Roll No. | | | | | | | | | | | |

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST - 1

Sem & AY: Odd Sem. 2019-20 — Date: 27.09.2019

Course Code: PHY 101 — Time: 9.30AM to 10.30AM

Course Name: ENGINEERING PHYSICS — Max Marks: 30 Marks

Program & Sem: B.Tech (Physics Cycle) & I — Weightage: 15%

Instructions: (i) Read the questions properly and answer accordingly.
(ii) Question paper consists of 3 parts.

Part A (Memory Recall Questions)

Answer all the Questions. Each question carries four Marks (2Qx4M=8M)

1. (i) The Fermi level is

(a) An average value of all available energy levels

(b) An energy level at the top of the valence band.

(c) The highest occupied energy level at 0^0c

(d) The highest occupied energy level at 0^0K (C.O.NO.1)[Knowledge] [1M]

(ii) Phosphorous can be used as

a) Pentavalent impurity b) Trivalent impurity

c) intrinsic semiconductor d) Extrinsic Semiconductor

(C.O.NO.1)[Knowledge] [1M]

(iii) The displacement of charged particles under the action of an applied electric field is called

a) Dielectric polarization b) Dielectric breakdown

c) Dipole Moment d) Dielectric Permittivity (C.O.NO.1)[Knowledge] [1M]

(iv) Type 2 superconductors are known as

a) Hard superconductors b) Soft superconductors

c) Insulators d) Paramagnets (C.O.NO.1)[Knowledge] [1M]

2. (i) What is superconductivity. (C.O.NO.1)[Knowledge] [2M]

(ii) Define dielectric constant of a dielectric material. (C.O.NO.1)[Knowledge] [2M]

Part B (Thought Provoking Questions)

Answer both the Questions. Each question carries five marks. (2Q×5M=10M)

3. (i) With increase in temperature, the root mean square velocity of electrons in classical free electron theory

   a) Increases b) Independent of temperature

   c) Remains same d) Decreases

   (ii) Mention four postulates of classical free electron theory

(C.O.NO.1)[Comprehension]

4. (i) Type I superconducductors are not used as superconducting magnets because

   a) They are not perfect diamagnets b) The value of critical field is low

   c) They have two critical fields d) The value of critical field is high

   (ii) Explain Meissner effect with the help of neat diagram.

(C.O.NO.1)[Comprehension]

Part C (Problem Solving Questions)

Answer the Question. The Question Carries twelve marks. (1Q×12M=12M)

5. (i) Explain the construction and working of a solar cell with the help of a neat diagram

(C.O.NO.1)[Application][8 M]

   (ii) Explain the effect of temperature on four polarization mechanisms.

(C.O.NO.1)[Application][4 M]

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST-1

Odd Semester: 2019-20 | Date: 27^{th} September 2019

Course Code: PHY101 | Time: 1 Hour

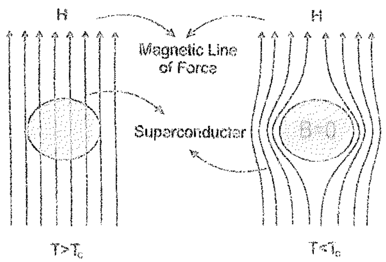
Course Name: Engineering Physics | Max Marks: 30 Marks

Programme & SEM: B.Tech, I SEM | Weightage: 15%

Part A

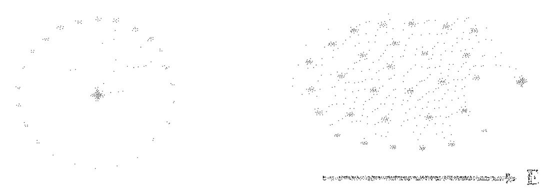
Q No	Solution	Scheme of Marking	Course Outcome No. as per the Handout	Bloom's Level	Learning Objective No. as per Handout	Max. Time required for each Question
1	d) The highest occupied energy level at 0^0K	1 marks	[CO1]	Knowledge	L4	1 Minutes
2	a) Pentavalent Impurity	1 marks	[CO1]	Knowledge	L6	1 Minutes
3	a) Dielectric polarization	1 marks	[CO1]	Knowledge	L10	1 Minutes
4	a) Critical Temperature	1 marks	[CO1]	Knowledge	L11	1 Minutes
5	The phenomenon of loss of resistivity of a certain materials when they are cooled below threshold temperatures is known as superconductivity	2 marks	[CO1]	Knowledge	L12	3 Minutes
6	The product of the magnitude of the charge (q) and distance between two charges (d) is called as dipole moment. Dipole moment $p = qd$ (coulomb-meter)	2 marks	[CO1]	Knowledge	L8	3 Minutes

PART -B

Q No	Solution	Scheme of Marking	Course Outcome No. as per the Handout	Bloom's Level	Learning Objective No. as per Handout	Max. Time required for each Question
1	a) Increases	1 marks	[CO1]	Comprehension	L2	2 Minutes
2	b) The value of critical field is low	1 marks	[CO1]	Comprehension	L8	2 Minutes
3	Meissner effect: "The phenomenon of expulsion of magnetic flux completely from the specimen during the transition from normal state to the superconducting state is called as 'Meissner effect.'" A conductor held in magnetic field at T > Tc [fig 1]. The magnetic field penetrates the body in normal state. When the superconducting material is cooled in the presence of magnetic field T < Tc ,the superconductor expels field lines as shown in fig 2. This process is called Meissner effect. The total magnetic induction inside the specimen is given by, B = 0 Therefore superconductors are called perfect diamanets  	1 marks 1 marks 1 marks 1 marks	[CO1]	Comprehension	L7	9Minutes

4	The valence electrons are free to move inside the metal which contribute electrical conductivity. The force between the free electrons and the ionic core is negligible. The electric potential due to the ionic core is constant throughout the body of the metal. The free electrons move about identical with the motion of gas molecules and hence assumed to obey the kinetic theory of gases. In the absence of external electric field they are at random motion and their average kinetic energy is $\frac{1}{2} m v_{th}^2 = 3/2\ k\ T$, where v_{th} is the thermal velocity, k, Boltzmann's constant and T is temperature.	Each postulate 1 Mark	[CO1]	Comprehension	L2	9 Minutes

PART -C

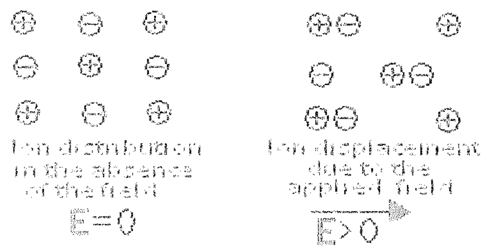
Q No	Solution	Scheme of Marking	Course Outcome No. as per the Handout	Bloom's Level	Learning Objective No. as per Handout	Max. Time required for each Question
1	a) 8.5 eV	1 mark	[CO1]	Application	L3	2Minutes
2	a) Sum of Ionic and Electronic polarizations	1 mark	[CO1]	Application	L10	2Minutes
3	1.Atomic or Electronic polarization *Electronic polarization occurs due to the displacement of the positively charged nucleus and the negatively charged electrons of an atom in the opposite directions when an electric field is applied.* The dipole moment-p_e due to electronic polarization is proportional to the applied electrical field strength (E). $p_e \alpha E$ Or $p_e = \propto_e E$ p_e is the dipole moment due to electronic polarization, E is applied the electric field and α_e is called the electronic polarizability. Electronic polarization is independent of temperature. Electronic polarization takes place in almost all dielectrics. Electronic polarization sets in very quickly because it involves the displacement of lighter electron cloud. It also disappears quickly after the electric field is switched off.  Charge distribution in the absence of the field Charge displacement due to the applied field	Each Mechanism 2.5 Marks	[CO1]	Application	L12	12 Minutes

2.Ionic polarization

Ionic polarization occurs only in those dielectric materials which possess ionic bonds such as in NaCl. When ionic solids are subjected to an external electric field, the adjacent ions of opposite sign undergo displacement. The displacement causes an increase or decrease in the distance of separation between them depending upon the location of the ion pair in the lattice. Ionic polarization is independent of temperature. Ionic polarization sets in slowly as it involved the movement of ions which are relatively heavier.

$p_i \alpha E$ Or $p_i = \alpha_i E$

where, p_i is the dipole moment due to ionic polarization, α_i is the ionic polarizability and E is the applied electric field.



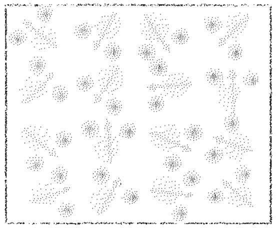
Ionic polarization

3.Orientation polarization

Orientation polarization occurs in liquids or solids – which possess molecules with permanent dipole moment (i.e., in polar dielectrics). The orientation of these molecules will be random normally due to thermal agitation. Because of the randomness in orientation, the material has zero net dipole moment. But under the influence of an applied electric field, each of the dipoles undergo rotation so as to reorient along the direction of the field because of which, the overall cancellation of dipole moments due to randomness does not hold good any more. Thus the material acquires electrical polarization. Orientation polarization depends strongly on the temperature. Orientation polarization takes more time to set than ionic polarization.

$p_o \alpha E$ Or $p_o = \alpha_o E$

where p_o is dipole moment due to orientation polarization, α_o is the orientational polarizability and E is the applied electric field.



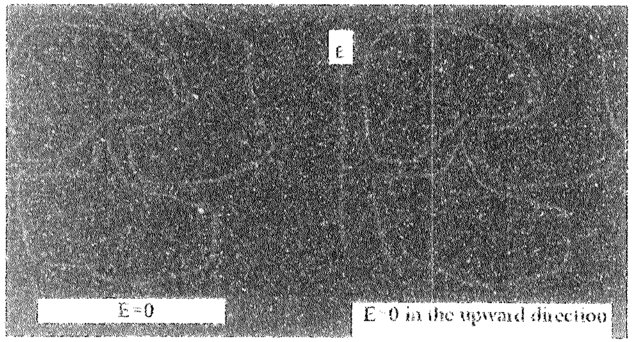
Dipole orientation in the absence of the field

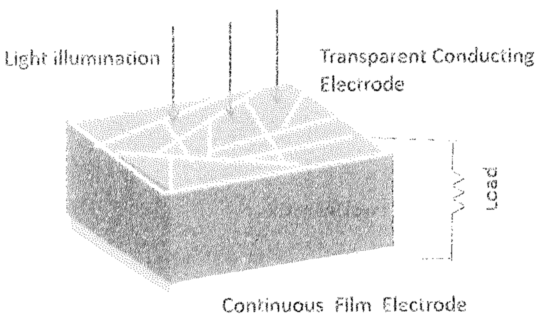
Dipole alignment due to the applied field

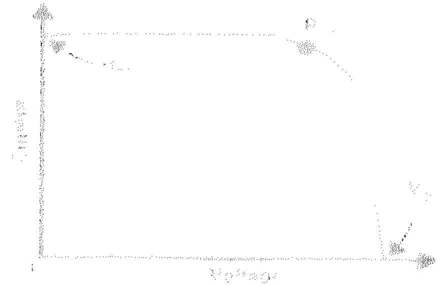
4. Interface or Space charge polarization

Space charge polarization occurs in multiphase dielectric materials in which there is a change of resistivity between different phases. When such materials are subjected to an electric field, especially at high temperature the charges get accumulated at the interface because of sudden change in conductivity. Since the accumulation of charges with opposite polarity occurs at opposite parts in the low resistivity phase, in effect it leads to development of dipole moment within the low resistivity phase domain.

It occurs in ferrites and semiconductors. The value of space charge polarization is very small compared to other types of polarizations. The space charge polarization is not an important factor in most dielectrics.



4	Solar cells (photovoltaic cells) convert solar energy in to electrical energy. They primarily consist of wafer thin p-n junction diodes. Each solar cell is very small and series combination of many such solar cells, which gives rise to a photovoltaic module, combination of these modules make a solar cell array panel. Solar Cell is a p-n junction diode. The upper layer is n-type semiconductor and lower layer is p-type semiconductor. When sunlight photons excite the electrons they jump from valance band to conduction band creating electron and hole charge carriers. The electrons from conduction band in n-type semiconductor move towards the p-type through the circuit and this flow generates electric current. The amount of electric current produced depends on the amount of light incident on it. Modern solar cells are only microns thick and have practical every day efficiencies of about 10-20%  The voltage – current graphs or the volt-ampere (V-I) curve of a solar cell is determined by connecting a resistance box and a voltmeter across a solar cell. The resistance values are varied step by step, and the corresponding voltages across the resistance box are measured using a voltmeter. From the acknowledged values of V and R, the value of I is determined using the relation $I=\frac{V}{R}$ The current obtained by short-circuit in the two terminal of the solar cell is called short – circuit current (I_{sc}). The voltage built up in open circuit is called as open-circuit voltage (V_{oc}).	Diagram Each 1 Mark Efficiency 1 Mark Fill Factor 1 Mark Rest any six valid points 6 Marks	[CO1]	Application	L5	12 Minutes

	Max power, P_{max} is obtained when the area of the rectangle formed is the largest. The corresponding voltage is V_{max} and current is I_{max}.  Efficiency of a solar cell can be defined as the ratio of total power converted by the solar cell to the total power available for energy conversion. $\eta = \frac{Maximum\ output\ electrical\ power}{Input\ optical\ power\ \ (or) light\ intensity\ X\ area\ of\ the\ solar\ cell}$ Fill factor is defined as the ratio of maximum output power to ideal output power $f = \frac{Pmax}{Voc * Isc}$					

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PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem. 2019-20 — **Date**: 16.11.2019

Course Code: PHY 101 — **Time**: 9.30 AM to 10.30 AM

Course Name: ENGINEERING PHYSICS — **Max Marks**: 30

Program: B.Tech (Physics Cycle) & I — **Weightage**: 15%

Instructions:

(i) *Read the question properly and answer accordingly.*

(ii) *Question paper consists of 3 parts.*

(iii) Scientific and Non-programmable calculators are permitted.

(iv) Given $k = 1.38\times10^{-23}\,J/K$, $c = 3\times10^{8}\,m/s$, $h = 6.626\times10^{-34}\,Js$, $e = 1.6\times10^{-19}\,C$

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries two marks. (4Qx2M=8M)

1. Define induced absorption and stimulated emission. (C.O.NO.2) [Knowledge]
2. Define total internal reflection. (C.O.NO.2) [Knowledge]
3. Name the different types of fibers based on mode of propagation. (C.O.NO.2) [Knowledge]
4. Define population inversion (C.O.NO.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries five marks. (2Qx5M=10M)

5. Explain optical fiber communication through block diagram. (C.O.NO.2) [Comprehension]
6. The refractive indices of core and cladding are 1.51 and 1.49 respectively in an optical fiber. Find the numerical aperture and angle of acceptance. (C.O.NO.2) [Comprehension]

Part C [Problem Solving Questions]

Answer the Question. The Question carries twelve marks. (1Qx12M=12M)

7. It is observed that, a wavelength of 10.6 μm is emitted by a laser system which is used in drilling. The active medium of that laser is formed by a mixture of CO_2, N_2 and He.

   a) Identify the laser system. [1M]
   (C.O.NO.2) [Comprehension]

   b) Name the pumping mechanism used in the above mentioned laser. [1M]
   (C.O.NO.2) [Comprehension]

   c) Explain the construction and working of the above mentioned laser system with the help of necessary diagrams. [10M]
   (C.O.NO.2) [Comprehension]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: I

Course Code: PHY 101

Course Name: Engineering Physics

Date: 16-11-2019

Time: 9.30 am to 10.30 am

Max Marks: 30

Weightage: 15

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	CO 2	Module 2		2								2
2	CO 2	Module 3		2								2
3	CO 2	Module 3		2								2
4	CO 2	Module 2		2								2
5	CO 2	Module 3					5					5
6	CO 2	Module 3					5					5
7	CO 2	Module 2								12		12
	Total Marks											30

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SOLUTION

Date: 16- 11-2019

Semester: I

Time: 9.30 AM to 10.30 AM

Course Code: PHY 101

Max Marks: 30

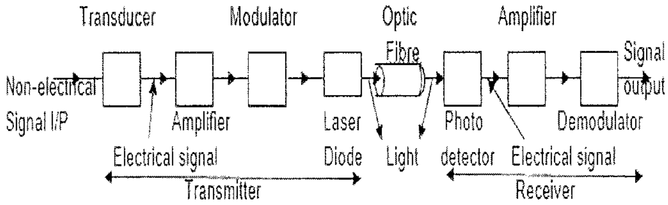
Course Name: **Engineering Physics**

Weightage:15%

Part A (4Q x 2M = 8Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	The absorption of an incident photon by an atom, as a result of which atom makes a transition from ground state to an excited state is called Induced absorption. The interaction of photon of relevant energy with an excited atom triggers the excited atom to drop to the lower energy state giving up a photon is called Stimulated emission.	1 mark for each definition	**3**
2	When a ray of light travels from a denser medium to rarer medium and the angle of incidence is greater than critical angle, the ray will be completely reflected back into the same medium. This is called TIR.	2 marks	**3**
3	Single mode and multi-mode	1 mark for each	**3**
4	An artificial situation in which the number of atoms in the excited state are greater than number atoms in the ground state is called as population inversion	2 marks	**3**

Part B (2Q x 5M = 10 Marks)

<table>
<tr><th>Q No</th><th>Solution</th><th>Scheme of Marking</th><th>Max. Time required for each Question</th></tr>
<tr><td>5</td><td>

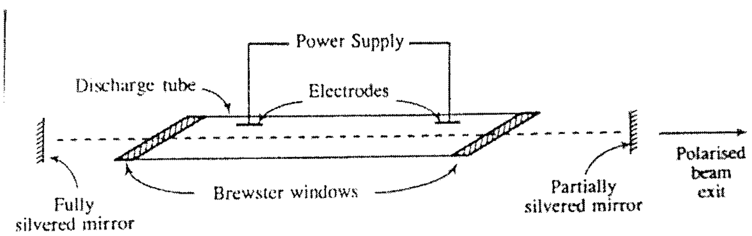
(Bock diagram of Optical Fibre Communication System)

The non-electrical signal such as sound, to be communicated over a long distance, is first converted into an electrical signal using a transducer (say, microphone).
The electrical signal is then amplified using electronic amplifiers and modulated with a high frequency electrical signal.
The modulated signal is then fed to a laser diode, which converts the signal into corresponding optical signal.
The light signal is transmitted through an optic fiber.
At the receiver, the light signal is fed to a photo-detector, which converts it into electrical signal.
This is amplified, demodulated and then fed to a transducer (say, loud speaker) which converts the electrical signal back to the original sound signal.
If it is transfer of digital data from one computer to another, then there is no need for the transducer, as the input and output signals are both electrical.
</td><td>2 Marks for Labelled Diagram

Explanation – 3 Marks</td><td>10 Minutes</td></tr>
<tr><td>6</td><td>Given n_1= 1.51
n_2= 1.49
$$NA = \sqrt{n_1{}^2 - n_2{}^2}$$
Ans = 0.244
$$\theta_0 = Sin^{-1}(NA)$$
Ans =14.17°</td><td>Given Data 1 Mark
NA formula 1 Mark
Substitution 0.5 mark
Ans NA 0.5 Mark

Acceptance angle formula 1 Mark
Substitution 0.5 mark
Ans 0.5 Mark</td><td>10 Minutes</td></tr>
</table>

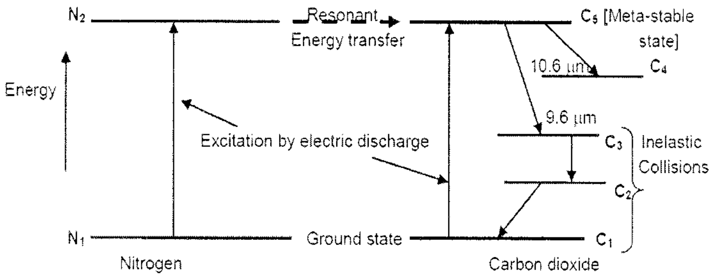
Part C (1Q x 12M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7 i	CO_2 Laser	1 Mark	20 Minutes
7 ii	Electric discharge	1 Mark	
7iii	Construction The carbon dioxide laser consists of a tube of about 25 cm length and 2.5 cm diameter. • The ends of the tube are closed with Brewster's windows which gives makes the laser beam plane polarized. • Beyond the windows are arranged mirrors of which one is perfectly reflecting and the other is partly reflecting. This forms the resonant cavity. • The active medium in this laser is a mixture of CO_2, N_2 and He gases in the ratio 1:2:3, with pressures 0.32, 1.2 and 7 mm of Hg respectively.  CARBON DIOXIDE LASER Working 1. When a high D. C. voltage is applied to the gas, electric discharge takes place through the gas mixture, during discharge many electrons are rendered free from the gas atoms. These free electrons collide with N_2 and CO_2 molecules, so these molecules absorb energy and get excited to higher energy levels. It is called collision of first kind Here, $e_1 + N_2 \rightarrow e_2 + N_2^*$ Where e_1 and e_2 are the energy values of the electrons before and after collision, N_2 and N_2^* are the energy values of N_2 molecules in the ground and v=1 state. 2. There is a close coincidence in energy of energy levels of CO_2 and v=1 state of N_2 molecule and hence more CO_2 molecules are raised to the level E_5 by collision with N_2 molecules. This transfer of energy between N_2 and	2 marks for construction diagram 2 marks for explanation Energy level diagram 2 Marks Explanation 4 Marks	

CO_2, in the excited states, is called **resonant energy transfer**. And this type of collision is known as collision of second kind.

$CO_2 + N_2^* \rightarrow CO_2^* + N_2$

3. Thus the population of E5 state of CO_2 increases rapidly which leads to population inversion between E_5 level with respect to the E_3 and E_4 levels.
4. Transition from the level E_5 to E_4 produces laser of wavelength **10.6 μm** and that from E_5 to E_3 results in a laser beam of wavelength **9.6 μm**. Both these radiations lie in the IR region.
5. E_2 level has a tendency of being over populated as not only molecules from E_3 and E_4 but molecules from E_1 also accumulate there by absorbing thermal energy. This adversely affect the population inversion for E_5 level.
6. CO_2 molecules in E_2 level undergo collisions with He present in the tube and comes back to ground state and further laser emission continues.
7. Helium gas has excellent thermal conductivity and transfers the heat of discharge to the tube wall.
8. The discharge tube containing the gas mixture is continuously cooled by circulating water



Energy level diagram

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SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20
Course Code: PHY 101
Course Name: ENGINEERING PHYSICS
Program & Sem: B.Tech (Physics Cycle), & I

Date: 28 December 2019
Time: 9:30 AM TO 12:30 PM
Max Marks: 100
Weightage: 50%

Instructions:

(i) Read all the questions carefully and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and Non-programmable calculators are permitted.
(iv) Given : Planck's constant $h = 6.625\times10^{-34}$ *Js; Boltzmann's constant* $k_B = 1.38\times10^{-23}$ *J/K, Speed of light* $c = 3\times10^{8}$ *m/s, Mass of the electron* $m = 9.1\times10^{-31}$ *kg, Charge of the electron* $e = 1.6\times10^{-19}$ *C*

Part A [Memory Recall Questions]

Answer all the Questions. **(30 Marks)**

1. Fill in the blanks **(15Qx1M=15M)**

(a) Acronym LASER stands for --------------- (C.O.No.2) [Knowledge]

(b) The emission of photon without being aided by any external agency is called----------- (C.O.No.2) [Knowledge]

(c) Transmission of light in the optical fiber is based on the principle of------------ (C.O.No.2) [Knowledge]

(d) The maximum angle below which a ray of light can enter through one end of the fiber and get totally internally reflected inside the core of the fiber is called -------------- (C.O.No.2) [Knowledge]

(e) When the light enters from denser to rarer medium, the light bends-------from the normal. (C.O.No.2) [Knowledge]

(f) ----------converts light signal into electrical signal in point to point communication system. (C.O.No.2) [Knowledge]

(g) The de Broglie wavelength (λ) associated with a particle having mass 'm' and velocity 'v' is given by the relation------------- (C.O.No.3) [Knowledge]

(h) The rate at which the phase of the wave propagates in space is called--------------- (C.O.No.3) [Knowledge]

(i) Superconductors are those materials whose--------------falls to zero below critical temperature. (C.O.No.1) [Knowledge]

(j) According to BCS theory, the cooper pair is pair of------------ (C.O.No.1) [Knowledge]

(k) A semiconductor in its purest form is called------------ (C.O.No.1) [Knowledge]

(l). -----------polarization occurs due to the displacement of the positively charged nucleus and the negatively charged electrons of an atom in the opposite directions when an electric field is applied. (C.O.No.1) [Knowledge]

(m) -----------polarization occurs in liquids or solids which possess molecules with permanent dipole moment (i.e., in polar dielectrics) (C.O.No.1) [Knowledge]

(n) Solar cell is a device which converts light energy into------------energy (C.O.No.1) [Knowledge]

(o) The minimum magnetic field required to destroy the superconductivity in the material is called------------- (C.O.No.1) [Knowledge]

2. (a) Mention the characteristic properties of matter waves. [3M] (C.O.No.3) [Knowledge]

(b) What is group velocity? [2M] (C.O.No.3) [Knowledge]

3. (a) What is attenuation? Mention the causes of attenuation in optical fibers [3M] (C.O.No.2) [Knowledge]

(b) Define efficiency of solar cell. [2M] (C.O.No.1) [Knowledge]

4. (a) What is Meissner effect? [3M] (C.O.No.1) [Knowledge]

(b) Define fill factor of a solar cell [2M] (C.O.No.1) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 8 marks. (5Qx8M=40M)

5. (a) Derive the relation between group velocity (V_g) and phase velocity (V_p). [5M] (C.O.No.3) [Comprehension]

(b) The trotting speed of an elephant is 10 m/s. Calculate the associated de Broglie wavelength. (Mass of the elephant = 1000 kg). [3M] (C.O.No.3) [Application]

6. Explain in detail the types of polarization in dielectrics. [8M] (C.O.No.1) [Comprehension]

7. (a) Explain the principle and working of semiconductor laser with neat diagram. [6M] (C.O.No.2) [Comprehension]

(b) Calculate the minimum energy of an electron in an infinite deep potential well of width 4 nm. [2M] (C.O.No.3) [Application]

8. (a) A step index fiber has a numerical aperture of 0.26, core refractive index of 1.5 and core diameter of 100 μm. Calculate the refractive index of cladding.

[4M] (C.O.No.2) [Application]

(b) The ratio of population of two energy levels is 10^{-30}. Find the wavelength of light emitted at 300 K. [4M] (C.O.No.2) [Application]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A	
1 (a)	CO2	02	01			01
(b)	CO2	02	01			01
(c)	CO2	03	01			01
(d)	CO2	03	01			01
(e)	CO2	03	01			01
(f)	CO2	03	01			01
(g)	CO3	04	01			01
(h)	CO3	04	01			01
(i)	CO1	01	01			01
(j)	CO1	01	01			01
(k)	CO1	01	01			01
(l)	CO1	01	01			01
(m)	CO1	01	01			01
(n)	CO1	01	01			01
(o)	CO1	01	01			01
2	(a) CO3	03	03			03

	(b)CO1	01	02			02
3	(a) CO2 (b) CO1	03 01	03 02			03 02
4	(a) CO1 (b) CO1	01 01	03 02			03 02
5	(a) CO3 (b) CO3	04 04		5	03	08
6	CO1	01		08		08
7	(a) CO2 (b) CO3	02 05		06	02	08
8	(a) CO2 (b) CO2	03 02			04 04	08
9	(a) CO3 (b) CO1	04 01	03	05		08
10	CO3	05		10		10
11	CO3	05		10		10
12	CO2	03		10		10
13	CO2	02		10		10
	Total Marks		33	64	13	110

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature:

Reviewer Commend:

SCHOOL OF ENGINEERING

SOLUTION

Semester: Odd Sem. 2019-20
Course Code: PHY 101
Course Name: Engineering Physics
Program & Sem: B.Tech, I SEM

Date: 28.12.2019
Time: 3 HRS
Max Marks: 100
Weightage: 50%

Part A (30 Marks)

Q No	**Solution**	**Scheme of Marking**	**Max. Time required for each Question**
1 (a)	Light amplification by stimulated emission of radiations	01	01 min
(b)	Spontaneous emission	01	01 min
(c)	Total internal reflection	01	01 min
(d)	Acceptance angle	01	01 min
(e)	Away	01	01 min
(f)	Photo detector	01	01 min
(g)	$\lambda = \frac{h}{mv}$	01	01 min
(h)	Phase velocity	01	01 min
(i)	Resistivity	01	01 min
(j)	Electron-electron	01	01 min
(k)	Intrinsic semiconductor	01	01 min
(l)	Electronic	01	01 min
(m)	Orientation	01	01 min
(n)	Electrical	01	01 min
(o)	Critical magnetic field	01	01 min
2	(a) Matter waves are the waves that are associated with a moving particle. The wavelength λ of the waves are given by	03	03 min

	$\lambda = \frac{h}{mv}$ where 'm' is the mass of the particle and 'v' is the velocity of the particle. Lighter is the particle, greater is the wavelength associated with it. Smaller is the velocity of the particle, greater is the wavelength associated with it. Matter waves are independent of the charge of the particles. The velocity of matter waves depends on the velocity of particle. i.e., it is not a constant, while the velocity of electromagnetic wave is constant (b) Group velocity is the velocity of the wave packet which is formed due to superposition of two or more traveling waves of slightly different wavelengths. Or Group Velocity is the velocity with which the envelope of the wave packet, propagates through space	2	03 min
3	(a) The loss of power of optical signals in the fibre during transmission is known as attenuation. 1) Absorption 2) Scattering 3) Radiation Loss or Bending Loss (b) Efficiency of a solar cell can be defined as the ratio of maximum output electrical power converted by the solar cell to the total input optical power available for energy conversion.	03 02	03 min 03 min
4	(a) A superconducting material kept in a weak magnetic field expels the magnetic flux out of its body when it is cooled below the critical temperature and thus becomes perfect diamagnetic. This effect is called Meissner effect. (b)The fill factor of a solar cell is defined as the ratio of the maximum output power of solar cell to the ideal power.	03 02	03 min 03 min

Part B (5Q x 8M = 40 Marks)

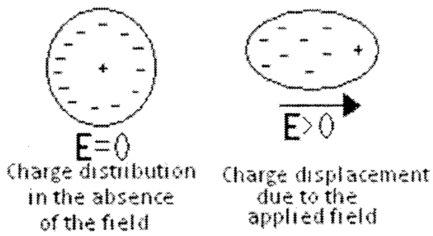
Q No	Solution	Scheme of Marking	Max. Tim required for each Question
5	(a) We have the equation for group velocity and phase velocity as $V_g = \frac{d\omega}{dk}$ ---------- (1) $V_P = \frac{\omega}{k}$ ------------ (2) Where 'ω' is the angular frequency of the wave and 'k' is the propagation constant From equation (2) $\omega = V_p k$ $\therefore V_g = \frac{d\omega}{dk} = \frac{d}{dk}(V_P k)$	 01 01	10 min

	$V_g = V_P + k \frac{dV_p}{dk}$ $= V_P + k \frac{dVp}{d\lambda} . \frac{d\lambda}{dk}$ ----------- (3) [÷, × by dλ] But $k = \frac{2\pi}{\lambda}$ $\frac{dk}{d\lambda} = 2\pi \frac{d}{d\lambda}\left(\frac{1}{\lambda}\right) = -2\pi \frac{1}{\lambda^2}$ $\therefore \frac{d\lambda}{dk} = -\frac{\lambda^2}{2\pi}$ Hence equation (3) because $V_g = V_p + \frac{2\pi}{\lambda} \frac{dV_p}{d\lambda}\left(-\frac{\lambda^2}{2\pi}\right)$ $V_g = V_p - \lambda \frac{dV_p}{d\lambda}$ $\therefore V_g < V_p$ (b) Sol: m = 1000 kg, v = 10 m/s $\lambda = \frac{h}{mv}$ $\lambda = 6.625 \times 10^{-38}$ m	01 01 01 01 01 01	05 min
6	**<u>Electronic polarization</u>** **Electronic polarization occurs due to the displacement of the positively charged nucleus and the negatively charged electrons of an atom in the opposite directions when an electric field is applied.** The dipole moment-μ due to electronic polarization is proportional to the applied electrical field strength (E).	02	15 min

$$\mu_e \propto E$$

$$\mu_e = \alpha_e E$$

μ_e is the dipole moment due to electronic polarization E is applied the electric field and α_e is called the electronic polarizability. Electronic polarization is independent of temperature. Electronic polarization takes place in almost all dielectrics. Electronic polarization sets in very quickly because it involves the displacement of lighter electron cloud. It also disappears quickly after the electric field is switched off.



Electronic polarization

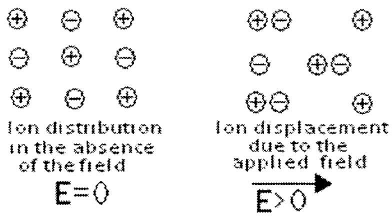
Ionic polarization

Ionic polarization is due to the displacement of the positively and negatively charged ions in the ionic crystal in the opposite directions when the electric filed is applied.

For example, when electric field is applied to ionic crystals like NaCl and KCl- ionic polarization sets in. Ionic polarization is independent of temperature.Ionic polarization sets in slowly as it involved the movement of ions which are relatively heavier. 02

$$\mu_i = \alpha_i E$$

Where, μ_1 is the dipole moment due to ionic polarization, α_i is the ionic polarizability and E is the applied electric field.



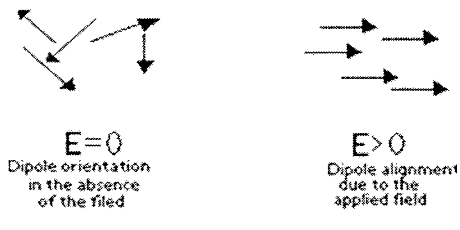
Ionic polarization

Orientation polarization

Orientation polarization occurs in liquids or solids – which possess molecules with permanent dipole moment (i.e., in polar dielectrics). The orientation of these molecules will be random normally due to thermal agitation.Because of the randomness in orientation, the material has net zero dipole moment.**But under the influence of an applied electric field, each of the dipoles undergo rotation so as to reorient along the direction of the field because of which, the overall cancellation of dipole moments due to randomness does not hold good any more.Thus the material acquires electrical polarization**. Orientation polarization depends strongly on the temperature.Orientation polarization takes more time to set than ionic polarization. 02

$$\mu_O = \alpha_O E$$

where μ_o is dipole moment due to orientation polarization, α_o is the orientational polarizability and applied electric field E.



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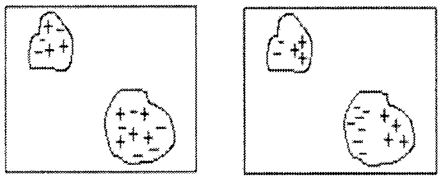
Orientational polarization

Space charge polarization

Space charge polarization occurs due to the accumulation of charges at the interfaces in multiphase dielectrics.It occurs in ferrites and semiconductors.The value of space charge polarization is very small compared to other types of

	polarizations.The space charge polarization is not an important factor in most dielectrics .  E=0 E>0 **Space charge polarization**	02	
7	(a) Consider a two level energy system with ground state energy E_1 and excited state energy E_2. Let N_1 and N_2 be the number densities of atoms in the ground state and excited state respectively. Let photons of energy $hv= (E2 - E1)$ and having energy density (v) be incident on the system. This interaction of radiation with matter results in three processes. 1. **Stimulated Absorption**:	0.5 0.5	10 min

When an incident radiation falls on a system, the atoms in the lower energy level will absorb the radiation and move to excited level – stimulated (induced) absorption.
The rate at which this absorption takes place (Y_{12}) is proportional to the number of atoms in the lower energy level (N_1) and the energy density (ε) of incident radiation.
i.e, $Y_{12} \propto N_1$ and $Y_{12} \propto \varepsilon(\upsilon)$
Combining these eqns:
$\boldsymbol{Y_{12} = B_{12} N_1 \, \varepsilon(\upsilon)}$ ....(1)
Where B_{12} is a constant of proportionality that depends on E_1 and E_2

2. Spontaneous Emission:
An atom in the excited state, of energy E_2, makes a transition to the ground state, of energy E_1, on its own within a fraction of a second, typically 10^{-9} s, resulting in the emission of radiation of energy $E_2 - E_1$. This is known as spontaneous emission. 0.5
The rate at which this emission takes place (W_{21}) is proportional to the number of atoms in the energy level E_2
ie, $W_{21} \propto N_2$
Or $\boldsymbol{W_{21} = A_{21} N_2}$ ....(2) where A_{21} is the constant of proportionality.

3. Stimulated Emission:
The de-excitation of an atom from higher energy level to lower energy level with the help of an incident photon is known as stimulated emission.
The rate at which this emission takes place (Y_{21}) is proportional to the number of atoms in the energy level E_2 and the incident energy density. 0.5
ie, $Y_{21} \propto N_2 \varepsilon(\upsilon)$
Or
$\boldsymbol{Y_{21} = B_{21} N_2 \varepsilon(\upsilon)}$.........(3)
Where B_{21} is the constant of proportionality

Let, the system be in **thermal equilibrium**, i.e. total energy of the system remains unchanged.
So, Absorption = Emission
Rate of absorption = Rate of spontaneous emission + Rate of stimulated emission
Using equations 1, 2, 3
$Y_{12} = W_{21} + Y_{21}$............(4)
$B_{12} N_1 \varepsilon(\upsilon) + A_{21} N_2 = B_{21} N_2 \varepsilon(\upsilon)$
$so, (B_{12} N_1 - B_{21} N_2)\, \varepsilon(\upsilon) = A_{21} N_2$

$$\text{So. } \varepsilon(\upsilon) = \frac{A_{21} N_2}{(B_{12} N_1 - B_{21} N_2)}$$

$$\text{by rearranging we get } \varepsilon(\upsilon) = \frac{A_{21}}{\left(N_1/N_2\right) B_{12} - B_{21}}$$

02

$$= \frac{A_{21}}{B_{21}} \left[\frac{1}{\frac{B_{12} N_1}{B_{21} N_2} - 1} \right] \text{.........(5)}$$

From Boltzmann's relation,

	$\frac{N_1}{N_2} = e^{(E_2 - E_1)/k_B T} = e^{h\upsilon/k_B T}$ Therefore $\varepsilon(\upsilon) = \frac{A_{21}}{B_{21}}\left[\frac{1}{\frac{B_{12}}{B_{21}} e^{h\nu/kT} - 1}\right]$ ....(6) According to Max Planck, if $\varepsilon(\upsilon)$ is the energy density (energy/unit volume) emitted by the black body through radiation of frequency ν, at a temperature T, then $\varepsilon(\nu) = \frac{8\pi h\nu^3}{c^3}\left[\frac{1}{e^{h\nu/kT} - 1}\right]$ ....(7) Comparing eqns (5) and (6), we have $\frac{A_{21}}{B_{21}} = \frac{8\pi h\nu^3}{c^3}$ and $\frac{B_{12}}{B_{21}} = 1$, or $B_{12}=B_{21}$ So, dropping subscripts, we refer A_{21} and B_{21}, B_{12} as A and B respectively. Hence, at thermal equilibrium the equation of energy density is $\varepsilon(\nu) = \frac{A}{B\left[e^{h\nu/kT} - 1\right]}$ ....(8) (b) L = 4 nm = 4×10^{-9} m We know for minimum energy n=1 $E_n = \frac{n^2 h^2}{8mL^2}$ $= \frac{(6.625\times10^{-34})^2}{(8\times9.1\times10^{-31}\times(4\times10^{-9})^2)}$ $= 3.764\times10^{-21}$ J = 0.0235 eV.	01 01 01 01	05 min
8	(a) $n_1 = 1.5$, NA = 0.26 $NA = \sqrt{n_1^2 - n_2^2}$ $0.26 = \sqrt{1.5^2 - n_2^2}$ $0.26^2 = 1.5^2 - n_2^2$ $n_2 = \sqrt{1.5^2 - 0.26^2}$ $n_2 = \mathbf{1.477}$	01 01 01 01	7 mir
	(b) Given: $N_2/N_1 = 10^{-30}$, T = 300 K, λ = ? We have, $\frac{N_2}{N_1} = e^{-h\nu/kT} = e^{-hc/\lambda kT}$ Taking natural logarithm. ln(10^{-30}) = - h c / λ k T = - 6.625 x 10^{-34} x 3 x 10^{8}/ λ 1.38 x 10^{-23} x 300. i.e , - 69.0775 = - 0.048 x 10^{-3}/ λ Hence, λ = 0.048 x 10^{-3}/69.0775 = 6.9498 x 10^{-7} m = <u>6949.8 Å</u>	01 01 01 01	8 min

<table>
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(a) We have the expression for group velocity as,
$V_g = \frac{d\omega}{dk}$ --------------------------- (1)
But $\omega = 2\pi\gamma = 2\pi \frac{E}{h}$ ------------------ (2) $[\because E = h\gamma \Rightarrow \frac{E}{h}]$
$\therefore d\omega = \left(\frac{2\pi}{h}\right) dE$ ---------------------- (3)
Also $K = \frac{2\pi}{\lambda} = 2\pi \frac{P}{h}$ ----------------- (4) $[\because \lambda = \frac{h}{p} \Rightarrow \frac{1}{\lambda} = \frac{P}{h}]$
$\therefore dK = \left(\frac{2\pi}{h}\right) dP$ ---------------------- (5)

Dividing Equation (3) by equation (5)
$\frac{d\omega}{dk} = \frac{\left(\frac{2\pi}{h}\right) dE}{\left(\frac{2\pi}{h}\right) dP}$
$\therefore \frac{d\omega}{dk} = \frac{dE}{dP}$ -------------------------- (6)
But we know that, $E = \frac{P^2}{2m}$ where P is the momentum of the particle
$\therefore \frac{dE}{dP} = \frac{2P}{2m}$ or $\frac{dE}{dP} = \frac{P}{m}$
But $P = mv_{particle}$, where $v_{particle}$ is the velocity of the particle
$\therefore \frac{dE}{dP} = \frac{mv_{particle}}{m}$
$\frac{dE}{dP} = v_{partilce}$ ------------------------ (7)
From equation (1), (6) and (7)
$\Rightarrow v_g = \frac{d\omega}{dk} = \frac{dE}{dp} = v_{particle}$ $\therefore v_g = v_{particle}$
$\therefore$ The de Broglie wave group associated with a particle travels with a velocity equal to the velocity of the particle itself.
(b)
1. The energy values of the conduction electrons are quantized. The allowed energy values are realized in terms of a set of energy levels.
2. The distribution of electrons in the various allowed energy levels occurs as per Pauli Exclusion Principle.
3. The free electrons travel in a constant potential inside the metal but stay confined within its boundaries.
4. The attraction between the free electrons and the lattice ions, and the repulsion between the electrons themselves are ignored.
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Part C

(3Q x 10M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time require for eac Questi
10	Consider a particle of mass m moving with velocity 'v'. The de-Broglie wavelength associated with the particle is $\lambda = \frac{h}{p}$. If we consider the particle is moving only along x-axis (one –dimensional) and exhibiting simple harmonic wave pattern the travelling wave equation can be written as $\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2}$	01	24 mi
	The solution of the above eqn is $y = Ae^{i(kx-\omega t)}$, where y is displacement, ω is angular frequency, A is amplitude of wave, v is velocity of wave. Analogous to this, the equation of the travelling wave in the present case is $\frac{d^2\Psi}{dx^2} = \frac{1}{u^2}\frac{d^2\Psi}{dt^2}$ ....(1) Solution of the equation(1) is $\Psi = \Psi_0 e^{i(kx-\omega t)}$ ...(2), where Ψ_0 is constant.	02	
	Differentiating eqn(2) w.r.t. t twice, we get $\Rightarrow \frac{\partial \psi}{\partial t} = -i\omega\Psi_0 e^{i(kx-\omega t)}$. $\Rightarrow \frac{\partial^2 \psi}{\partial t^2} = i^2\omega^2\Psi_0 e^{i(kx-\omega t)} = -\varpi^2\Psi$..........(3), $\because i^2 = -1$ Substitute eqn(3) in (1) $\Rightarrow \frac{\partial^2 \psi}{\partial x^2} = -\frac{\varpi^2}{u^2}\Psi$..........(4) now $\varpi = 2\pi\nu, u = \nu\lambda$ where ν is the frequency of matter wave and λ is de-Broglie wavelength given by $\lambda = \frac{h}{p}$	02	
	Putting the values in (4) we get $\frac{\partial^2 \psi}{\partial x^2} = -\frac{4\pi^2\nu^2}{\nu^2\lambda^2}\Psi = -\frac{4\pi^2 p^2}{h^2}\Psi$ $\frac{\partial^2 \psi}{\partial x^2} + \frac{4\pi^2 p^2}{h^2}\Psi = 0$..............(5)	02	
	The total energy of the particle in non-relativistic case is E=K.E.+P.E. $E = \frac{1}{2}mv^2 + V$ Since p=mv, $E = \frac{p^2}{2m} + V \Rightarrow p^2 = 2m(E-V)$	02	
	Substituting in eqn(5) $\frac{\partial^2 \psi}{\partial x^2} + \frac{4\pi^2 \times 2m(E-V)}{h^2}\Psi = 0$		

01

Hence $\frac{\partial^2\psi}{\partial x^2} - \frac{8\pi^2 m(E-V)}{h^2}\Psi = 0$

This equation represents the time independent Schrödinger wave equation.

Since only the space coordinate 'x' appears in the equation, partial derivative can be replaced by total derivative and then the above equation can be written as:

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m(E-V)}{h^2}\Psi = 0 \quad \text{......................(6)} \quad \text{Or}$$

$$\frac{d^2\psi}{dx^2} + \frac{2m(E-V)}{\hbar^2}\Psi = 0, where.\ \hbar = \frac{h}{2\pi}$$

11

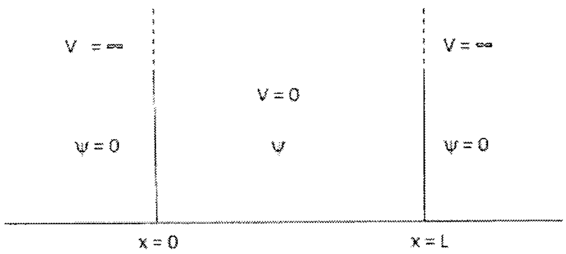
Particle in a one dimensional potential well of infinite height.

24 mi

[Derive the expression for wave function of a particle in an infinite potential well]

Consider a one dimensional problem in which a particle of mass 'm' moving with speed 'v' along x-axis is confined to a box of length (width) L with perfectly rigid walls at x=0 and x=L. Within x=0 and x=L, its potential V will be zero, outside this region, it is taken to be infinite.

02



As the particle is confined to the box and does not exist at the walls and beyond them, the wave function exists only within the box. In other words, $\psi = 0$ for $x \le 0$ and $x \ge L$ and $\psi = \psi$, for $0 < x < L$.

Such a configuration of potential in space is called infinite potential well. A particle bound within such an infinite potential well defined in three dimensions is referred to as particle in a box.

Schrödinger's time independent equation is:

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m(E-V)}{h^2}\psi = 0$$

01

Putting V = 0, for 0 < x < L, the equation becomes,

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 mE}{h^2}\psi = 0 \quad \text{--------------------------- (1)}$$

$$\text{Put, } \frac{8\pi^2 mE}{h^2} = K^2 \quad \text{--------------------------- (2)}$$

Then equation (1) becomes, $\frac{d^2\psi}{dx^2} + K^2\psi = 0$ --------------------------- (3)

02

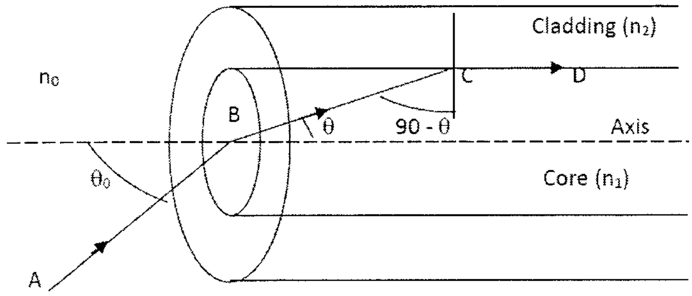
The general solution to equation (3) is of the form,

ψ = A Sin Kx + B Cos Kx --------- (4),

	where A and B are arbitrary constants and can be evaluated by applying the boundary conditions. Applying the boundary condition, $\psi = 0$ for $x = 0$, the above equation becomes: $0 = A \sin 0 + B \cos 0$, or, $B = 0$. Then equation (4) becomes, $\psi = A \sin Kx$ ------------------------ (5) Now, applying the boundary condition $\psi = 0$ for $x = L$, equation (5) becomes, $0 = A \sin KL$ ---------------------- (6) In the above equation, $A \neq 0$, and therefore $\sin KL = 0$. Or, $KL = n\pi$, where n = 1, 2, 3, ... $\therefore K = \frac{n\pi}{L}$ --------------------- (7) Substituting eq. (7) in eq. (5), the wave function of the particle is:	02	
	$\psi = A Sin\left(\frac{n\pi x}{L}\right)$ --------- (9) To normalize the wave function, let us evaluate $\int_0^L \psi^2 dx$. $\int_0^L \psi^2 dx = \int_0^L A^2 Sin^2\left(\frac{n\pi x}{L}\right)dx = A^2 \int_0^L \left[\frac{1 - Cos\left(\frac{2n\pi x}{L}\right)}{2}\right]dx$ $= \frac{A^2}{2}\left[x - \frac{Sin\left(\frac{2n\pi x}{L}\right)}{\left(\frac{2n\pi}{L}\right)}\right]_0^L$ $= \frac{A^2}{2}(L - 0) = \frac{A^2 L}{2}$ For the function to be normalized, $\int_0^L \psi^2 dx = 1$. Or, $\frac{A^2 L}{2} = 1$, or, $A^2 = \frac{2}{L}$ and hence $A = \sqrt{\frac{2}{L}}$ Substituting the value of A in eq. (9), we get **the normalized wave function** as: $\psi_n = \sqrt{\frac{2}{L}} Sin\left(\frac{n\pi x}{L}\right)$ ------(10)	03	

12 **Expression for Numerical Aperture**: 24 mi

Consider a ray of light AB entering an optical fibre at an angle of incidence equal to the acceptance angle θ_0. It proceeds along BCD, as shown in figure. 02



Applying Snell's law for refraction at B, 02

$$n_0 \sin\theta_a = n_1 \sin\theta$$

$$\text{Or, } \sin\theta_a = \frac{n_1}{n_0}\sin\theta \text{ ------------------------------ (1)}$$

At C, the angle of refraction is 90°. Hence for refraction at C,

$$n_1 \sin(90-\theta) = n_2 \sin 90$$

$$\text{Or, } \cos\theta = \frac{n_2}{n_1}$$

$$\therefore \sin\theta = \sqrt{1-\cos^2\theta} = \sqrt{1-\left(\frac{n_2}{n_1}\right)^2}$$ 03

$$\text{Or, } \sin\theta = \frac{\sqrt{n_1^2-n_2^2}}{n_1}$$

Substituting this in eq. (1), we get,

$$\sin\theta_0 = \frac{n_1}{n_0}\times\frac{\sqrt{n_1^2-n_2^2}}{n_1} = \frac{\sqrt{n_1^2-n_2^2}}{n_0} \text{ -------------- (2)}$$

But, $\sin\theta_0$ = numerical aperture (NA)

$$\therefore \boxed{NA = \frac{\sqrt{n_1^2-n_2^2}}{n_0}}$$ 03

If the surrounding medium is air, $n_0 = 1$ and therefore,

$$\boxed{NA = \sqrt{n_1^2 - n_2^2}}$$

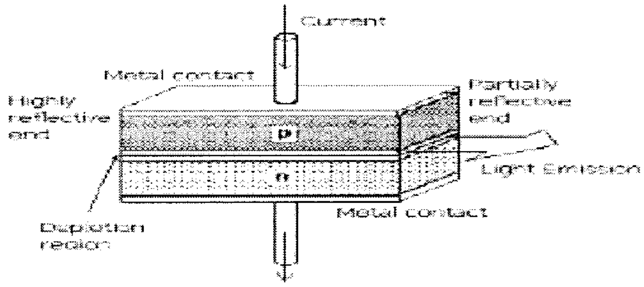
13 **Principle: Radiative recombination** 01 24 mi

- When the junction is forward biased, holes from p region move towards n region and electrons from n region move towards p region and the recombine with each other.
- During the recombination process, the light radiation (photons) is released from a certain specified direct band gap semiconductors like Ga-As.

- This light radiation is known as recombination radiation.
- The photon emitted during recombination stimulates other electrons and holes to recombine. As a result, stimulated emission takes place which produces laser.

Construction

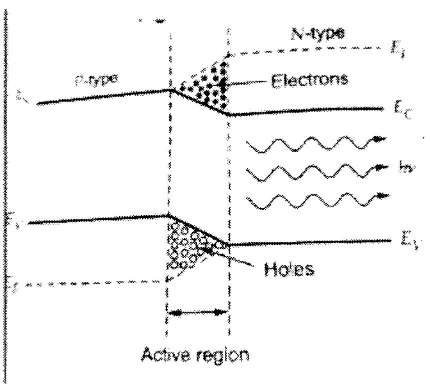
A semiconductor laser is a specially fabricated pn junction device (both the p and n regions are highly doped) which emits coherent light when it is forward biased. It is made from Gallium Arsenide (GaAs) which operated at low temperature and emits light in near IR region. They are of very small size, each side is in the order of **1 mm**. The p and n regions are made from same semiconductor material (GaAs). The p type region is formed by doping with **zinc** atoms and n type by doping with **tellurium.** Doping concentration is very high in the order of $\mathbf{10^{17}}$ **to** $\mathbf{10^{19}}$ **atoms/cm^3**. The top and bottom faces has metal contacts to pass the current. The front and rare faces are polished to constitute the resonator 02



02

Working:

- When the junction is forward biased, at low voltage the electron and hole recombine and cause spontaneous emission.
- But when the forward voltage reaches a threshold value the carrier concentration rises to very high value. 03
- As a result the junction contains large number of electrons in the conduction band and at the same time large number of holes in the valence band.
- Thus the upper energy level has large number of electrons and the lower energy level has large number of vacancy, thus population inversion is achieved.
- The recombination of electron and hole leads to spontaneous emission and
- When the forward – biased voltage is increased, more and more light photons are emitted and the light production instantly becomes stronger. These photons will trigger a chain of stimulated recombination resulting in the release of photons in phase.
- The photons moving at the plane of the junction travels back and forth by reflection between two sides placed parallel and opposite to each other and grow in strength.
- The wavelength of laser light is given by $\lambda = \frac{hc}{E_g}$



Under forward bias 02

9. Show that group velocity of de Broglie wave is equal to particle velocity
[8M] (C.O.No.3) [Comprehension]

Part C [Problem Solving Questions]

Answer any three Questions. Each Question carries 10 marks. **(3Qx10M=30M)**

10. Derive Schrodinger's time independent one dimensional wave equation.
(C.O.No.3) [Comprehension]

11. Derive an expression for normalized wave function for a particle in one dimensional potential well of infinite height, using Schrodinger's time independent wave equation.
(C.O.No.3) [Comprehension]

12. Derive an expression for numerical aperture in terms of refractive indices of core and cladding of an optical fiber. (C.O.No.2) [Comprehension]

13. Derive an expression for energy density at thermal equilibrium condition in terms of Einstein's coefficients
(C.O.No.2) [Comprehension]