. Define Numerical aperture,Acceptance angle and Acceptance cone?
j. Define Lasing Action,pumping?

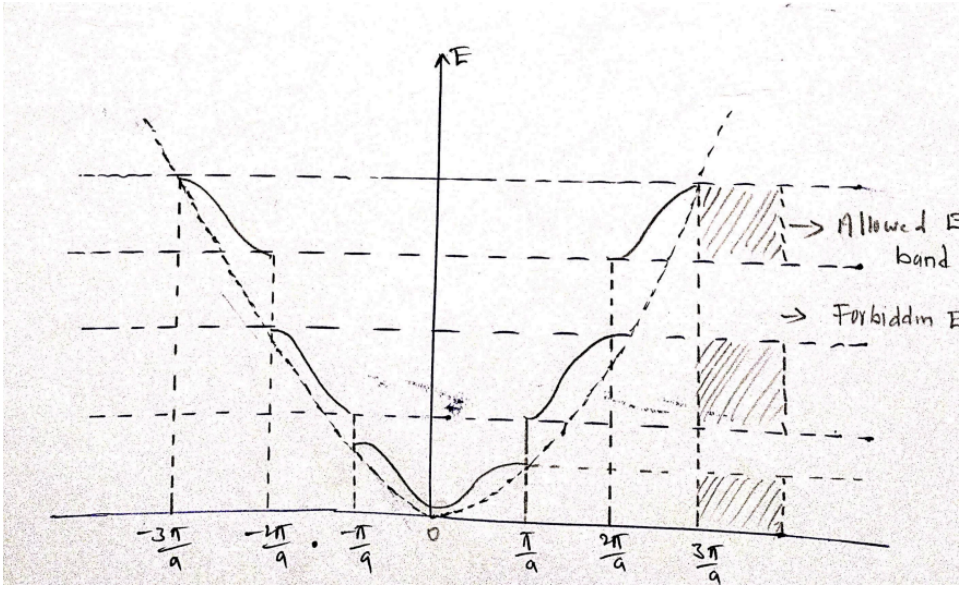
Answers

A. MODEL PAPER – I

a. Name the experiment which supports concept of dual nature of light?

i. The experiment that supports the concept of dual nature of light is the Double-slit experiment.

b. Draw E-K diagram?



c. Explain the working principle of a Solar cell?

i. A solar cell, also known as a photovoltaic cell, is a device that converts the energy from sunlight into electrical energy. The working principle of a solar cell is based on the photovoltaic effect.

When light hits the solar cell, it creates an electric field across the p-n junction, which separates the electrons and holes in the semiconductor material. The electrons are then forced to flow in one direction, creating a current, while the holes flow in the opposite direction.

d. What is zener break down voltage?

i. Zener breakdown voltage is a phenomenon that occurs in a reverse-biased p-n junction of a semiconductor, known as a Zener diode. When the reverse voltage across the Zener diode exceeds a certain threshold voltage called the Zener voltage, the diode undergoes Zener breakdown and starts to conduct current in the reverse direction.

e. Define Electric dipole,Electric Susceptibility and polarizability?

i. An electric dipole is a pair of electric charges of equal magnitude and opposite sign separated by a distance. It has a measurable dipole moment that describes the strength and orientation of the dipole. Electric dipoles are important in many areas of physics, including electromagnetism and quantum mechanics.

ii. Electric susceptibility is a measure of the ability of a material to become polarized in response to an electric field. It is defined as the ratio of the polarization density to the electric field strength. Electric susceptibility is a dimensionless quantity that is used to characterize the electrical properties of materials, including their dielectric constant and conductivity.

iii. Polarizability is a measure of the ease with which a molecule or atom can be polarized by an external electric field. It is defined as the ratio of the induced electric dipole moment to the strength of the electric field. Polarizability is a fundamental property of matter that affects many physical and chemical processes, including intermolecular interactions, optical properties, and chemical reactions.

f. What is magneto resistance and magneto striction?

i. Magneto-resistance is a change in the electrical resistance of a material when subjected to a magnetic field. It is caused by the interaction between the magnetic

field and the electrons in the material, which can affect their motion and result in a change in resistance. Magneto-resistance is used in many applications, including magnetic sensors and data storage devices.

ii. Magnetostriction is a property of materials that causes them to change shape or dimensions when subjected to a magnetic field. It is caused by the interaction between the magnetic field and the crystal structure of the material, which can result in the movement of atoms and a change in the material's shape. Magnetostriction is used in many applications, including sensors and actuators.

g. What is Nano scale?

i. The nanoscale is a length scale that is typically defined as being between 1 and 100 nanometers (nm). It is the scale at which matter exhibits unique properties that are different from those observed at larger scales.

ii. At the nanoscale, the properties of materials can be controlled and manipulated in ways that are not possible at larger scales, due to the increased surface area and quantum effects. Nanotechnology is the study and application of materials and devices at the nanoscale, with the aim of developing new technologies and materials that can be used in a variety of fields, including electronics, medicine, and energy.

h. Origin of Nano science – Explain?

i. Give the basic principle of optical fiber?

i. The basic principle of optical fiber is the transmission of light through a very thin, flexible, and transparent fiber made of glass or plastic. The fiber acts as a waveguide, confining the light to travel along the length of the fiber by reflecting off its inner surface.

ii. Working principle: Total Internal Reflection

j. What is lasing action?

i. Lasing action is the process by which a laser emits a coherent and monochromatic beam of light. It occurs when the gain in the laser's active medium (such as a crystal, gas, or semiconductor) exceeds the losses due to absorption and scattering.

B. MODEL PAPER – II

a. What is photo electric effect?

i. When a high frequency of light is incident on a metal surface, electrons are emitted from the surface of the metal. The metal electrons are called photo electrons and this phenomenon is called photoelectric effect.

ii. The effect occurs because light energy is absorbed by electrons in the material, causing them to be excited to a higher energy state and eventually to be ejected from the material's surface.

b. Write Fermi –Dirac distribution function?

i. The Fermi-Dirac distribution function is a quantum mechanical probability distribution that describes the statistical behavior of a large number of identical fermions, such as electrons, in a system at thermal equilibrium. The distribution

function is given by:

$$f(E) = \frac{1}{e^{(E - E_F)/kT} + 1}$$

Explain the symbols

c. Write any two characteristics of PIN diode

i. Two characteristics of a PIN diode are:
   1. High speed: PIN diodes have a relatively low level of capacitance and high level of doping concentration, making them suitable for high-frequency applications. They can be used in applications such as microwave switching, optical communication, and radar systems.
   2. Low noise: PIN diodes have a low level of noise compared to other diodes, which makes them suitable for use in low-noise amplifiers and other applications where noise is a concern. This is due to their low level of current leakage and low junction capacitance.

d. What is intrinsic semiconductor? Give one example?

i. An intrinsic semiconductor is a pure semiconductor material that has no intentional impurities added to it, resulting in a very low concentration of charge carriers (electrons and holes) at room temperature. This means that the conductivity of an intrinsic semiconductor is very low in the absence of external factors such as temperature, light, or electric fields.

ii. An example of an intrinsic semiconductor is pure silicon or germanium.

e. Define piezoelectric materials?

i. Piezoelectric materials are a class of materials that can generate an electric charge in response to applied mechanical stress or deformation, and conversely can undergo mechanical deformation in response to applied electric fields.

ii. Piezoelectric materials find widespread use in a range of applications, including sensors, actuators, transducers, and energy harvesting devices.

f. Give any two applications of multiferroics?

i. Multiferroics, materials that exhibit multiple ferroic orders, have several potential applications due to their unique properties. Here are two examples:
   1. Magnetic memory: Multiferroic materials are being studied for use in magnetic memory, where they could enable low-power, high-density, and non-volatile data storage.
   2. Spintronic devices: Multiferroic materials are also being investigated for use in spintronic devices, which rely on the spin of electrons rather than their charge.

g. Give any one characteristic to find the structure of nano materials?

i. X-ray diffraction (XRD). XRD is a non-destructive analytical technique that can provide information on the crystal structure, crystal size, and crystallographic orientation of a material. By analyzing the diffraction pattern of X-rays that are scattered by a sample, the structure of the material can be determined at the atomic or molecular level.

h. Define quantum confinement?

i. Quantum confinement refers to the effect of restricting the movement of free electrons and holes in a material to a small region, resulting in quantization of their energy levels. This confinement occurs due to the presence of interfaces or boundaries that limit the dimensions of the material, such as in nanoparticles or thin films. The resulting energy levels of the confined electrons and holes differ from those of bulk materials, leading to unique optical and electronic properties.

i. Define population inversion?

i. Population inversion is a phenomenon in which the majority of particles in a system, such as atoms or molecules, are excited and reside in higher energy levels rather than the ground state.

ii. This occurs when more particles are stimulated to a higher energy level than the number of particles that naturally return to a lower energy level by spontaneous emission. Population inversion is a crucial requirement for the operation of lasers, as it creates a condition where stimulated emission can dominate over absorption, leading to amplification of light.

j. what is the material numerical aperture of an optical fiber cable with a clad index of 1.378 and core index of 1.546?

To calculate the material numerical aperture (NA) of an optical fiber cable, we can use the following formula:

NA = √(n1^2 - n2^2)

where n1 is the refractive index of the core, and n2 is the refractive index of the cladding.

Given that the core index (n1) is 1.546 and the clad index (n2) is 1.378, we can substitute these values into the formula to get:

NA = √(1.546^2 - 1.378^2) ≈ 0.329

Therefore, the material numerical aperture of the optical fiber cable is approximately 0.329.

C. MODEL PAPER – III

a. What are the properties of matter waves?

Matter waves are a type of wave that is associated with particles such as electrons, protons, and atoms. They have properties that are similar to those of other types of waves such as light waves.

The properties of matter waves include:

1. Wavelength: Matter waves have a wavelength that is inversely proportional to the momentum of the particle. This means that particles with higher momentum have shorter wavelengths.
2. Frequency: Matter waves have a frequency that is directly proportional to the energy of the particle.

3. Interference: Matter waves can interfere with each other, leading to constructive or destructive interference.
4. Diffraction: Matter waves can diffract around obstacles, leading to the formation of diffraction patterns.
5. Uncertainty principle: The position and momentum of a particle cannot be measured simultaneously with arbitrary precision due to the uncertainty principle.

b. What are the examples of conductors,semiconductors and insulators?

Conductors, semiconductors, and insulators are materials that have different electrical conductivity properties.

i. 1. Conductors: These are materials that allow electric current to flow through them easily. Metals like copper, aluminum, and silver are good conductors of electricity.
ii. 2. Semiconductors: These are materials that have intermediate conductivity between conductors and insulators. Examples of semiconductors include silicon (Si), germanium (Ge), and selenium (Se).
iii. 3. Insulators: These are materials that do not allow electric current to flow through them easily. Examples of insulators include rubber, glass, wood, air, mica, plastic, and paper.

c. Give the difference between PIN diode and APD (Avalanche photo Diode)?

Pin diode and Avalanche Photo Diode (APD) are two types of photodiodes that differ in their sensitivity and operating voltage.

i. 1. Sensitivity: APD has a much higher level of sensitivity compared to PIN diode. The avalanche action increases the gain of the diode many times, providing much higher sensitivity.
ii. 2. Operating Voltage: APD requires a higher operating voltage than PIN diode because it operates under high reverse bias conditions. APD is basically a P-I-N diode with very high reverse bias voltage, typically around 50 volts, while PIN diodes are reverse biased to only 3 volts.
iii. 3. Cost: APDs are generally more expensive than PIN diodes due to their higher sensitivity and more complex design.

d. What is the principle of Solar cells?

The principle of solar cells is based on the photovoltaic effect, which is the conversion of light energy into electrical energy.

i. A solar cell is made up of a layer of p-type silicon placed next to a layer of n-type silicon. In the n-type layer, there is an excess of electrons, and in the p-type layer, there is a deficiency of electrons. When light falls on a solar cell, photons from the light are absorbed by the semiconductor material in the cell. This causes electrons to be excited from their lower-energy state to a higher-energy state and creates electron-hole pairs. The electric field at the junction between the p-type and n-type layers separates these electron-hole pairs, creating a flow of electrons that generates electricity.

e. List the applications of super ionic conductors?

Superionic conductors have various applications in different fields such as energy engineering, ceramic industry, and sensor technology. Some of the specific applications of superionic conductors are:

i. 1. Solid-state batteries: Halide superionic conductors have emerged as promising solid electrolyte materials for all-solid-state batteries.
ii. 2. Sensors: Superionic conductors can be used in the development of sensors for detecting oxygen, hydrogen, carbon dioxide, and moisture.
iii. 3. Energy storage: Superionic conductors can be used in energy storage devices such as microbatteries.
iv. 4. High-temperature fuel cells: Superionic conductors can be used as electrolytes in high-temperature fuel cells.
v. 5. Electrochromic devices: Superionic conductors can be used in electrochromic devices that change color when a voltage is applied to them.

f. Give the difference between Solid and Liquid electrolytes?

Solid and liquid electrolytes differ in their physical state and properties.

1. Physical State: Solid electrolytes are in a solid state, while liquid electrolytes are in a liquid state.
2. Ionic Conductivity: Solid electrolytes have lower ionic conductivity compared to liquid electrolytes because the ions have less mobility in solids than in liquids.
3. Stability: Solid electrolytes are more stable than liquid electrolytes because they do not evaporate or leak easily.
4. Safety: Solid electrolytes are generally safer than liquid electrolytes because they are less flammable and less prone to leakage or explosion.
5. Applications: Solid electrolytes are used in electrochemical sensors for the measurement of partial pressures of gases or the concentrations of gases in liquids, as well as in all-solid-state batteries. Liquid electrolytes are commonly used in fuel cells, which convert chemical energy into electrical energy.

g. What is Nanotechnology?

i. Nanotechnology is the science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers. It involves the manipulation of matter on an atomic, molecular, and supramolecular scale to produce new structures, materials, and devices.
ii. Nanotechnology encompasses the understanding of fundamental physics, chemistry, biology, and technology of nanometer-scale objects. It has a wide range of applications in various fields such as medicine, consumer products, energy, materials science, and manufacturing.

h. What are the examples of 1-D,2-D and 3-D nanomaterials?

Nanomaterials can be categorized into zero-dimensional (0D), one-dimensional (1D), two-dimensional (2D), and three-dimensional (3D) structures based on their dimensions.

i. **0D Nanomaterials**: These are materials that have all three dimensions confined to the nanoscale. Examples of 0D nanomaterials include nanoparticles, nanocrystals, and nanoclusters.
ii. **1D Nanomaterials**: These are materials that have one dimension outside the nanoscale while the other two dimensions are within the nanoscale. Examples of 1D nanomaterials include nanotubes, nanorods, and nanowires.
iii. **2D Nanomaterials**: These are materials that have two dimensions outside the nanoscale while one dimension is within the nanoscale. Examples of 2D

nanomaterials include Nano thin films, nano plates, graphene, transition metal dichalcogenides, and hexagonal boron nitride.

iv. **3D Nanomaterials**: These are materials that are not confined to the nanoscale in any dimension.Examples:- 3D particles of precipitates, Colloids, quantum dots, tiny particles of semi- conductor materials.

i. Define Numerical aperture,Acceptance angle and Acceptance cone?

i. **Numerical aperture (NA)** is a measure of the light-gathering ability and resolution of an optical system, such as a microscope objective or a fiber optic cable. It is defined as the product of the refractive index of the medium in which the lens operates and the sine of half the angle of acceptance cone.

ii. **Acceptance angle** refers to the maximum angle at which light can enter an optical fiber or other optical system and still be transmitted through it. It is determined by the numerical aperture of the system.

iii. **Acceptance cone** refers to the range of angles within which an optical system can accept incoming light. It is determined by the numerical aperture of the system.

j. Define Lasing Action,pumping?

i. **Lasing action** is the process of producing coherent light by stimulated emission of radiation in a laser cavity. It involves the amplification of light by stimulated emission, which occurs when an excited atom or molecule emits a photon that has the same frequency, phase, and direction as the incident photon.

ii. **Pumping** is the process of providing energy to the gain medium of a laser to excite its atoms or molecules into higher energy states. This can be achieved through various methods such as optical pumping, electrical pumping, and chemical pumping. The energy absorbed by the gain medium produces excited atoms or molecules that can undergo stimulated emission to produce coherent light.