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B.Tech. DEGREE EXAMINATION, JULY 2022
Fourth Semester

18ECE322T – OPTO ELECTRONICS

(For the candidates admitted from the academic year 2020-2021 to 2021-2022)

Note:

- (i) **Part - A** should be answered in OMR sheet within first 40 minutes and OMR sheet should be handed over to hall invigilator at the end of 40th minute.
- (ii) **Part - B** should be answered in answer booklet.

Time: 2½ Hours

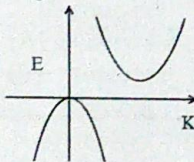
Max. Marks: 75

PART – A (25 × 1 = 25 Marks)

Marks BL CO PO

Answer **ALL** Questions

- If 'h' is planck's constant and 'c' is velocity of light in vacuum, then band gap wavelength (λ_g) and band gap energy (E_g) are related as
 (A) $\lambda_g = hc / E_g$ (B) $\lambda_g = hc.E_g$
 (C) $\lambda_g = E_g / hc$ (D) $\lambda_g = \frac{1}{hc / E_g}$
- A junction between two different semiconductor crystals with different bandgaps is called _____
 (A) Homojunction (B) Heterojunction
 (C) Double heterojunction (D) Double homojunction
- What can you infer about the semiconductor material from the given E-K diagram?



- It is a direct bandgap semiconductor with effective electron mass greater than hole mass
 - It is an indirect bandgap semiconductor with effective electron mass lesser than the hole mass
 - It is an indirect bandgap semiconductor with effective electron mass greater than hole mass
 - It is a direct band gap semiconductor with effective electron mass lesser than hole mass
- If ' R_r ' denotes radiative recombination rate per unit volume and ' Δn ' denotes excess electron concentration, then radiative lifetime is expressed as
 (A) $\tau_r = R_r / \Delta n$ (B) $\tau_r = R_r . \Delta n$
 (C) $\tau_r = R_r - \Delta n$ (D) $\tau_r = \Delta n / R_r$
 - Find the value of Brewster angle for glass given that its refractive index in air is 1.5
 (A) 55.3° (B) 56.3°
 (C) 54.3° (D) 57.3°
 - Which of the following material is not suitable for making an LED?
 (A) Gallium Arsenide (B) Gallium Aluminum Arsenide
 (C) Indium Gallium Arsenide (D) Silicon Phosphide.

7. What is the penetration depth of the primary electrons in Zinc Sulphide (ZnS) material if the energy of incident beam is 5 KeV? (Note: for ZnS , $b=0.151$, and $K=1.2 \times 10^{-4}$)
 (A) $0.667 \mu m$ (B) $0.562 \mu m$
 (C) $0.744 \mu m$ (D) $0.682 \mu m$
8. In numerical display, for N elements the number of external connections required for a common anode method is
 (A) N (B) $N+1$
 (C) $N-1$ (D) N^2
9. The recombination zone in a semiconductor material is frequently called
 (A) Active region (B) Coupling region
 (C) Heterojunction region (D) Inactive region
10. Population inversion in a lasing medium is achieved when _____
 (A) Density of excited electrons > Density of excited electrons <
 Density of electrons in ground state Density of electrons in ground state
 (C) No pump is available (D) Density of excited electrons = 0
11. The responsivity of a given PIN photodiode is 0.65 A/W for a wavelength of 850 nm . What is the output photocurrent when incident optical power is $12 \mu W$?
 (A) $5.4 \mu A$ (B) $18.46 \mu A$
 (C) $7.8 \mu A$ (D) $6.5 \mu A$
12. The potential energy barrier for electrons moving from the metal to the semiconductor is called the _____
 (A) Space charge layer (B) Built-in potential
 (C) Schottky barrier height (D) Barrier layers
13. The simple configuration of avalanche photodiodes (APD) is _____
 (A) $n^+ p \pi p^+$ (B) $n p^+ \pi p^+$
 (C) $n^+ p^+ \pi p$ (D) $n^+ p^+ \pi p^+$
14. The photo detective elements used in array detector are called _____
 (A) Frames (B) Pixels
 (C) Arrays (D) Source
15. The penetration depth of the radiation into the photodetector is decided by _____
 (A) Absorption coefficient (B) Speed of light
 (C) Amount of light (D) Charge carrier at junction
16. The amount of rotation per unit length due to Faraday rotation is given by _____
 (A) $\theta = VB / L$ (B) $\theta = V / BL$
 (C) $\theta = VBL$ (D) $\theta = 1 / VBL$
17. An _____ allows light to pass in one direction and not in the opposite direction.
 (A) Optical circulator (B) Optical isolator
 (C) Optical coupler (D) Optical beam splitter
18. The Bragg and the Raman-Nath configurations, differ mainly in the _____ between the acoustic and optical waves.
 (A) Intensity (B) Interaction length
 (C) Polarization (D) Molecular vibration

19. In an acoustic optic modulator, if an optical beam of 633 nm wavelength is modulated with acoustic wavelength of $4.3 \times 10^{-5} m$, then the angle of diffraction is _____
 (A) 0.17° (B) 0.42°
 (C) 0.73° (D) 0.36°
20. An intense light beam of frequency ω passing through an appropriate crystal (quartz) generates a light beam of the frequency _____
 (A) $\left(\frac{1}{2}\omega\right)$ (B) 2ω
 (C) ω^2 (D) ω^4
21. High performance discrete devices can be efficiently integrated using _____
 (A) Hybrid integration (B) Vertical integration
 (C) Monolithic integration (D) Planar regrowth method
22. In the integrated optic high voltage sensor circuit if the two branches of the interferometer are covered by metal electrodes it forms a _____
 (A) Capacitive voltage divider (B) Inductive voltage divider
 (C) Resistive voltage divider (D) Capacitive voltage multiplier
23. In an integrated - optic Doppler velocimeter the Doppler effect produces a shift in the signal beam frequency from f_0 to $f_0 + f_s$, where f_s is given by
 (A) $f_s = 2\gamma / \lambda_0$ (B) $f_s = \gamma / 2\lambda_0$
 (C) $f_s = \gamma^2 / \lambda_0$ (D) $f_s = (\gamma / \lambda_0)^2$
24. Which of the following devices have two 3-dB couplers, where splitting of an incident beam takes place followed by recombination at the second 3-dB coupler?
 (A) Fabry-Perot interferometers (B) Interference filter based devices
 (C) Angular dispersion based devices (D) Mach-Zehnder interferometers
25. A commonly used electro-optic material is _____
 (A) $LiNbO_3$ (B) $LiNbO_2$
 (C) $LiNbO_3$ (D) Li_3NbO

PART - B (5 × 10 = 50 Marks)

Answer ALL Questions

- | | Marks | BL | CO | PO |
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| 26. a.i. Define snell's law and derive the same. | 6 | 3 | 1 | 1 |
| ii. The Cauchy dispersion relation for Zinc Selenide ($ZnSe$) is described by a Cauchy expression of the form $n = 2.4365 + \frac{0.0485}{\lambda^2} + \frac{0.0061}{\lambda^4} - 0.0003\lambda^2$ in which λ is in μm . What are the n_{-2} , n_0 , n_2 and n_4 coefficients? | 4 | 3 | 1 | 2 |
| (OR) | | | | |
| b.i. With neat energy band diagrams, explain the process of radiative and non-radiative recombinations inside a semiconductor. | 6 | 3 | 1 | 1 |
| ii. Optical beam irradiating GaAs semiconductor produces $0.5 \times 10^{23} cm^{-3} / s$ electron-hole pairs. The steady state concentration of photoelectrons is $\Delta_n = 10^{14} cm^{-3}$. | 4 | 3 | 1 | 2 |
| (1) Find the electron/hole recombination life time (τ). (2) Find the radiative recombination coefficient (B_r). | | | | |

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|----------|---|----|---|---|---|
| 27. a.i. | With neat energy band diagram explain the structure of double heterojunction LED. | 5 | 3 | 2 | 4 |
| ii. | Explain the optical feedback and threshold condition for laser oscillation. | 5 | 3 | 2 | 1 |
| (OR) | | | | | |
| b.i. | What is plasma display? Explain its principle of operation with neat diagram. | 5 | 3 | 2 | 1 |
| ii. | What is a LCD cell? How can it be used in LCD display devices? | 5 | 3 | 2 | 1 |
| 28. a. | Briefly discuss the construction and working of | | | | |
| (i) | Avalanche Photodiode (APD) | 5 | 3 | 3 | 1 |
| (ii) | Charge coupled device (CCD) | 5 | 3 | 3 | 1 |
| (OR) | | | | | |
| b.i. | Consider a InGaAs pin photodiode used in a receiver circuit with a load resistor of 27 k Ω . The total capacitance of the detector and the input of the amplifier together is 16 PF. The photodiode has a dark current of 2 nA. The incident radiation is 5 nW at 1550 nm, where the responsivity is 0.8 A/W. Assuming that the amplifier is noiseless, calculate the SNR at 27°C. | 5 | 4 | 3 | 2 |
| ii. | With a neat diagram, explain the construction and working of pin photodiode. | 5 | 3 | 3 | 1 |
| 29. a.i. | Define electro optic effect. Explain the working principle of dual channel waveguide electro optic modulator in detail. | 8 | 3 | 4 | 1 |
| ii. | Consider a SF57 dense flint glass rod which rotates the optical field of the 633 nm polarized laser beam from a He-Ne laser. If the crystal length is 2 cm, and the magnetic field is 0.9 T. What is the rotation of the optical field? (Note: Verdet constant of SF57 dense flint glass rod is 20 rad T ⁻¹ m ⁻¹). | 2 | 4 | 4 | 2 |
| (OR) | | | | | |
| b.i. | With neat diagram, explain Bragg and Raman Nath type acousto optic modulator in detail. | 8 | 3 | 4 | 2 |
| ii. | Explain any four switching parameters of the photonic switches. | 2 | 3 | 4 | 2 |
| 30. a. | With a neat diagram, describe about the Mach-Zehnder interferometer with input and output 3-dB couplers and arrive at the expression for half wave voltage. | 10 | 3 | 5 | 3 |
| (OR) | | | | | |
| b. | Explain in detail about | | | | |
| (i) | Integrated optic high voltage sensor | 5 | 3 | 5 | 1 |
| (ii) | Integrated optic chemical sensor | 5 | 3 | 5 | 1 |

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