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, $m_e = 9.1 \times 10^{-31}$ kg

$h = 6.626 \times 10^{-34}$ 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

$\mu_h = 450$ cm^2/V.s (at 300 K)

1 eV = 1.6×10^{-19} J

$k = 1.38 \times 10^{-23}$ J/K

$\mu_e = 1350$ cm^2/V.s (at 300 K)

$N_A = 6.022 \times 10^{23}$ / 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 [8]

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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, $m_e = 9.1 \times 10^{-31}$ kg

$h = 6.626 \times 10^{-34}$ Js

Permittivity of Silicon, $\varepsilon = \varepsilon_r\, \varepsilon_o = 11.9 \times 8.85 \times 10^{-12}$ F/m

$n_i = 1.45 \times 10^{10}$ cm^{-3} for silicon

$\mu_h = 450$ $cm^2/V.s$ (at 300 K)

1 eV = 1.6×10^{-19} J

$k = 1.38 \times 10^{-23}$ J/K

$\mu_e = 1350$ $cm^2/V.s$ (at 300 K)

$N_A = 6.022 \times 10^{23}$ / 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]

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, $m_e = 9.1\times10^{-31}$ 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 300K)

1 eV = 1.6×10^{-19} J

$k = 1.38\times10^{-23}$ J/K

$\mu_e = 1350$ cm^2/V.s (at 300K)

$N_A = 6.022\times10^{23}$ / 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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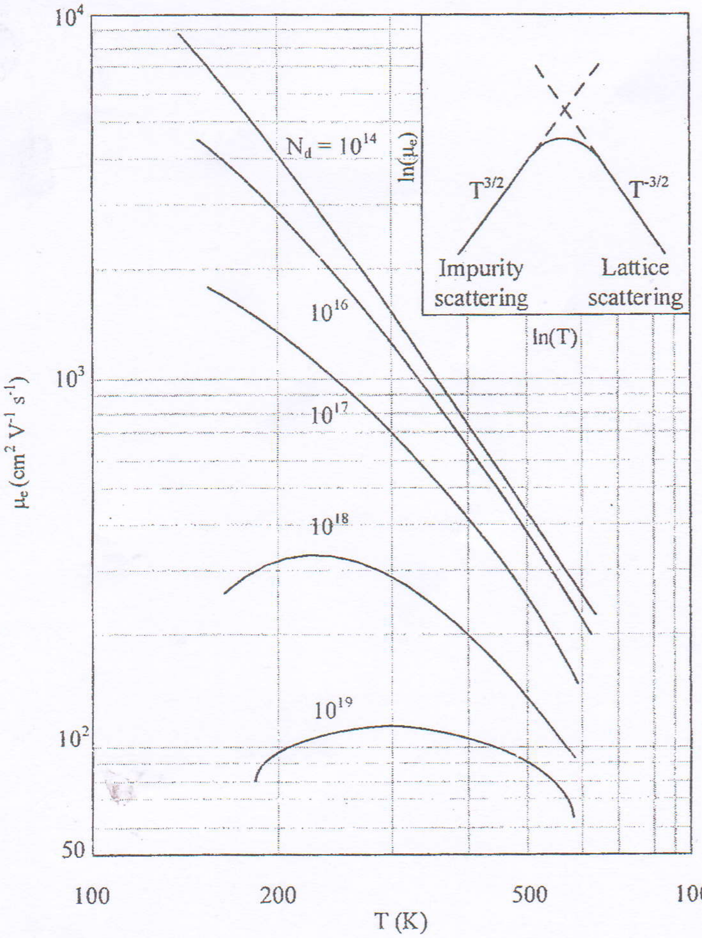

Figure: log-log plot of drift mobility versus temperature for n-type Silicon sample.

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; $\mu_n = 1350 cm^2/v.s$ (at 300K)
- ✓ $\mu_h = 450\ cm^2/v.s$ (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 $3\times10^4\ Am^{-2}k^{-2}$ 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 $10.5 g/cm^3$ 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 is $10^{17}\ cm^{-3}$ 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

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INSTITUTE OF ENGINEERING

Examination Control Division

2072 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; $\mu_n=1350cm^2/v.s$ (at 300K)*
- ✓ *$\mu_h=450\ cm^2/v.s$ (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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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
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;* $\mu_n = 1350 cm^2/v.s$ (at 300K)
- ✓ $\mu_h = 450 cm^2/v.s$ (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

2068 Baishakh

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

- ✓ 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.*
- ✓ $h = 6.624 \times 10^{-34}$ JS; $\quad$ $1\ ev = 1.6 \times 10^{-19} J$
- ✓ $k = 1.38 \times 10^{-23}$ JK; $\quad$ $n_i = 1.45 \times 10^{10}/cm^3$ for s;
- ✓ $\mu_n = 1350 cm^2 v^{-1} s^{-1}$ (at 300K); $\quad$ $\mu_h = 450 cm^2 v^{-1} s^{-1}$ (at 300K)
- ✓ $\varepsilon = \varepsilon_0 \varepsilon_r = 11.9 \times 8.85 \times 10^{-12}$ F/m; $\quad$ $Eg = 1.1 ev$
- ✓ $N_A = 6.624 \times 10^{-23}$ /mol $\quad$ $e = 1.602 \times 10^{-19} C$
- ✓ $M_{at} = 16$ g/mol (oxygen) $\quad$ Mass of photon $= 1.673 \times 10^{-27}$ kg
- ✓ Velocity of light $= 3 \times 10^8$ m/s

1. a) From the expression $E_h = \frac{h^2}{8ml^2}(h_x^2 + h_y^2 + h_z^2)$, define number of states and density of states functions in quantum mechanics. Derive appropriate expressions for them. [6]

   b) The mean speed of conduction electrons in copper is 1.5×10^6 m/s. The cross sectional area of scattering is $3.9 \times 10^{-22} m^2$. Estimate the drift mobility of electrons and conductivity of copper. Given density of copper is $8.96 g/cm^3$ and the atomic mass is 63.56 g/mole. [6]

2. a) Show that effective mass of an electron inside the crystal is inversely proportional to the curvature of energy with respect to wave number space. [6]

   b) Copper has FCC (Face- centered - cubic) structure. Find the packing density and atomic concentration for copper if radius of copper atom is 0.128nm. [4]

3. a) Define local field in relation to polarization. Derive the Clausius-Massotti Equation for ionic polarization, relating polarizability with the permittivity. [10]

   b) Classify the magnetic materials based on magnetization and explain each of them briefly. [10]

4. a) What is superconductor? Differentiate between Type-I and Type-II superconductor. [3+5]

   b) Explain how donor dopants contribute electrons in conduction band in n-type extrinsic semiconductor. Also prove that conductivity $\sigma \simeq e\, n\, \mu_e$; where symbols have their usual meanings. [10]

5. a) A pn-junction is formed at 300k. The acceptor and donor concentration in p-side and n-side are $10^{16} cm^{-3}$ and $10^{17} cm^{-3}$ respectively. Find :

      i) Built-in potential [2.5]
      ii) Width of deplection layer [2.5]
      iii) Maximum electric field [1]
      iv) Width in n and p sides [2]
      v) Fermi level n and p sides [2]

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

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INSTITUTE OF ENGINEERING
Examination Control Division
2068 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.*
- ✓ *Mass of electron me* $= 9.1 \times 10^{-31}$ *kg;* $k = 1.38 \times 10^{-23}$ *J/K;* $h = 6.65 \times 10^{-34}$ *JS; 1eV* $= 1.6 \times 10^{-19}$ *J; ni* $= 1.45 \times 10^{10}/cm^3$ *for Si;*
- ✓ $\mu_h = 450 cm^2 v^{-1} S^{-1}$ *(at 300K);* $\mu_e = 1350 cm^2 V^{-1} S^{-1}$ *(at 300K);*
- ✓ $N_A = 6.022 \times 10^{23}/mol;$

1. a) What do you mean by barrier penetration? How the wave function of particle is given when the particle penetrates the barrier? [8]

   b) A transmitter type vacuum tube has a cylindrical cathode, which is 4m long and 2mm diameter. Estimate the saturation current if the tube is operated at 160°C. The emission constant $A_0 = 3 \times 10^4$ $Am^{-2}K^{-2}$, work function ϕ= 2.6eV. [4]

   c) Conduction electrons with drift mobility of $53 cm^2V^{-1}S^{-1}$ and mean speed of $2.2 \times 10^6 ms^{-1}$ collides. Calculate the mean free path of electrons between collision. [4]

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

   b) What is electric dipole moment? Derive the Clausius- Masotti equation for electronic polarization, relating polarizability with the permittivity. [3+7]

3. a) What is the significance of Hysteresis loop? Explain. [4]

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

   c) A p-n junction is made by silicon doped with 10^{17} donor atoms per cm^3 with silicon doped 10^{16} acceptor atoms per cm^3 at room temperature. Calculate built in potential across the junction and diffusion co-efficient in both parts. [6]

4. a) A pn junction is formed at 300k. The acceptor and donor concentration in p-side and n-side are 10^{18} cm^{-3} and $10^{16} cm^{-3}$ respectively. Calculate: [8]

   i) Built in potential
   ii) Width of deplection layer
   iii) Maximum value of electric field

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

5. a) Explain about intrinsic Fermi level of a pure semiconductor and derive a relationship of the intrinsic Fermi level assuming that intrinsic carrier concentration is known. [2+4]

   b) Explain how carrier concentration of a semi-conductor depends on temperature with necessary diagrams and graphs. [6]

   c) What do you understand by diffusion of charge carriers in semiconductor? How does diffusion contribute to conductivity of a semiconductor? [4]

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