KATHMANDU UNIVERSITY
End Semester Examination [C]
December, 2024

Marks Scored:

Level : B.E.
Year : II

Course : EEEG 207
Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date 18 DEC 2024

SECTION "A"

[20Q. × 0.5 = 10 marks]

Choose and encircle the most appropriate option from each set of choices. Symbols have their usual meaning.

1. If the quantum mechanical state of a system is described by $\psi_x = \psi_0 e^{ik(x-a)}$ for $|x| \le L$ and $\psi_x = 0$, otherwise then
   a. the particle has a definite position but uncertainty in momentum.
   b. the particle has a definite momentum but uncertainty in position.
   c. the particle has uncertainties both in position and momentum.
   d. the particle has no uncertainties in either position or momentum

2. If the kinetic energy of an electron is reduced to half of its original value, then the new de-Broglie wavelength is
   a. $\frac{h}{\sqrt{mE}}$ b. $\frac{\sqrt{2mE}}{h}$ c. $\frac{h}{\sqrt{2mE}}$ d. unchanged

3. Which of the following operator is associated with kinetic energy is
   a. $-\frac{\hbar^2}{2m}\nabla^2$ b. $-\frac{\hbar^2}{2m}\nabla^2 + V$ c. $i\hbar\frac{\partial}{\partial x}$ d. $-\frac{\hbar}{2m}\nabla^2$

4. The effective density of state for the valance band is
   a. $N_v = \left[\frac{2\pi m_e^* k_B T}{h^2}\right]^{3/2}$ b. $N_v = 2\left[\frac{2\pi m_e^* k_B T}{h^2}\right]^{3/2}$
   c. $N_v = \left[\frac{2\pi m_h^* k_B T}{h^2}\right]^{3/2}$ d. $N_v = 2\left[\frac{2\pi m_h^* k_B T}{h^2}\right]^{3/2}$

5. Electrons in a material have a density of $10^{20} cm^{-3}$ and a mobility of $800 cm^2/Vs$. If a uniform electric field of $1V/cm$ exerts across this conductor, determine the electron current density.
   a. $1.28\times10^3\ A/cm^2$ b. $1.28\times10^4\ A/cm^2$ c. $1.28\times10^5\ A/cm^2$ d. $1.28\times10^6\ A/cm^2$

6. A super conductor material when placed in a magnetic field will
   a. attract the magnetic field towards its center
   b. repel all the magnetic lines of forces passing through it
   c. attract the magnetic field but transfer it into a concentrated zone
   d. not influence the magnetic field

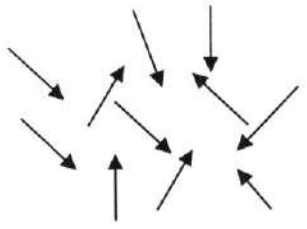
7. As temperature rises, more and more EHPs are produced, which results in a heavy increase in n_o and hence a contact potential
   a. decreases
   b. increases
   c. remains same
   d. first increases and then decreases

8. The diffusion coefficient of electron in silicon at $300\,K$ if $\mu_e = 0.19 m^2/Vs$ is
   a. $1.36\times10^{-1} m^2/s$ b. $1.36\times10^{-3} m^2/s$ c. $4.9\times10^{-3} m^2/s$ d. $4.9\times10^{-1} m^2/s$

9. When a metal and n-type semi-conductor contact is formed, if the work function of the metal is greater than the semi-conductor then the junction is called
   a. n-type rectifying contact. b. p-type rectifying contact.
   c. n-type ohmic contact. d. p-type ohmic contact.

10. In intrinsic semiconductor Fermi level lies in the
   a. middle of the valance band and conduction band
   b. towards the valance band
   c. towards the conduction band
   d. just below the conduction band

11. Which materials does the following figure represent?



   a. Paramagnetic b. Diamagnetic c. Ferromagnetic d. Anti-ferromagnetic

12. Which of the following statement does not decrease the eddy current on transformer?
   a. Core can be made of ferrites.
   b. Core can be made of pressed iron powder where by each powder is covered by insulating coating.
   c. The cross section area of the sheet used in core is reduced.
   d. Core can be made up of the substance which increases the conductivity.

13. The characteristics penetration depth W as that the distance at which intensity of the light wave is
   a. $\frac{\lambda}{4\pi K}$ b. $\frac{4\pi K}{\lambda}$ c. $\frac{2\omega K}{c}$ d. $\frac{4\pi}{\lambda K}$

14. Which of the following is not the property of LASER light?
   a. Coherence b. Directionality c. Highly intense d. Chromaticity

15. The minimum value of electric field at which the positive and negative ions of a dielectric get free is called
   a. critical electric field b. polarization vector
   c. dielectric strength d. dielectric constant

16. χ_1 and χ_2 are susceptibilities of a diamagnetic substance at temperatures $T_1^0 K$ and $T_2^0 K$ respectively, then

a. $\chi_1 T_1 = \chi_2 T_2$ b. $\chi_1 \sqrt{T_1} = \chi_2 \sqrt{T_2}$ c. $\chi_1 = \chi_2$ d. $\chi_1 T_2 = \chi_2 T_1$

17. The material in which spontaneous polarization changes with temperature is known as

a. Piezoelectric b. Ferroelectric c. Pyroelectric d. Dielectric

18. Piezoelectric effect is when materials produce electric charges when _____

a. Voltage applied
b. Mechanical stress is applied
c. Electric field is applied
d. Magnetic field is applied

19. Tunnel diode is

a. positive resistance device
b. negative resistance device
c. amplifying device
d. regulating device

20. Fluorescence is a result of transition of electron from

a. singlet ground state to singlet excited state.
b. lower singlet excited state to singlet ground state.
c. triplet excited state to singlet ground state.
d. triplet ground state to singlet excited state.

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SECTION "B"
[5 Q. × 8 = 40 marks]

Attempt ANY FIVE questions. Symbols have their usual meanings unless stated and missing parameters can be assumed suitably.

1.

a. Solve the Schrodinger wave equation for a particle in a box of infinite height with 'a' as the parameter and obtain its eigen values. [4]

b. The electron in hydrogen atom may be thought of as confined to a nucleus of radius $5\times10^{-11}m$. Calculate the minimum uncertainty in the momentum of electron. Also calculate the minimum kinetic energy of the electron. [2]

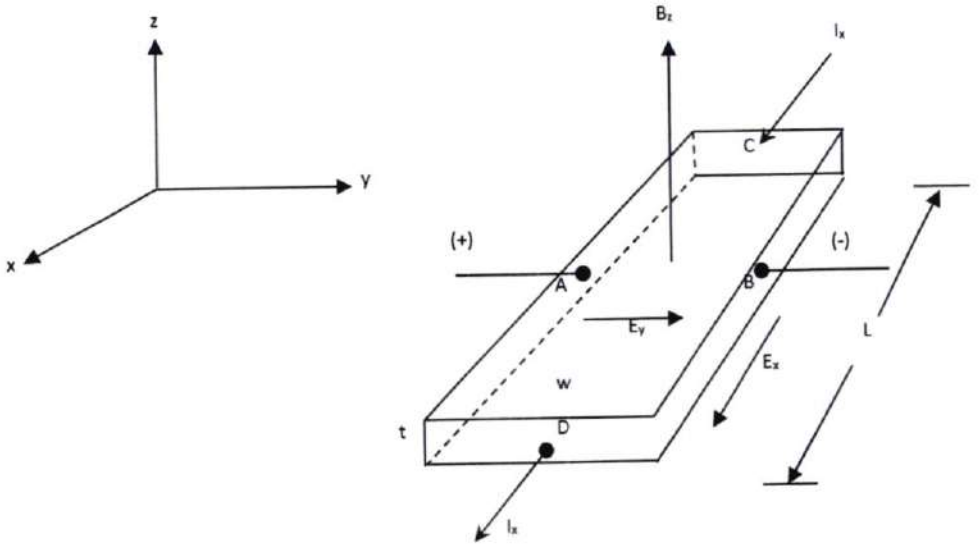
c. Normalize the wave function $\Psi(x,t)=Ae^{-\lambda|x|}e^{-i\omega t}$ where A, λ and ω are real constants. [2]

2.

a. Derive an expression for the carrier concentration of electrons and holes in intrinsic semiconductor. [4]

b. What do you mean by superconductivity? Explain the magnetic properties of super conductor. [2]

c. Consider a semiconductor bar with $w=0.1mm$, $t=10\mu m$, *and* $L=5mm$. For $B_Z=10^{-4}Wb/cm^2$ and a current of 1mA, we have $V_{AB}=-2mV$, $V_{CD}=100mV$. Find the type, concentration, and mobility of the majority carrier.
Given $n_0=3.125\times10^{17}cm^{-3}$ [2]



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3.

a. What is diffusion current? Derive the continuity equation for diffusion current. [4]
b. Derive an expression of capacitance for $p^+ - n$ junction diode. [4]

4.

a. What is contact potential and prove that $V_0 = \frac{kT}{q} \ln \frac{p_p}{p_n}$. [4]
b. Aluminum is alloyed in to n-type Si sample ($N_d = 10^{16}\, cm^{-3}$) forming an abrupt junction of circular cross section with a diameter of 0.02 inch. Assume that the accepter concentrations in the allowed re-grown region are $N_a = 4 \times 10^{18}\, cm^{-3}$. Calculate V_0, X_{no}, X_{po} and Q_+ for this junction at equilibrium $300\,K$.
Given [$n_i = 1.5 \times 10^{10}\, cm^{-3}$, $\varepsilon_r = 11.8$ for silicon.] [4]

5.

a. What are the factors responsible for hysteresis loss? Prove that the area of B-H curve is equal to the hysteresis loss per unit volume of the specimen in one cycle. [3]
b. What is called dielectric materials? Explain the different type of polarization. [3]
c. Write short notes about Piezoelectric and Pyroelectric materials. [2]

6.

a. What is tunnel diode? Explain how tunnel diode explains the negative current voltage characteristics with band diagram and I-V characteristics curve. [4]
b. Write short notes about Phosphorescence. [2]
c. Sketch the energy band diagram of metal and n-type semiconductor junction when $\Phi_m > \Phi_s$. [2]