TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE 502)*

- ✓ 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.*
- ✓ *Values of commonly used constants are given below:*

Mass of electron, $m_e = 9.1\times10^{-31}$ kg
$h = 6.626\times10^{-34}$ Js
Permittivity of Silicon, $\varepsilon = \varepsilon_r\,\varepsilon_o = 11.9\times8.85\times10^{-12}$ F/m
$n_i = 1.45\times10^{10}$ cm^{-3} for silicon
$\mu_h = 450$ cm^2/V.s (at 300 K)

$1\text{ eV} = 1.6\times10^{-19}$ J
$k = 1.38\times10^{-23}$ J/K
$\mu_e = 1350$ cm^2/V.s (at 300 K)
$N_A = 6.022\times10^{23}$ / mol

1. a) Explain the significance of operators in quantum mechanics. How do you calculate the expected energy value of a particle represented by $\psi(x,t)$ confined at a boundary of 0 to L? [4+4]
   b) Explain the thermionic emission in metal. Using image charge method, derive an expression of emission current density for Schottky effect. [2+6]
2. a) Calculate the lattice constant, face diagonal, body diagonal and packing density of body centered cubic (BCC) crystal unit cell. [4]
   b) Drift mobility of conduction electron is 43 cm^{2}V^{-1}s^{-1} and mean speed is 1.2×10^6ms^{-1}. Calculate the mean free path of electrons between collisions. [4]
   c) How does a superconductor expel all the magnetic lines of force at T<Tc? [4]
   d) How does Meissner effect help to differentiate superconductor as type-I and type-II? Explain in brief. [4]
3. a) Explain how? [4×2]
      (i) If the spacing between parallel plates of a capacitor is less, the dielectric breakdown will occur soon.
      (ii) Average dipole moment in dipolar polarization depends on temperature.
   b) Distinguish between ferromagnetic and anti-ferromagnetic materials. Give an example for each class of material. [4+1]
   c) Explain about the applications of soft magnetic materials. [3]
4. a) The density of states related effective masses of electrons and holes in silicon are approximately $1.08m_e$ and $0.6m_e$ respectively. The electron and hole drift mobilities at room temperature are 1350 and 450 cm^{2}V^{-1}s^{-1} respectively. Calculate intrinsic concentration and intrinsic resistivity of silicon at T = 300K. The energy band gap for silicon is 1.1eV. [8]
   b) Explain how does the band bends in semiconductor. [4]
   c) Describe the Direct and indirect recombination process between an electron and hole in semiconductor with necessary diagrams. [4]
5. a) What is PN junction? Derive the relation for built in potential and depletion layer of a PN junction. [8]
   b) Find the resistance of p-n junction Germanium diode if temperature is 27°C and $I_o = 1\mu A$ for an applied forward bias of 0.2 Volt. [4]
   c) Explain the importance of Fermi energy level in semiconductor. [4]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Chaitra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE 502)*

- ✓ 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.*
- ✓ *Values of commonly used constants are given below:*

Mass of electron, $m_e = 9.1*10^{-31}$ kg; *1ev=$1.6*10^{-19}$ J;*
$h = 6.624*10^{-34}$ JS; *K=$1.38*10^{-23}$ J/K;*
$\varepsilon_o\varepsilon_r = 11.9*8.85*10^{-12}$ F/m for Si *n_i=$1.45*10^{10}$ /cm^3 for Si)*
$\mu_e = 1350$ cm^2/v.s. at 300 K *$\mu_h = 450$ cm^2/v.s. at 300 K*
e=$1.6*10^{-19}$ c *$N_A = 6.022*10^{23}$ /mol*

1. a) Starting from the suitable equation, prove that the energy of an electron that is confined in an infinite potential well of width L is quantized. [8]

   b) An electron is confined to an infinite potential well of size 0.1nm. Calculate the ground energy of the electron and radian frequency. How can this electron be put to the third energy level? [4]

2. a) Derive Einstein's relation between mobility and diffusion co-efficient. Also define the terms electron mobility, conductivity and resistivity. [5+3]

   b) Explain the concept of effective mass in crystal with necessary mathematical expression. [6]

3. a) Define polarization. Derive the Clausius-Massoti equation showing the relation between relative permittivity and electronic polarizability. [8]

   b) Describe how thermal breakdown and electromechanical breakdown results in dielectric breakdown in solids. [4]

   c) Classify the magnetic material based on magnetization and explain each of them briefly. [8]

4. a) Explain how strong magnetic field effects superconductor. [4]

   b) Describe the phenomenon of generation of electrons and holes, and conduction in semiconductor. Also derive equation for conductivity. [6]

   c) How band bending occurs in semiconductors? Derive Einstein relationship. [10]

5. a) A pn junction semiconductor has resistivity of 5Ω cm. If mobility of holes is 450 cm^2/Vs, and electron mobility is three times the mobility of holes at room temperature, find

      i) Built in potential
      ii) Depletion width that lies in n-region and p-region respectively
      iii) Built in electric field at x=0. [6]

   b) Calculate the resistance of pure silicon cubic crystal of 1cm^3 at room temperature. What will be the resistance of the cubic 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 $5*10^{22}$cm^{-3}, n_i=$1.45*10^{10}$cm^{-3}. [8]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Ashwin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE 502)*

- ✓ 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;
$h = 6.624*10^{-34}$ JS;
$\varepsilon_o\varepsilon_r = 11.9*8.85*10^{-12}$ F/m for Si
$\mu_e = 1350$ cm^2/v.s. at 300 K
$e=1.6*10^{-19}$ c
$1ev=1.6*10^{-19}$ J;
$K=1.38*10^{-23}$ J/K;
$n_i=1.45*10^{10}$ /cm^3 for Si)
$\mu_h = 450$ cm^2/v.s. at 300 K
$N_A = 6.022*10^{23}$ /mol

1. a) What is tunneling in quantum mechanics? Explain with necessary mathematical expression, the nature of wave function in different regions in case of tunneling. [8]

   b) Calculate the Fermi energy level at absolute zero for the copper having electron concentration of 8.43×10^{28}m^{-3}. [4]

   c) X-rays of wavelength 0.9 A° fall on a metal plate having work function of 2 eV. Find the wavelength associated with emitted photoelectrons. [4]

2. a) Drift mobility of conduction electron is 43 cm^2/V.s and mean speed is 1.2×10^6 m/s. Calculate mean free path of electrons between collisions. [4]

   b) What is Meisner effect? Explain the difference between type I and type II super conductors. [2+6]

   c) For silver with E_{F0}=5.5ev and ∅=4.5 ev, calculate the toal number of status per unit volume and compare this with atomic concentration of silver. Density and atomic mass of silver are 10.5 g/cm^3 and 107.9 g/mol respectively. [4]

3. a) Define magnetic domain and domain walls in magnetic materials. Explain in brief about losses that would occur in magnetic materials. [2+4+2]

   b) Define local field in relation to polarization. Derive the Clausius-Massoti Equation for ionic polarization, relating polarizability with the permittivity. [8]

4. a) An n-type silicon wafer is uniformly doped with 10^{16} antimony atoms per cm^3. Where will be the Fermi level compared to its intrinsic Fermi level? [6]

   b) Explain the diffusion process in semiconductor and derive the Einstein relation for diffusion process. [10]

5. a) Define p-type semiconductor. Derive an expression for minority carrier suppression and hence prove that the conductivity in p-type semiconductor is mainly due to the hole. [8]

   b) If it is desired to raise Fermi level to 0.7 eV above the intrinsic Fermi level at room temperature, what type of dopant is to be used? Also determine its doping level if the used intrinsic semiconductor is silicon. [4]

   c) 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. [4]

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13 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*
- ✓ *Values of commonly used constants are given below:*

Mass of electron, $m_e = 9.1\times10^{-31}$ kg
$h = 6.626\times10^{-34}$ Js
Permittivity of Silicon, $\varepsilon = \varepsilon_r\,\varepsilon_o = 11.9\times8.85\times10^{-12}$ F/m
$n_i = 1.45\times10^{10}$ cm^{-3} for silicon
$\mu_h = 450$ cm^2/V.s (at 300 K)

1 eV $= 1.6\times10^{-19}$ J
$k = 1.38\times10^{-23}$ J/K
$\mu_e = 1350$ cm^2/V.s (at 300 K)
$N_A = 6.022\times10^{23}$ / mol

1. a) Calculate the temperature at which there is 98% probability that a state 0.3 ev below the fermi energy level will be occupied by an electron. [4]
   b) Prove that the energy of a particle confined in an infinite potential well is quantized. Also find the expression for normalized wave function. [8]
2. a) Draw face centered cubic (FCC) unit cell and find body diagonal and packing density. [6]
   b) The conductivity and drift mobility of copper conductor is $63.5*10^6$ s/m and 43 cm^2/v/s. Calculate Fermi level for copper conductor. [4]
3. a) Show that the dielectric loss per unit volume is a function of frequency of the applied field and the loss tangent. [6]
   b) What do you mean by piezo-electric materials? Explain piezoelectric effect in terms of polarization. [4]
4. a) On the basis of magnetic vector, explain the ferromagnetism, ferrimagnetism and antiferromagnetism. [4+2]
   b) What is Meissner effect? Explain the difference between type I and type II superconductors. Type II superconductor is also called hard superconductor, why? [2+4+2]
5. a) Differentiate between non-degenerate and degenerate semiconductors. [6]
   b) What is Built-in potential and depletion width? Derive the expression of these with necessary diagram. [6]
   c) Calculate the resistance of pure silicon cubic crystal of 1 cm^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 $5*10^{22}$ cm^{-3}, ni = $1.45*10^{10}$ cm-3. [8]
6. a) Calculate the diffusion coefficient of electrons at 300K in n-type silicon semiconductor. Also find current density if electron concentration gradient is 10^3 electrons per centimeter. [4]
   b) Obtain the expression to evaluate built in potential and width of depletion layer of p-n junction with necessary diagrams. [10]

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13 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Ashwin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*
- ✓ *Values of commonly used constants are given below:*

Mass of electron, $m_e = 9.1\times10^{-31}$ kg
$h = 6.626\times10^{-34}$ Js
Permittivity of Silicon, $\varepsilon = \varepsilon_r\,\varepsilon_0 = 11.9\times8.85\times10^{-12}$ F/m
$n_i = 1.45\times10^{10}$ cm^{-3} for silicon
$\mu_h = 450$ cm^2/V.s (at 300 K)
1 eV $= 1.6\times10^{-19}$ J
$k = 1.38\times10^{-23}$ J/K
$\mu_e = 1350$ cm^2/V.s (at 300 K)
$N_A = 6.022\times10^{23}$ / mol

1. a) Derive the time independent Schrodinger's equation, starting with classical wave equation, $y = A\sin 2\pi\left(ft - \frac{x}{\lambda}\right)$, where notations have their usual meanings. [8]

   b) Find the probability that an energy state 5KT above the Fermi level will not occupied by an electron. [4]

2. a) Draw a neat diagram of face centered cubic (FCC) unit cell crystal structure for copper and find

   (i) Number of atoms per unit cell
   (ii) Packing density
   (iii)Atomic concentration if radius of copper atom is 0.128 nm
   (iv)Density of crystal given that atomic mass of Cu is 63.55 g mol^{-1} [8]

   b) What is an effective mass of a free electron? Show that effective mass of a free electron is equal to mass of free electron in vacuum. [1+3]

3. a) What is local field in polarization? Derive the Clasuius- Massotti equation for electronic polarization. [8]

   b) Differentiate between Ferro and Piezo electricity. [4]

4. a) Explain the significance of hysteresis loop while selecting materials for preparing magnetic materials. [4]

   b) Explain the domain theory of magnetism in detail. [6]

   c) Define superconductor, critical magnetic field, and critical current density. [4]

5. a) 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. [8]

   b) A silicon wafer is uniformly doped with 10^{16} Boron atoms per cm^3. Where will be the Fermi level compared to its intrinsic Fermi level? Where will be the Fermi level is shifted if the sample is further doped with 10^{17} antimony atom per cm^3? [6]

6. a) Explain the diffusion process in semiconductor and derive the Einstein relation for diffusion process. [8]

   b) Derive an expression of a built-in potential and depletion width of a pn junction with necessary diagram. [8]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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**.*
- ✓ ***Necessary Graph is attached herewith.***
- ✓ *Assume suitable data if necessary.*
- ✓ *Values of commonly used constants are given below:*

Mass of electron, $m_e = 9.1\times10^{-31}$ kg
$\hbar = 6.626\times10^{-34}$ Js
Permittivity of Silicon, $\varepsilon = \varepsilon_r\,\varepsilon_o = 11.9\times8.85\times10^{-12}$ F/m
$n_i = 1.45\times10^{10}$ cm^{-3} for silicon
$\mu_h = 450$ cm^2/V.s (at 300K)
1 eV = 1.6×10^{-19} J
k = 1.38×10^{-23} J/K
$\mu_e = 1350$ cm^2/V.s (at 300K)
$N_A = 6.022\times10^{23}$ / mol

1. a) Define population density. Prove that fermi energy in a metal is independent of temperature and depends only in its electron concentration. [2+6]

   b) Consider a Al-Cu thermocouple pair, Estimate the potential difference available from this thermo-couple if one junctions is held at 0°C and other at 100°C. [4]

Metal	Fermi Energy, EF (eV)	Constant (x)
Al	11.6	2.78
Cu	7.0	-1.79

2. a) Explain how energy bands are formed in solids taking the example of N number of Lithium atoms for the explanation. [6]

   b) Drift mobility of conduction electron is 43cm^{2}V^{-1}S^{-1} and mean speed is 1.2*10^6 ms^{-1}. Calculate the mean free path of electrons between collisions. [4]

3. a) Show that dipolar polarization is a temperature dependent parameter. [6]

   b) Determine electronic polarizability due to valence electrons per Si-atoms. If the sample is supplied by a voltage on its electrode by how much is the local field greater than the applied field? Take ϵ_r = 11.9 and number of Si-atoms per unit volume = 5×10^{28} m^{-3}. [4]

4. a) Differentiate between ferrimagnetic and ferromagnetic materials. [6]

   b) What is Meissner effect? Differentiate between type I and type II superconductors. [4]

5. a) 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. [6]

   Describe the importance of determining Fermi energy in semiconductor materials. [6]

   The density of states related effective masses of electrons and holes in silicon are approximately 1.08m_e and 0.56m_e respectively. The electron and hole drift mobilities at room temperature are 1350 and 450cm^{2}V^{-1}S^{-1} respectively. Calculate intrinsic concentration and intrinsic resistivity of silicon. The energy band gap for silicon is 1.1ev. [8]

6. a) 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 and conductivity. [6]

   b) Explain how does the temperature affect the formation of carrier concentration in semiconductor? [6]

   c) Differentiate between si and GaAs with their respective E-k curve. [6]

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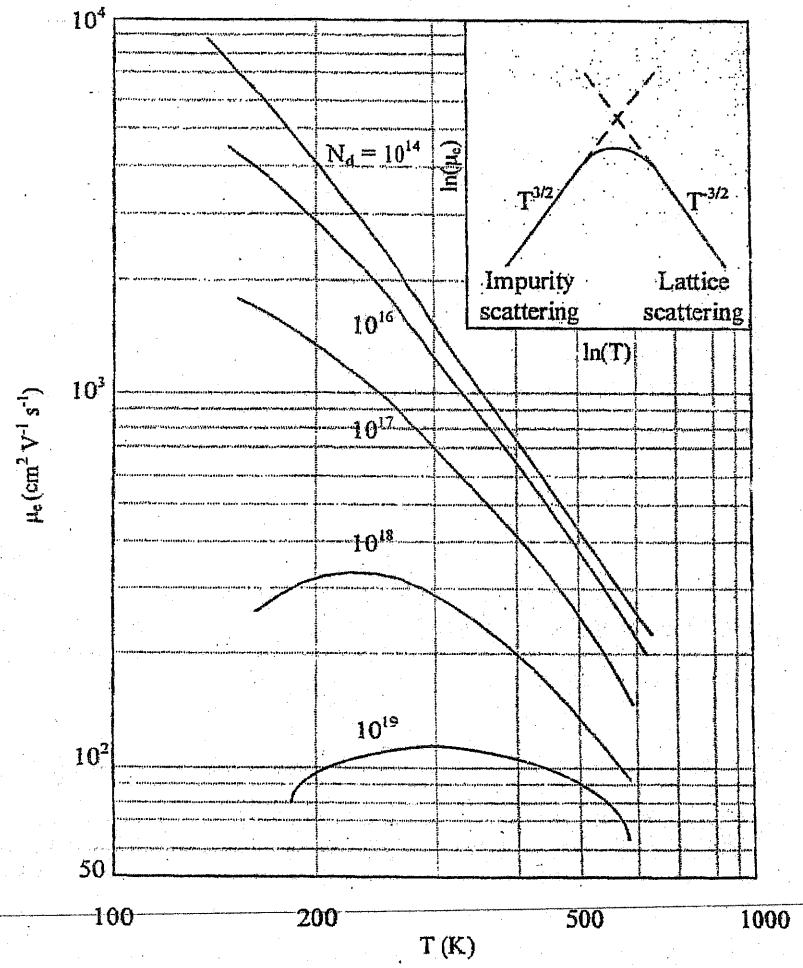

Figure: log-log plot of drift mobility versus temperature for n-type Silicon sample.

23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Ahswin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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**.*
- ✓ ***Necessary Graph is attached herewith.***
- ✓ *Assume suitable data if necessary.*
- ✓ *Value of commonly used constants are given below:*

Mass of electron, $m_e = 9.1 \times 10^{-31}$ kg
h = 6.626×10^{-34} Js
Permittivity of Silicon, $\varepsilon = \varepsilon_r \varepsilon_0 = 11.9 \times 8.85 \times 10^{-12}$ F/m
$n_i = 1.45 \times 10^{10}$ cm^{-3} for silicon
μ_h = 450 cm^2/V.s (at 300K)

1 eV = 1.6×10^{-19} J
k = 1.38×10^{-23} J/K
μ_e = 1350 cm^2/V.s (at 300K)
$N_A = 6.022 \times 10^{23}$ / mol

1. a) Explain the importance of quantum mechanics. Differentiate between classical and quantum mechanics with suitable examples. [8]

   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? [4]

2. a) What happen when inter-atomic separation between two helium atoms is very less? Describe on the basis of formation of bonding and antibonding molecular orbital. [6]

   b) Prove that for a simple cubic structure, the lattice constant: $a = \left[\frac{NM}{\rho N_A}\right]^{1/3}$ where, N is the number of atoms per unit cell, M is atomic weight, N_A is Avogadro's number and ρ is density of crystal material. [4]

3. a) Define local electric field and derive clausius-massotti equation. [6]

   b) The number of electrons per unit volume of Silicon is 6×10^{22}cm^{-3}. Calculate: [4]

   i) Electronic polarizability due to valence electrons per Silicon atom.

   ii) If the Silicon crystal sample is electrode on opposite faces, by how many times the local field is greater than the applied field?

4. a) What is a domain wall? How does a domain wall motion occur? [6]

   b) Explain about the applications of soft magnetic materials. [4]

5. a) A superconductor in its superconducting state expels all the magnetic lines of forces, justify. [6]

   b) Explain how carrier concentration of an n-type extrinsic semiconductor depends on temperature with necessary diagram and graphs. [6]

   c) Four micrograms of antimony are thoroughly mixed in molten form with 100 gms of pure germanium. Find the density of antimony atoms, density of donated electrons and the total resistance of a bar of such n-type material of 2 cm long, 0.012×0.012 cm in cross-section. Take, density of Ge = 5.46 gm/cm^3 and atomic weight of Sb = 121.76. [8]

6. a) The current density in semiconductor devices is affected both by diffusion and drifting of electrons and holes, justify. [6]

   b) Sample of silicon wafer is doped with 10^{15} Antinomy atoms/cm^3. Find the carrier concentrations, its resistance and the shift in Fermi level from its intrinsic Fermi level at 27°C. If this sample is further doped with 10^{22} Boron atoms/cm^3, what will be the change in its resistance. [6]

   c) Show that in n-type semiconductor minority carries concentrations are suppressed. [6]

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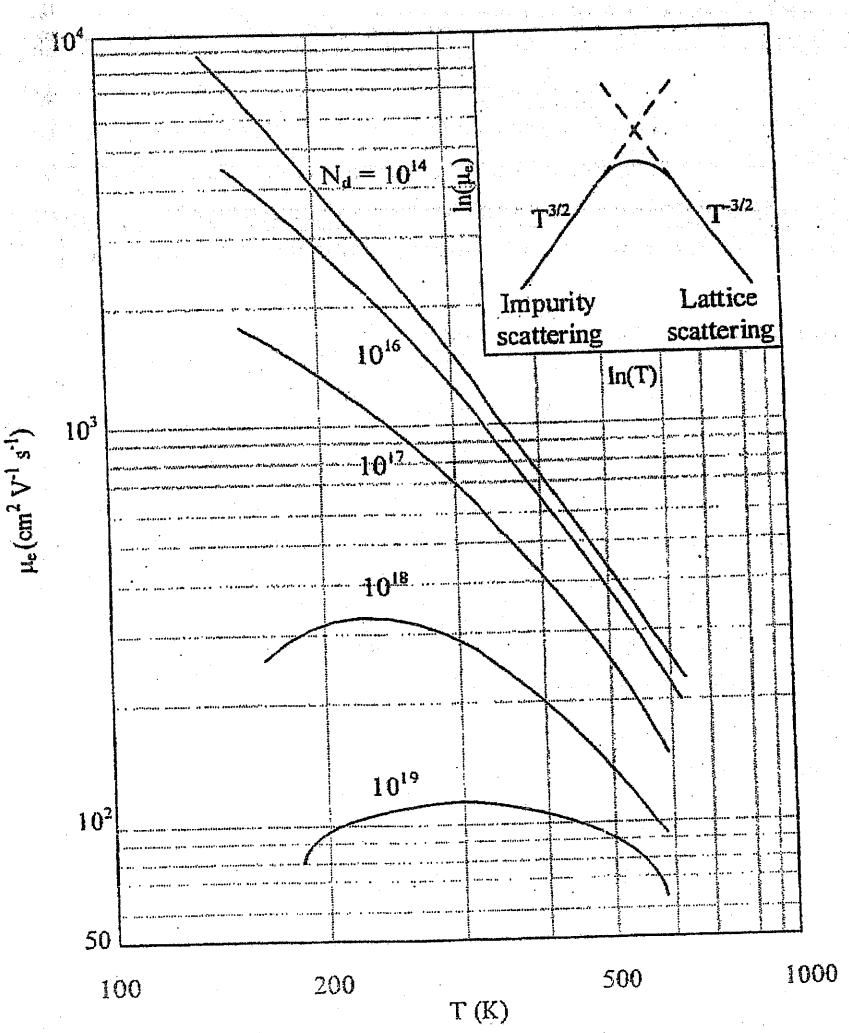

Figure: log-log plot of drift mobility versus temperature for n-type Silicon sample.

23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Shrawan

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*
- ✓ ***Values of commonly used constants are given below.***
- ✓ ***Mass of electron ,m_e=9.1*10^{-31}kg; 1ev=1.6*10^{-19}J***
- ✓ ***h=6.65*10^{-34}Js; k=1.38*10^{-23}J/k;***
- ✓ ***Permittivity of silicon=$\varepsilon_0\varepsilon_r$=11.9*8.85*10^{-12}F/m***
- ✓ ***n_{i0}=1.45*10^{10}/cm^3 for silicon; μ_n=1350cm^2/v.s(at 300K)***
- ✓ ***μ_h=450 cm^2/v.s(at 300K); N_A=6.022*10^{23}/mol***

1. a) What do you understand by number of states and density of states in quantum mechanics? Derive appropriate expressions for them. [8]

   b) A transmitter type vacuum tube operated at 1500°C has a cylindrical Thorium coated Tungsten cathode which is 5 cm long with diameter of 1.5 mm. Determine the saturation current of vacuum tube if the cathode has emission constant of 3×10^4 Am^{-2}k^{-2} and work function of 2.6eV. [4]

2. a) Define and explain the effective mass of electron within a crystal. How do you understand negative and infinite mass of electron? [6]

   b) For silver with E_{FO} = 5.5ev and ϕ = 4.5 ev, calculate the total number of states per unit volume and compare this with atomic concentration of silver. Density and atomic mass of silver are 10.5g/cm^3 and 107.9g/mol respectively. [4]

3. a) Define local field in relation to polarization. Derive the Clausius-Massotti equation for ionic polarization, relating polarizability with the permittivity. [6]

   b) Name the field of application of different types of dielectric materials. [4]

4. a) Classify the magnetic material based on magnetization. [6]

   b) What type of magnetic material would you chose for electromagnetic relays? Justify. [6]

5. a) For a specimen of V_3Ga, the critical fields are 0.176T and 0.528T for 14K and 13K respectively. Calculate the critical temperature. Also calculate critical fields at 0K and 4.2K. [6]

   b) What is diffusion? Derive Einstein relationship for an n-type semiconductor. [6]

   c) A silicon ingot is doped with 10^{16} arsenic atoms/cm^3. Find the carrier concentrations conductivity of the sample and the shift in Fermi level from its intrinsic Fermi level at 27°C. [6]

6. a) Suppose a P-N junction is created on silicon wafer at room temperature. If the donor level on N-side is10^{17} cm^{-3} and acceptor level on P-Side is 10^{16} cm^{-3} calculate built in potential (V_o) and depletion width (W_o). [6]

   b) Calculate the resistance of pure silicon cubic crystal of 1 cm^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 $5*10^{22}$cm^{-3}, $n_i = 1.45*10^{10}$cm^{-3}. [6]

   c) What are energy bands? Distinguish between a conductor, an insulator and a semiconductor on the basis of energy diagram. Write two characteristic features to distinguish between n-type and p-type semiconductors. [6]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

Exam.	Regular		
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Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*
- ✓ ***Values of commonly used constants are given below.***
- ✓ ***Mass of electron ,m_e=9.1*10^{-31}kg;*** ***1ev=1.6*10^{-19}J***
- ✓ ***h=6.65*10^{-34}Js;*** ***k=1.38*10^{-23}J/k;***
- ✓ ***Permittivity of silicon=$\varepsilon_0\varepsilon_r$=11.9*8.85*10^{-12}F/m***
- ✓ ***n_{i0}=1.45*10^{10}/cm^3 for silicon;*** ***μ_n=1350cm^2/v.s(at 300K)***
- ✓ ***μ_h=450 cm^2/v.s(at 300K);*** ***N_A=6.022*10^{23}/mol***

1. a) Define Fermi Energy. What is the probability that an electron having energy less than Fermi energy will occupy an energy level at absolute zero temperature? Determine the expectation value for any property of a particle described by a wave function Ψ. [8]

   b) An electron is confined to an infinite potential well of size 0.1 nm. Calculate the ground energy of the electron and radian frequency. How this electron can be put to the third energy level? [4]

2. a) What is effective mass? The electron at the top of valence band is said to have negative effective mass. Explain with the help of E-k diagram. [2+4]

   b) Formation of H_2 molecule is more stable than the formation of H_3 molecule. Justify with the help of electron energy versus inter-atomic separation between H-atoms. [6]

3. a) Show that the dielectric loss per unit volume is a function of frequency of the applied field and the loss tangent. [6]

   b) Describe how thermal breakdown and electromechanical breakdown results in dielectric breakdown in solids. [4]

   c) Based on magnetization vector, explain the diamagnetism, ferromagnetism and ferrimagnetisms. [8]

4. a) Explain how strong magnetic field effects superconductor. Derive the relation of critical current in superconductor with necessary diagram. [8]

   b) How band bending occurs in semiconductors? Derive Einstein relationship. [10]

   c) If it is desired that the Fermi-level is to be raised to 0.1 eV above intrinsic Fermi-level at room temperature, what type of dopant is to be used? Determine its doping level. [6]

5. a) Present a comparison between Si and GaAs semiconductors with the help of their basic properties and E-k diagram. [6]

   b) Derive the expression of a built-in potential and depletion width of a pn junction with necessary diagrams. [8]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*
- ✓ ***Values of commonly used constants are given below.***
- ✓ ***Mass of electron ,m_e=9.1*10^{-31}kg; 1ev=1.6*10^{-19}J***
- ✓ ***h=6.65*10^{-34}Js; k=1.38*10^{-23}J/k;***
- ✓ ***Permittivity of silicon=$\varepsilon_0\varepsilon_r$=11.9*8.85*10^{-12}F/m***
- ✓ ***n_{i0}=1.45*10^{10}/cm^3 for silicon; μ_n=1350cm^2/v.s(at 300K)***
- ✓ ***μ_h=450 cm^2/v.s(at 300K); N_A=6.022*10^{23}/mol***

1. a) What is Thermionic emission and work function? Derive the Richardson's expression for the thermionic emission for Schottky effect. [8]
   b) Consider two copper wires separated only by their surface oxide layer (CuO) of thickness 3 nm. The surface oxide layer offer potential barrier of height 10eV to the conduction electrons in copper. What is the transmission probability for conduction electrons in copper, which have kinetic energy of about 7eV? [4]
2. a) Define lattice and basis of a crystal and draw a neat diagram of body centered cubic structure of chromium and determine its packing density and state its co-ordination number. [2+4]
   b) What is an effective mass of a free electron? Show that effective mass of a free electron is equal to mass of free electron in vacuum. [1+3]
3. a) What are the different types of polarization mechanism in di-electric medium? [6]
   b) Describe how thermal breakdown and electromechanical breakdown results in dielectric breakdown in solids. [4]
4. a) Explain deperming method of demagnetization. If you place graphite in a non-uniform magnetic field what will happen? [3+3]
   b) What are magnetic domains? Explain the behavior of magnetic domains in presence of external magnetic field. [1+3]
5. a) What is Meissner effect? Explain in brief about type-I and type-II superconductor. [8]
   b) Differentiate Non-Degenerate and Degenerate semiconductors. [4]
6. a) In doped semiconductors, carrier concentration and drift mobility both are highly dependent on temperature, justify. [6]
   b) Compute the intrinsic concentration and intrinsic resistivity of silicon at 27°C. Given that: $m_e^* = 1.08m_e$ $\mu_e = 1350\ cm^2/V.s$ $m_h^* = 0.6m_e$ $\mu_h = 450\ cm^2/V.s$ [6]
   Where, m_e^* and m_h^* are effective masses of electron and holes respectively and μ_e and μ_h are electron and hole drift mobility's respectively. The band gap of Silicon = 1.1 eV
7. a) Find the resistance of 1 cm^3 silicon crystal doped with arsenic, the doping density is such that every Arsenic atom sites every 10^9 silicon atoms. Atomic concentration of silicon is $5\times10^{22}\ cm^{-3}$, $n_i = 1\times10^{10}\ cm^{-3}$, $\mu_e = 1350\ cm^2V^{-1}s^{-1}$ and $\mu_h = 450\ cm^2V^{-1}s^{-1}$. Find the resistance if the above silicon sample is further doped with Boron, the doping density is such that every Boron atom sites every 10^6 silicon atoms. [8]
   b) Prove that the position of Fermi level is near the middle of band gap in pure silicon semiconductor. [6]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Kartik

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*
- ✓ ***Values of commonly used constants are given below.***
- ✓ ***Mass of electron ,m_e=9.1*10^{-31}kg; 1ev=1.6*10^{-19}J***
- ✓ ***h=6.65*10^{-34}Js; k=1.38*10^{-23}J/k;***
- ✓ ***Permittivity of silicon=$\varepsilon_0\varepsilon_r$=11.9*8.85*10^{-12}F/m***
- ✓ ***n_{i0}=1.45*10^{10}/cm^3 for silicon; μ_n=1350cm^2/v.s(at 300K)***
- ✓ ***μ_h=450 cm^2/v.s(at 300K); N_A=6.022*10^{23}/mol***

1. a) What is density of states? Describe any statistical tool used in quantum mechanics to predict number of energy states being occupied by an electron. [1+4]

   b) A 3nm thick oxide layer of CuO separates two copper conductors providing a barrier height of 10eV for the conduction of electrons in copper. Determine the transmission coefficient if the energy of electron is 5eV. What will be the new transmission coefficient if the thickness of CuO was reduced to 1nm. [6]

2. a) If electrical conductivity of potassium is 1.39×10^5 Sm/cm, calculate the drift mobility of electron at room temperature. Molar mass and density of potassium are 39.95 and 0.91 gm/cc. [4]

   b) Taking the reference of formation of Lithium (Li) solid from N Lithium atoms explain clearly how the continuous energy band are formed in the solid metal. [6]

3. a) Derive the mathematical relation showing the relation between ionic polarization and relative permittivity, using Clausis-Massotti equation. [6]

   b) What is ferroelectricity and piezoelectricity? Write their similarities and differences. [4]

4. a) Classify magnetic materials based on their magnetic susceptibilities. What is the basic difference between ferromagnetic and ferrimagnetic material? [8]

   b) Explain how strong magnetic field effects superconductor. Derive the relation of critical current in superconductor with necessary diagram. [8]

   c) Describe briefly about domain theory of magnetism. [4]

5. a) Describe the importance of Fermi energy. Also differentiate between a degenerate and a non-degenerate semiconductor. [3+4]

   b) What is PN junction? Derive the relation for built in potential and depletion layer of a PN junction. [10]

6. a) Calculate the diffusion coefficient of electrons at 30°C in silicon doped with 10^{15} Arsenic atoms cm^{-3}. Given that the drift mobility of electron with 10^{15} cm^{-3} dopants is 1300 cm^{2}V^{-1}s^{-1}. [4]

   b) The effective density of states at conduction band and valence band are $2.9*10^{19}$ cm^{-3} and $1.1*10^{19}$ cm^{-3} respectively. Calculate the intrinsic concentration and intrinsic resistivity of silicon at 300 K temperature. [8]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Shawan

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*
- ✓ ***Values of commonly used constants are given below.***
- ✓ ***Mass of electron ,m_e=9.1*10^{-31}kg; 1ev=1.6*10^{-19}J***
- ✓ ***h=6.65*10^{-34}Js; k=1.38*10^{-23}J/k;***
- ✓ ***Permittivity of silicon=$\varepsilon_0\varepsilon_r$=11.9*8.85*10^{-12}F/m***
- ✓ ***n_{i0}=1.45*10^{10}/cm^3 for silicon; μ_n=1350cm^2/v.s(at 300K)***
- ✓ ***μ_h=450 cm^2/v.s(at 300K); N_A=6.022*10^{23}/mol***

1. a) Derive the relation of energy level inside a potential well of width L. Show mathematically that energy level in a copper wire of length L is quantized similar to energy level inside a potential well. [8]
   b) An electron is confined in an infinite potential well. The length of confinement is 0.01 nm. Find the energy and wave function of electron at third energy level. [4]

2. a) Derive the expression for effective mass of electron and show that it can be positive as well as negative. [8]
   b) The width of energy band is typically 10ev calculate: [4]
      i) The density of states at the center of the band
      ii) The number of states per unit volume within a small energy range KT above the center.

3. a) Derive Clausis Massoti equally showing the relation between electronic polarization and relative permittivity. [6]
   b) Derive the relation for average dipole energy of Hcl molecule when it is applied with electric fied of magnitude E. [4]
   c) Calculate the intrinsic conductivity and resistivity of Ga As at room temperature. The intrinsic concentration electron mobility and hole mobility of QaAs are 1.8×10^6 per cm^{-3}, 8500 $cm^2\ v^{-1}s^{-1}$ and 400 $cm^2\ v^{-1}s^{-1}$ respectively at 300K. [4]

4. a) Based on magnetization, differentiate between feromagnetism, ferrimagnetism, antiferrimagnetism and paramagnetism. [4]
   b) Explain the significance of hysteresis loop while selecting materials for preparing magnetic materials. [4]

5. a) What is critical current? Prove that the critical current decreases linearly with the increase in applied field for a wire. [8]
   b) A pn juction semiconductor has resistivity of 5Ω-cm. If mobility of hole is 450 $cm^2V^{-1}s^{-1}$ and electron mobility is three times the mobility of hole. At room temperature , find (i) Built in potential (ii) deletion width that lies in n-region and p-region and (iii) Built in electric field at x = 0 (Given $n_i = 1.45*10^{10}$ cm^{-3} at T=300K, $\varepsilon_r = 11.9$ for si). [8]

6. a) What is minority carrier suppression? Prove electron concentration and conduction in n-type semiconductor is defined by impurity donor. [8]
   b) Derive the relation for finding the concentration of electron in an extrinsic semi-conductor. [6]
   c) What is minority charge suppression in extrinsic semi-conductor? [4]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*
- ✓ ***Values of commonly used constants are given below.***
- ✓ *Mass of electron ,m_e=9.1*10^{-31}kg; 1ev=1.6*10^{-19}J*
- ✓ *h=6.65*10^{-34}Js; k=1.38*10^{-23}J/k;*
- ✓ *Permittivity of silicon=$\varepsilon_0\varepsilon_r$=11.9*8.85*10^{-12}F/m*
- ✓ *n_{i0}=1.45*10^{10}/cm^3 for silicon; μ_n=1350cm^2/v.s(at 300K)*
- ✓ *μ_h=450 cm^2/v.s(at 300K); N_A=6.022*10^{23}/mol*

1. a) From free electron theory of metal, show that E-K diagram is parabolic. Also show the energy of electron in a linear metal is quantized. [4+4]
   b) Find the wavelength of an electron accelerated by 100V. [4]
2. a) Explain with neat diagram how energy levels are filled and different energy bands are formed when N numbers of Lithium atoms are brought together. [6]
   b) Calculate the lattice constants, face diagonal, body diagonal and packing density of body centered cube (BCC) crystal unit cell. [4]
3. a) What are the different types of dielectric breakdown? Explain any two of them. [4]
   b) Explain mathematically how relative permittivity is related with electronic polarizability using Clausius Massoti equation. [6]
4. a) A crystal of iron created magnetic field around it but a piece of iron doesn't why? [6]
   b) How hysteresis loop plays an important role in classifying magnetic materials? Explain. [4]
5. a) Define Critical magnetic field and Critical current in a super-conductor with mathematical relation involved. [8]
   b) What is reverse saturation current in pn junction semiconductor? [4]
6. a) Derive the Einstein relationship showing the relation between electron diffusion co-efficient in n-type semiconductor and electron mobility. [8]
   b) Explain how PN junction is formed when n-type and p-type semiconductor are brought together. Derive the relation of built-in-potential of a PN junction. [6]
7. a) Calculate the resistance of pure silicon cubic crystal of 1 cm^3 at room temperature. What will be the resistance of the cube when it is doped with1arsenic in 10^9 silicon atoms and 1 boron atom per million silicon atoms? Atomic concentration of silicon is 5*10^{22} cm^{-3}. Use other required data from above given list. [8]
   b) An n-type semiconductor doped with 10^{16}cm^{-3} phosphorus atoms has been doped with 10^{16}cm^{-3} boron atoms. Calculate the electron concentration in the semiconductor. [4]

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24 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material (EE502)

- ✓ 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.*

Values of commonly used constants are given below.
*Mass of electron ,m_e=9.1*10^{-31}kg; 1ev=1.6*10^{-19}J*
*h=6.65*10^{-34}Js; k=1.38*10^{-23}J/k;*
*Permittivity of silicon=$\varepsilon_0\varepsilon_r$=11.9*8.85**10^{-12}F/m*
*n_{i0}=1.45*10^{10}/cm^3 for silicon; μ_n=1350cm^2/v.s(at 300K)*
*μ_h=450 cm^2/v.s(at 300K); N_A=6.022*10^{23}/mol*

1. a) What is tunneling in quantum mechanics? Explain with necessary mathematical expression, the nature of wave function in different regions in case of tunneling. [8]
   b) What is fermi-Driac Distribution function? Prove that probability of finding electron 1.5 KT above the fermi level. [4]

2. a) Explain the formation of H_2 molecule using molecular orbital bonding theory. Draw the necessary diagrams also. [6]
   b) Electron mobility in Si is 1400 cm2 $V^{-1}s^{-1}$. Calculate the mean free time in scattering of electrons. Effective mass is $m_{*e}/m_e = 0.33$. [4]
   c) Derive the Clausius -Massotti equation showing the relation between relative Permittivity and electronic polarizability. [6]

3. a) What are the different types of polarization in dielectric medium? Explain orientation polarization in detail. [4]
   b) Explain how strong magnetic field effects superconductor. Derive the relation of critical current in superconductor with necessary diagram. [8]
   c) Differentiate soft and hard magnetic material taking help of hysteresis loop. [6]

4. a) What are ferri magtetic materials? Explain how does its property differ with anti-ferromagnetic material? [4]
   b) Derive the relation for intrinsic concentration and explain how temperature effects intrinsic concentration with necessary diagram. [6]
   c) Derive Einstein relationship for a semi-conductor in equilibrium state. [6]

5. a) Derive the relation for finding built in potential of PN junction taking necessary assumptions. [6]
   b) Find the built-in potential for a p-n Si junction at room temperature if the bulk resistivity of Si is 1 Ω cm. Electron mobility in Si at room temperature is 1400 $cm^2V^{-1}S^{-1}$; $\mu n/\mu p = 3.1$; $n_i = 1.05 \times 1010$ cm−3. [6]
   c) An n-type silicon wafer is uniformly doped with 10^{10} antimony atoms per cm^{-3}.Where will be the Fermi level compared to its intrinsic Fermi level? Where will the Fermi level be shifted if the sample is further doped with 2*10^{15} boron atoms per cm^{-3}? [6]

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24 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Ashad

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Electrical Engineering Material *(EE502)*

- ✓ 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.*

Values of commonly used constants are given below.
*Mass of electron ,m_e=9.1*10^{-31}kg; 1ev=1.6*10^{-19}J*
*h=6.65*10^{-34}Js; k=1.38*10^{-23}J/k;*
*Permittivity of silicon=$\varepsilon_0\varepsilon_r$=11.9*8.85**10^{-12}F/m*
*n_{i0}=1.45*10^{10}/cm^3 for silicon; μ_n=1350cm^2/v.s(at 300K)*
*μ_h=450 cm^2/v.s(at 300K); N_A=6.022*10^{23}/mol*

1. a) What are the operators in quantum mechanics? Explain their uses in deducing the expected values of observable quantity. [8]
   b) For an electron confined to an infinite potential well of width 0.1 nm, determine the uncertainty in momentum and kinetic energy. [4]
   c) Draw a neat diagram of Face centered cubic (FCC) structure and calculate Body diagonal and Packing Density. [4]

2. a) Illustrating the E-K diagram, derive the relation for effective mass of electron for a crystal solid. [6]
   b) What is dielectric strength of a dielectric material? Discuss in brief the different types of breakdown in dielectric material. [6]
   c) Explain any two types of polarization in dielectric material with necessary mathematical relationship. [4]

3. a) Classify the magnetic material and explain each of them briefly. [4]
   b) Why hard magnetic materials is preferred for making permanent magnet while soft magnetic material is used for high frequency application. Explain with B-H curve. [6]
   c) What is Meissner effect in superconducting state? How Meissner effect helps to differentiate superconductor as Type I and Type II? Explain in brief. [8]

4. a) With the help of P-N juction, explain the phenomena of forward and reverse biased. [8]
   b) An n-type semiconductor doped with 10^{15} cm^{-3} phosphorous atoms has been doped with 10^{17} cm^{-3} boron atoms. Calculate the electron and hole concentrations in the semiconductors. [4]

5. a) Prove that the ratio of diffusion coefficient to drift mobility of a charge carrier of an extrinsic semiconductor remains unchanged if the temperature remains constant. [6]
   b) A pn-junction is formed at 300K. The acceptor and donor concentration in p-side and n- sides are 10^{16}/cm^3 and 10^{17}/cm^3 respectively. Find [8]
      a) Built in voltage
      b)Width of depletion layer.
      c) Width of depletion layer in n and p sides.
   c) Explain how are there many electrons available in conduction band in n-type semiconductor even if average thermal energy is insufficient to surmount the electrons from valence band to conduction band. [4]

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