LSSBM's

PADM. DR. V.B.KOLTE COLLEGE OF ENGINEERING, MALKAPUR

Department of Applied Sciences & Humanities

Academic Session 2025-26 (Winter-2025)

CLASS TEST – I

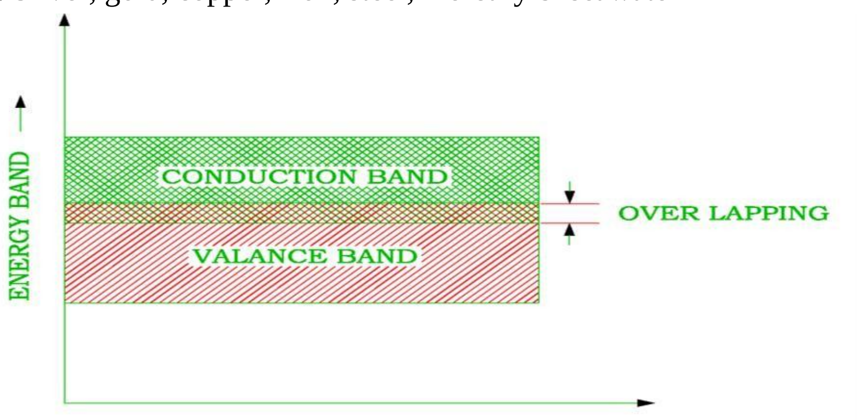
Model Answer: Session 2025-26

Subject: - Engineering Physics (1AS101BS)

Class: First Year **Semester: I**

Instructions for Physics Examiner:

1. **Do not evaluate based on word-to-word matching** with the model answer. Award marks based on the **presence of relevant keywords and concepts**.
2. The **student's answer may differ** from the model answer. The examiner should assess the **student's level of understanding** rather than the exact wording.
3. **Minor language errors** (spelling, grammar) should be ignored while evaluating Physics papers. *(This point is not applicable to English or Communication Skills subjects.)*
4. For **diagrams**, credit should be given if the **main components or principles** are correctly shown, even if the diagram differs from the one in the model answer.
5. For **numerical problems**, give marks **stepwise**. If students assume different constant values, minor variations in the final answer should be accepted **if the method is correct**.
6. For certain descriptive or conceptual questions, marks may be awarded **at the examiner's discretion** if the answer reflects **relevant understanding**.

Que. No.	Sub Que.	Model Answers	Marks	Total Marks
1	A	**Differentiate between conductors, insulators, and semiconductors based on their energy band structure.** **Ans:-** **Conductor:** Conductor are the material that allow the current to flow through them.Because their atomic structure lets the outer electron move freely from one atom to another. The electron carry negative charge so they replied by each other and the current flow. The energy gap between valence band and conduction band is zero. $E_g = 0$ eV For ex. Silver, gold, copper, Iron, steel, mercury & seawater  FIG A : ENERGY BAND DIAGRAM FOR CONDUCTOR	05	

Insulator

Insulator is a material that does not allow the current to flow. Insulator supports or keeps the electrical conductor away from each other. Vacuum is also an insulator but actually it is not a material. In insulator the valence band is completely filled and conduction band is empty. The two band is separate by the energy gap is known as forbidden energy gap E_g. In insulator the valence band and conduction band energy gap is greater than 3eV. $E_g > 3eV$

For ex. Paper plastic, rubber, glass and air

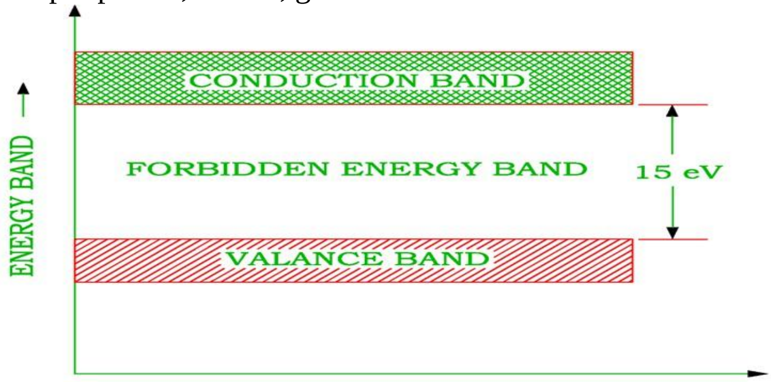


FIG C : ENERGY BAND DIAGRAM FOR INSULATOR

Semiconductor:

The material which is in between conductor and insulator is known as semiconductor. Its conducting property may be altered by doping in the material. When two differently doped region exist in some material then semiconductor junction is created. The energy gap between valence band and conduction band is less than 1eV. E_g <1eV at temperature 0K E_g = 0.785eV for Ge and for Si E_g = 1.21 eV. Energy band gap depends upon temperature. As temperature increases it act as a conductor and at 0K it act as insulator.

For ex. Germanium (Ge) & silicon (Si)

FIG B : ENERGY BAND DIAGRAM FOR SEMI CONDUCTOR

1 B

Compare the electrical properties of intrinsic and extrinsic semiconductors. **05**

Ans

Property	Intrinsic Semiconductor	Extrinsic Semiconductor
Definition	Pure semiconductor without any impurity	Doped semiconductor with a small amount of impurity
Carrier Concentration	Number of electrons = Number of holes	Majority carriers > Minority carriers (depends on doping)
Conductivity	Low electrical conductivity	Higher conductivity due to increased carrier concentration
Temperature Dependence	Conductivity increases with temperature	Conductivity increases with temperature but remains higher
Types of Charge Carriers	Electrons and holes in equal numbers	Either electrons (n-type) or holes (p-type) are majority

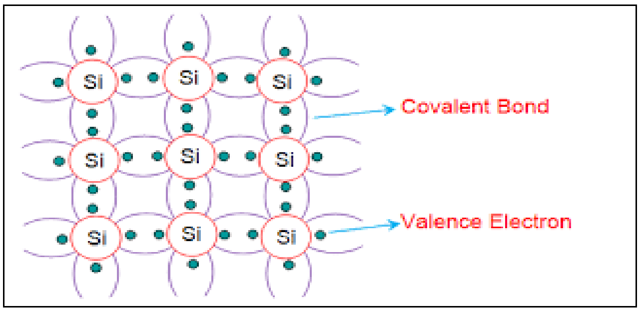
2 A

Define intrinsic and extrinsic semiconductors with suitable diagrams and examples. **05**

Ans

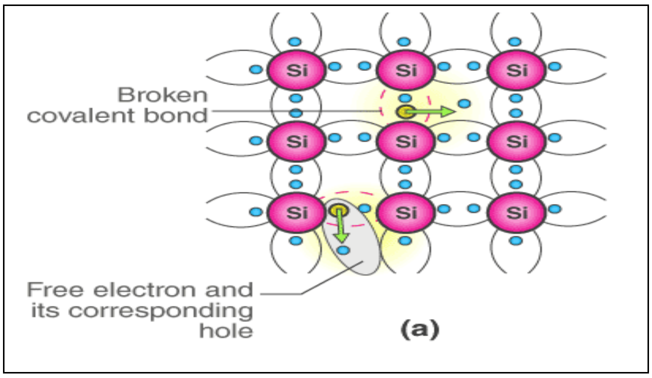
Intrinsic (pure) semiconductor:

An intrinsic semiconductor is made up from purely semiconducting material. In which no other material is doped. They are in the pure form such as Ge & Si. The semiconductor which have no impurity is called as the intrinsic semiconductor. If we take the two atom of Ge (32) and Si (14) they have 4 valence electron in the outer most orbit.



No electron from the covalant bond is free for conduction because it is surrounded by four additional electrons from neighbouring atoms, as seen in fig. So pure germanium and silicon act as *insulators at absolute 0k.*

Few valence electrons break the covalent connection and travel to the conduction band when the temperature rises from absolute 0K. The hole formed by the vacancy of an electron now acts as a positive charge. The number of electrons and holes in the intrinsic semiconductor remains constant as *temperature rises*. The intrinsic semiconductor acts as a conductor because of the thermally produced electrons and holes. Electrons and holes are known as intrinsic charge carriers.



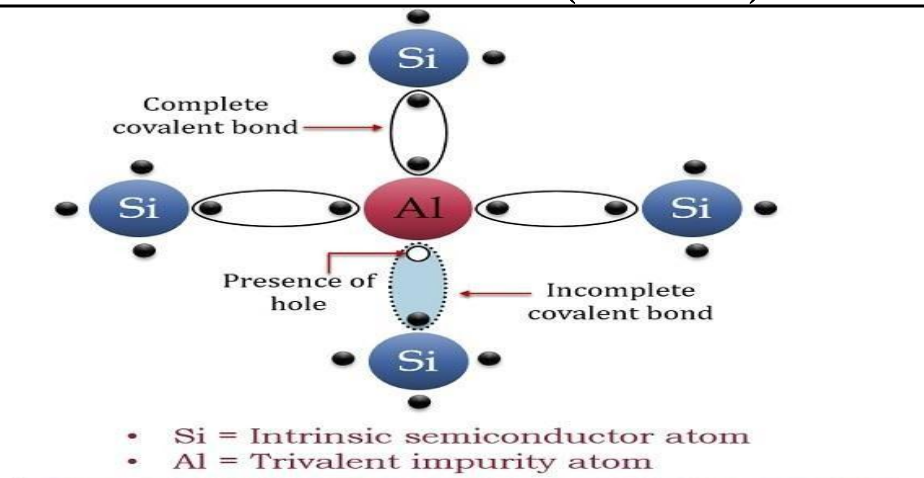
Extrinsic Semiconductor And Enery Level Diagram:

There are two types of extrinsic semiconductor depending the type of impuriy atoms added in it.

i. p-type semiconductor
ii. n-type semiconductor

p-type semiconductor

It is obtain by doping trivalent impurity in pure semiconductor (Si /Ge) such as Boron(b), aluminium(Al). When Al is doped in Si one atom of Si is replaced by Al. There are 3 electron in outer most shell so they from a covalent bond with the neighbouring atom and one is free. There is deficiency of one electron is known as hole. Trivalent impurity create one hole in pure Si structure which is ready to accept the electron. Trivalent impurity is known as acceptor impurity atom. In p- type semiconductor hole are more then electron. Themally generated electron hole are also present. Majority charge carrier are holes and minority charge carrier are electron



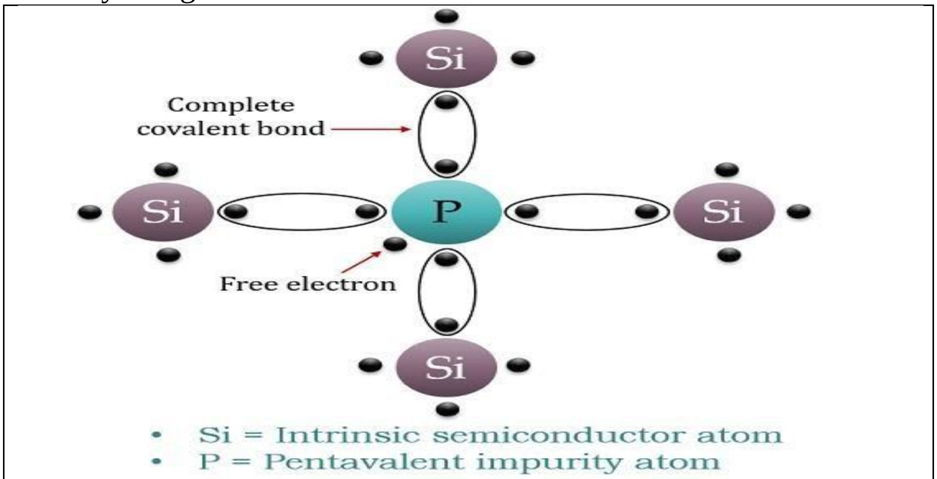
Formation of P type extrinsic semiconductor

n-type semiconductor

n- type semiconductor is obtain by adding pentavalent impurity in pure Ge or Si semiconductor. If we add phosphorus(P) in silicon(Si) ,then one atom of Si is replaced by Phosphorus. There 5 valence electron in outer most orbit so 4 makes the bonding with neighbouring atom and one electron is free.

Every pentavalent atom donate one free electron so pentavalent impurity are known as donor impurity. In n-type semiconductor number of electron is more then the number of holes.

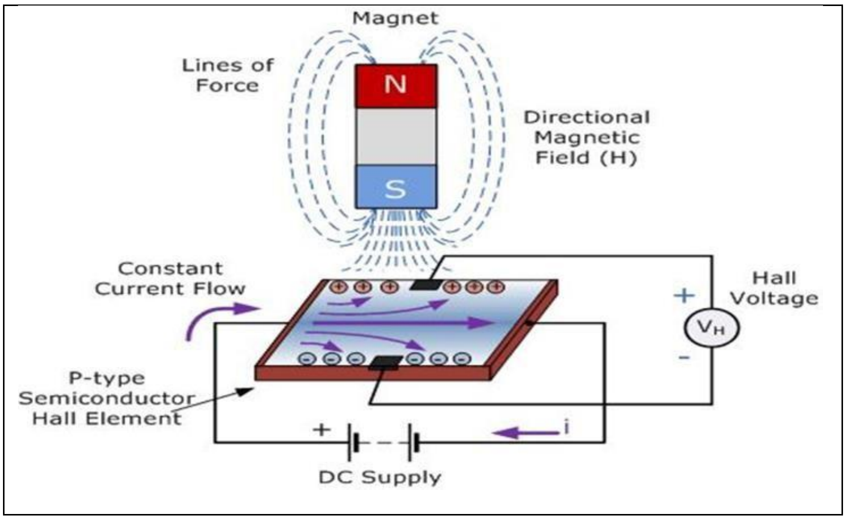
So in n-type semiconductor Majority charge carrier are electron, Minority charge carrier are hole.



Formation of N type extrinsic semiconductor

2	B	**Define Hall effect. Derive the expression for Hall voltage.** **Ans** The hall was discovered by Edwin hall in 1879.When a magnetic field is applied to a current carrying conductor in a direction perpendicular to that flow of current, a potential difference or transverse electric field is created across a conductor. This phenomenon is known as Hall effect. The voltage produce due to the application of magnetic field is also	05	

referred to as hall voltage of hall field



Consider an n-type semiconductor of thickness d and width w. let it carry a current in positive x direction and magnetic field is applied in z- direction.

As the current flow in positive x direction the electron flow. In opposite direction in negative x direction.The transverse magnetic field in negative z direction apply the force on the charge electron

they are deflected in the downward direction. The magnitude of force is

$$F_m = -q\,(V \times B)$$

$F_m = -\,q.V.B.\sin\theta$ $\theta = 90°$ Due to this the front part the electron are collected and on the opposite part the hole are collected.

In this case the electric field tis produce in – y direction. The accumulation of charges continues up to the electric field reaches to a particular value of E_H which oppose the further motion of electron.

This electric felid E_H is called as hall field and the potential developed in the surface is called hall voltage V_H

$$E_H = \frac{V_H}{w} \quad \text{.....................(a)}$$

When there is no further accumulation of charge the force on electron is

$$F_e = -q.E_H$$

In the steady state the upward electric force must and opposite to the magnetic force.

$$F_e = F_m$$

$$q.E_H = q.v.B$$

$$E_H = v.B \quad \text{...(b)}$$

The drift velocity in term of total current density is

$J = qnv \qquad V = \frac{J}{qn}$

put this value in eqn (b)

$$E_H = \frac{JB}{nq} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (c)$$

The denominator part is charge density charge per unit volume and the reciprocals of charge density is hall coefficient. RH.

$$R_H = \frac{1}{nq} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (d)$$

form eqn (c) and (d) we get

$$R_H = \frac{E_H}{JB}$$

$$J = \frac{I}{A} = \frac{I}{w \times d} \qquad E_H = \frac{V_H}{W}$$

putting the value we get

$$R_H = \frac{V_H\, W\, d}{W\, I\, B}$$

$$R_H = \frac{V_H\, d}{I\, B} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (e)$$

By knowing the value of thickness d V_H is the hall voltage , I is the current get from the ammeter, B is the applied magnetic field, R_H the hall coefficient is calculated.

Hall coefficient R_H negative for n- type semiconductor and positive for the p- type semiconductor.

Form the eqn d and e we get

$$\frac{1}{nq} = \frac{V_H\, d}{I\, B}$$

$$n = \frac{IB}{V_H\, d\, q}$$

All the quantities on the R.H.S can be measured so, concentration of charge carrier (n) can be calculated.

3 A State De-Broglie's hypothesis. Derive an expression for De-Broglie wavelength.

Ans

We have seen that radiation has dual nature, Wave like as well as particle like. In 1924 De-Broglie suggested that the same is true for matter. According to De-Broglie if radiation behaves like particle and nature loves symmetry, the material particle should also show wave like properties.

De-Broglie hypothesis says that, every moving particle has wave associated with it known as matter wave. The wavelength of matter wave associated with particle is given by,

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Where m, v and p are mass, velocity and momentum of particle

De-Broglie wavelength associated with photon: - The photon to be treated as particle having rest mass zero and travelling with the speed of light. The energy of photon is given by,

$$E = h\vartheta = \frac{h\vartheta}{\lambda} \qquad \ldots\ldots (1)$$

And according to Einstein mass energy relation, the material particle of mass m is equivalent to energy

$$E = mc^2$$

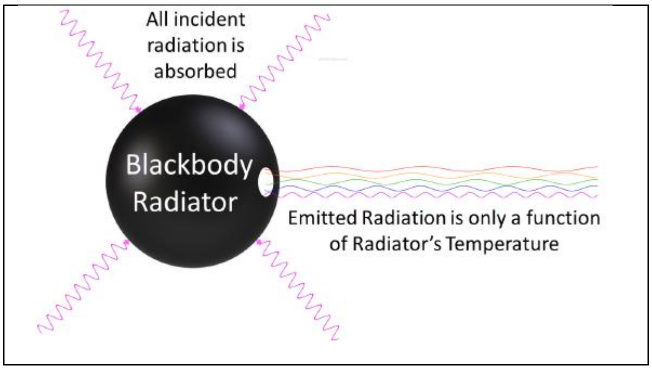
		….. (2) From equation (1) and (2) $$mc^2 = \frac{h\vartheta}{\lambda}$$ $$\lambda = \frac{h\vartheta}{mc^2}$$ Where mc is momentum of photon. This is the wavelength associated with photon.		
3	B	**State and derive Heisenberg's Uncertainty Principle.** **Ans** It states that, it is not possible to measure simultaneously both the position and momentum of a moving microscopic particle with absolute accuracy or certainty. $$\Delta x . \Delta p \geq \frac{h}{4\pi}$$ Where Δx=uncetainity in position Δp=uncertainty in momentum If Δx is small: - position of microscopic particle is known with high degree of accuracy, then Δp will be very large. If Δp is small: - Certainty in momentum will be very large (measured accurately) But larger uncertainty in measuring its position. $i.e.$ If we try to measure the position of particle with utmost accuracy $\Delta x \rightarrow 0$, the corresponding uncertainty in momentum becomes very large $\Delta p \rightarrow \infty$ and vice-versa. Let us consider a particle (like an electron) observed using a light microscope. To see the electron, light of wavelength λ is used. **According to the diffraction limit**, the uncertainty in position is approximately $$\Delta x = \lambda$$ When a photon hits the electron, it imparts momentum to it. The uncertainty in momentum due to the photon is approximately $$\Delta p = \frac{h}{\lambda}$$ Multiplying both uncertainties $$\Delta x . \Delta p = \lambda . \frac{h}{\lambda} = h$$ More accurate quantum mechanical treatment gives $$\Delta x . \Delta p = \frac{h}{4\pi}$$	05	

4	A	**State and explain Planck's hypothesis.**	5	

Ans

Wien's formula and Rayleigh

Jean's formula were derived on the basis of classical assumption that could not explain the energy distribution in black body spectrum. Planck's comes to the conclusion that the failure of this formulae is due to assumption that the energy absorbed or released by atom is considered to be continuous. So, Planck's proposed a quantum theory in which they said,



"Different atoms and molecule can emit or absorbs energy in discrete quantities only. The smallest amount of energy that can be emitted or absorbed in the form of electromagnetic radiation is known as quantum".

Planck's hypothesis states that:

Energy is not emitted or absorbed continuously, but in discrete packets called quanta.

Each quantum of energy is directly proportional to the frequency of radiation.

Mathematically,

Where $E = h\vartheta$

E = energy of a quantum

h = Planck's constant (6.626×10−34 J Sec.

ν = frequency of radiation $v = \frac{c}{\lambda}$

c = 3 x 10^8 m/s

Postulates of Planck's quantum theory: -

1) Energy is not emitted or absorbed continuously.
2) It is emitted or absorbed in the form of packets or bundles of energy called as quanta or photon.
3) The energy of photon is directly proportional to the frequency of radiation.

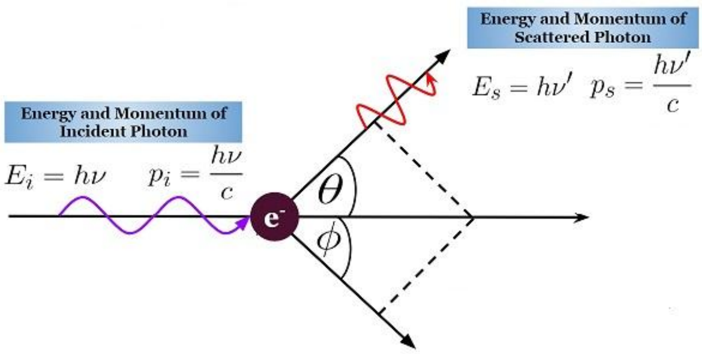
$$i.e.,\ E = h\vartheta$$

Where h is plank's constant and h = 6.626 × 10^{-34} J sec.

4	B	**Explain the Compton effect with neat diagram and derive Compton shift formula.**	5	

Ans

Compton effect: - The Compton Effect was discovered by A.H. Compton in 1923,
it is the scattering of high-frequency photons after an interaction with a charged particle called electron, it results in a decrease in energy and an increase in wavelength of a photon which may be X-Ray or Gamma Ray photon. When a monochromatic beam of X-ray is scattered by light element like carbon, the scattered radiation in addition to radiation of incident wavelength (λ) also contain the radiation of higher wavelength λ' . This phenomenon is known as Compton Effect. The difference $\Delta\lambda = \lambda' - \lambda$ is called as Compton shift. The amount of Compton shift was found to be independent of original wavelength and nature of scatterer. It was found to be depends only on angle of Scattering.



Explanation of Compton effect: -

1) A beam of monochromatic X-ray is consist of a stream of photons having energy $h\nu$ and momentum $\frac{h}{\lambda} = \frac{h\vartheta}{c}$. These photons travel in the direction of the beam with the speed of light.
2) The scattering of X-rays by atoms of graphite element is the result of elastic collisions between photons and electrons. This is an elastic collision so the energy and momentum will be conserved (i.e. in such a collision there is no loss of kinetic energy).
3) The outer shell electron is loosely bound with the atom and required a very small amount of energy to leave the atom but the X-ray photons have very high energy. So the loosely bound electron of the atom leaves atom the permanently. Therefore for the X-ray loosely bound electrons can be considered as free electrons at rest.
4) During the collision part of energy of photon is transferred to the electron. The electron recoils in some other direction and scattered photon has less energy and hence lower frequency or longer wavelength.

The amount of Compton shift is given by,

		$$\Delta h = \frac{h}{m_0 c}(1 - cos\theta)$$ $$= \frac{2h}{m_0 c} sin^2 \frac{\theta}{2}$$ $$= 2\lambda_e sin^2 \frac{\theta}{2}$$ Where $\lambda_e = \frac{h}{m_0 c} = 0.02426$ Å is called as Compton wavelength of electron. The Compton wavelength of electron is the wavelength of radiation whose photon has energy equals to rest energy of electron.		

Subject Incharge

Dr. Dipak Zope **Prof. M. Javed**