TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2082 Kartik

Exam.	Back (New Course)		
Level	BE	Full Marks	60
Programme	BEL	Pass Marks	24
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material (*ENEE 203*)

- ✓ *Candidates are required to give their answers in their own words as far as practicable.*
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*
- *Mass of electron, $m_{e=9.1*10^{-31}}Kg$;* *$1ev=1.6*10^{-19}J$*
- *$h=6.624\times10^{-34}Js$;* *$k=1.38*10^{-23}J/k$*
- *$n_i=1.45\times10^{10}/cm^3$ for si;* *$\mu_{n=1350cm^2V^{-1}S^{-1}}$ (at 300K)*
- *$\mu_{h=450cm^2/v.s}$ (at 300K)* *$N_{A=6.022*10^{23}/mol}$*
- *Permitivity of silicon $\varepsilon=\varepsilon_0\varepsilon_r = 11.9\times8.85\times10^{-12}F/m$*
- *Velocity of light=$3\times10^8m/s$* *mass of photon=$1.673*10^{-27}kg$*

1. a) Explain the concept of effective mass in crystal with necessary mathematical expression and diagrams. [5]

   b) In the photoelectric experiment, green light, with a wavelength of 522 nm is the longest wavelength radiation that can cause photoemission of electron from a clean sodium surface. Calculate the work function of sodium. If ultraviolet radiation with a wavelength 250 nm is incident to the sodium surface, what will be the kinetic energy of the photo-emitted electrons? [3]

2. a) Explain the formation of H_2 molecule using molecular orbital bonding theory and draw the necessary diagrams. [6]

   b) For a given fermi energy level E_F , show that the probability of emptying energy level KT below E_F is equal to probability of occupying level KT above E_F. [4]

3. a) Define local field in relation to polarization. Derive the Clausius-Massoti Equation for ionic polarization, relating polarizability with the permittivity. [4]

   b) Explain how? If the spacing between parallel plates of a capacitor is less, the dielectric breakdown will occur soon. [2]

   c) What do you mean by piezo-electric materials? Explain piezoelectric effect in terms of polarization. [4]

4. a) Distinguish between ferromagnetic and anti-ferromagnetic materials with suitable examples of each. Explain magnetostriction with neat diagram. [5]

   b) Explain the domain theory of magnetism in detail. [5]

5. a) How does Meissner effect help to differentiate superconductor as type-I and type-II? Explain in brief. Explain critical current in superconductor with necessary mathematical expression and diagram. [6]

   b) Explain how acceptor dopants contribute holes in valence band in p-type extrinsic semiconductor. Also prove that $\sigma = pe\mu_h$ where symbols have their usual meanings. [4]

6. a) Calculate the resistance of pure silicon cubic crystal of $1cm^3$ at room temperature. What will be the resistance of the cube when it is doped with 1 arsenic in 10^9 silicon atoms and 1 boron atom per billion silicon atoms? Atomic concentration of silicon is $5\times10^{22}cm^{-3}$, $n_i=1.45\times10^{10}cm^{-3}$. [4]

   b) Calculate the diffusion coefficient of electrons at 300 K in n-type silicon semiconductor with 10^{15} arsenic atoms per cm^3. (μ = 1300 cm^2 V^{-i} s^{-1}) [3]

   c) Explain the diffusion process in semiconductor and derive the Einstein relation for diffusion process. [5]

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- Mass of electron, $m_e = 9.1\times10^{-31}$kg; $1ev = 1.6\times10^{-19}$J
- $h = 6.624\times10^{-34}$Js; $k = 1.38\times10^{-23}$J/K
- $n_i = 1.45\times10^{10}/cm^3$ for Si; $\mu_n = 1350 cm^2V^{-1}S^{-1}$(at 300K)
- $\mu_h = 450 cm^2$/v.s (at 300K) $N_A = 6.022\times10^{23}$/mol
- Permittivity of silicon $\varepsilon = \varepsilon_r \varepsilon_o = 11.9\times8.85\times10^{-12}$F/m
- Velocity of light = 3×10^8 m/s mass of photon = 1.673×10^{-27} kg

1. a) With necessary mathematical expression, explain the nature of wave function in different regions in case of quantum leak. [5]
   b) An electron is confined to an infinite potential well of size 8.5 nm. Calculate the ground state energy of the electron and radian frequency. How this electron can be put to the fourth energy level? [3]
2. a) Using image charge method, derive an expression of emission current density for Schottky effect. [6]
   b) Find the temperature at which the probability of occupation of the energy state 0.75 eV above the Fermi energy is 30%. [4]
3. a) Derive the Clausius-Masotti equation showing the relation between electronic polarizability and relative permittivity. [4]
   b) A glass dielectric has dielectric constant 2.6 and loss tangent 7×10^{-5} at 1 MHz. Calculate the loss of power per unit volume if the signal applied to the glass has peak amplitude of 0.71 V/m. [2]
   c) Show that the dielectric loss per unit volume is a function of frequency of the applied field and the loss tangent. [4]
4. a) Classify the magnetic materials based on magnetization and explain each of them briefly. [5]
   b) Explain demagnetization of magnetic materials with the help of magnetic domain formation. Suggest which type of magnetic material is used for storing digital information and why? [5]
5. a) What is Meissner effect? Explain in brief about type-I and type-II superconductor. [6]
   b) Explain how donor dopants contribute electrons in conduction band in n-type extrinsic semiconductor. Also prove that $\sigma = ne\mu_e$ where symbols have their usual meanings. [4]
6. a) The density of states related effective masses of electrons and holes in silicon are approximately 1.08 m_e and 0.56 m_e respectively. The electron and hole drift mobilities at room temperature are 1350 and 450 $cm^2V^{-1}S^{-1}$ respectively. Calculate intrinsic concentration and intrinsic resistivity of silicon. The energy band gap for silicon is 1.1 eV. [4]
   b) An n-type semiconductor doped with 10^{16} cm^{-3} phosphorus atoms has been doped with $10^{17}cm^{-3}$ boron atoms. Calculate the electron and hole concentrations in the semiconductor. [3]
   c) Derive the expression for built-in potential in p-n junction. [5]

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