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; $\mu_n$=1350cm$^2$/v.s(at 300K)***
- ✓ ***$\mu_h$=450 cm$^2$/v.s(at 300K); $N_A$=6.022*10$^{23}$/mol***

1. a) 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 $\mu_e$ and $\mu_h$ 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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# 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;* $\mu_n=1350cm^2/v.s$*(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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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; $1\ ev = 1.6 \times 10^{-19} J$
- ✓ $k = 1.38 \times 10^{-23} JK$; $n_i = 1.45 \times 10^{10}/cm^3$ for s;
- ✓ $\mu_n = 1350 cm^2 v^{-1}s^{-1}$ (at 300K); $\mu_h = 450 cm^2 v^{-1}s^{-1}$ (at 300K)
- ✓ $\varepsilon = \varepsilon_0\varepsilon_r = 11.9 \times 8.85 \times 10^{-12}$ F/m; $Eg = 1.1ev$
- ✓ $N_A = 6.624 \times 10^{-23}$ /mol $e = 1.602 \times 10^{-19} C$
- ✓ $M_{at} = 16g/mol$ (oxygen) 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 $1.5 \times 10^6$ 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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| 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;*
- ✓ *$\mu_h$ = 450cm$^2$v$^{-1}$S$^{-1}$ (at 300K); $\mu_e$ = 1350cm$^2$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 $\phi$= 2.6eV. [4]

   c) Conduction electrons with drift mobility of 53cm$^2$V$^{-1}$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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INSTITUTE OF ENGINEERING

# Examination Control Division

**2070 Chaitra**

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

## *Subject:* - Digital Logic *(EX502)*

- ✓ 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.*

1. Define digital signal and explain Gray code with example. [1+5]
2. Prove that positive X-OR is equivalent to negative X-NOR. [5]
3. a) Convert the following term into standard min term. A+B'C. [3]
   b) Use K-map method to implement the following function and also draw the reduced circuit using NOR gate. [5]

   $F(A, B, C, D) = \Sigma_m (0, 2, 4, 6, 8, 10, 15)$ and

   $d = \Sigma_m (3, 11, 14)$
4. a) Realize the logic circuit of the following using 8:1 MUX. [4]

   $F(W, X, Y, Z) = \Sigma_m (1, 2, 5, 7, 8, 10, 12, 13, 15)$

   b) When $FF_H$ is ANDed with $CO_H$ what will be the resulting number? Subtract (26) 10 from (16) 10 using 2's complement binary method. [2+2]
5. a) Differentiate between level and Edge triggering? [3]
   b) Explain the operation of two bit magnitude comparator with truth table and circuit diagram. [5]
6. a) Describe different types of registers with diagram. [8]
   b) Illustrate how 1011 data can be stored and retrieve in parallel in serial out shift register with neat timing diagram and truth table. [8]
7. Differentiate synchronous and asynchronous sequential circuits. Explain the operation of mod-12 synchronous counter with timing diagram. [2+6]
8. a) Define state diagram and state table with example. [2]
   b) Design a sequential machine that has one serial input and one output z. The machine is required to give an output z = 1 when the input X contains the message 110. [8]
9. Draw the schematic diagram of TTL two input NOR Gate. [6]
10. Explain briefly the block diagram of an instrument to measure frequency. [5]

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INSTITUTE OF ENGINEERING
# Examination Control Division
**2069 Chaitra**

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

## *Subject*: - Digital Logic *(EX502)*

- ✓ 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.*

1. Define digital IC signal levels. What is Gray Code? Explain with example. [3+3]
2. Construct the given Boolean function: F = (A+B) (C+D) E using NOR gates only. [4]
3. Simplify F (A,B,C,D) = π (0,2,5,8,10) + d(7,15). Write its standard SOP and implement the simplified circuit using NOR gates only. [4+4]
4. a) What is priority Encoder? Design octal to binary priority encoder. [2+4]
   b) Design a 2 bit magnitude comparator. [4]
5. Design a combinational logic that performs multiplication between two 4 bit numbers using binary parallel adder and other gates. [8]
6. Draw the circuit diagram and explain the operation of positive edge triggered JK flip-flop. What are the drawbacks of JK flip-flop? [7+1]
7. Explain the Serial in Serial out (SISO) shift register with timing diagram. [4]
8. Design the synchronous decade counter and also show the timing diagram. [8]
9. Design a sequential machine that detects three consecutive zeros from an input data stream X by making output, Y = 1. [12]
10. Draw the schematic circuit for CMOS NAND gates. What do you mean by totem-pole output? [4+4]
11. Describe the operation of a frequency counter. [4]

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