($2\frac{1}{2}$ Hours) Total Marks: 75

N.B. : (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) Draw **neat** diagrams wherever **necessary**.
(5) Symbols have usual meaning unless otherwise stated.
(5) Use of **non-programmable** calculator is allowed.

List of Constants:

1.	Charge on electron	$e = 1.6 \times 10^{-19}$ C
2.	Electron mass	$m = 9.1 \times 10^{-31}$ Kg
3.	Planck's constant	$h = 6.62 \times 10^{-34}$ js
4.	Velocity of light in vacuum	$c = 3 \times 10^{8}$ m/s
5.	Permeability of free space	$\mu_o = 1.257 \times 10^{-6}$ N·A^{-2}
6.	Permittivity of free space	$\varepsilon_o = 8.85 \times 10^{-12}$ C^2 / N·m^2
7.	Avogadro 's number	$N_A = 6.02 \times 10^{26}$ Kg- mol^{-1}
8.	Boltzmann constant	$k = 1.38 \times 10^{-23}$ J/K $= 8.625 \times 10^{-5}$ e V/K
9.	Bohr magneton	$\mu_B = 9.27 \times 10^{-24}$ ampere- meter^2

1. (a) Attempt any **one:**---

(i) Explain thermionic emission in metals. Derive an expression for the emitted current density. 10

(ii) Derive the expression of Fermi energy and average energy of electron gas at absolute zero. Assume the expression of density of states. 10

(b) Attempt any **one:**---

(i) Explain drift velocity, relaxation time and mean free path as applied to free electron in a metal. 5

(ii) Find the temperature at which there is 1% probability that a state with energy 0.5 eV above fermi energy will be occupied. 5

2. (a) Attempt any **one:**---

(i) Discuss the Kronig- Penney model for behavior of an electron in a one dimensional periodic lattice. Show that it leads to the occurrence of allowed and forbidden bands for the electrons. 10

(ii) Explain Meissner effect in superconductors. Hence discuss Type I and Type II superconductors 10

(b) Attempt any **one:**---

(i) Explain how materials can be classified into conductors, insulators and semiconductors on the basis of E-K curve for the materials. 5

(ii) The critical temperature for a superconductor is 6.4 K in zero magnetic field. The critical magnetic field for the same material at 0 K is 7.5×10^4 A/m. Find the critical field at 3.6 K and 1K. 5

3. (a) Attempt any **one:**---

(i) Explain Langevin's classical theory of Paramagnetism. Derive an expression for the paramagnetic susceptibility of metal at ordinary temperature and normal field strength 10

(ii) Discuss Weiss field theory of Ferromagnetism. Hence derive a relation between ferromagnetic Curie temperature and Weiss constant 10

(b) Attempt any **one:**---

(i) Explain the origin of permanent magnetic dipole moments in a solid and obtain the relation between magnetic dipole moment and angular momentum of an orbiting electron. 5

(ii) A magnetic field strength of a material is 10^5 A/m. If the magnetic susceptibility of the material is $-(0.8 \times 10^{-5})$, calculate magnetization and magnetic flux density. 5

4. (a) Attempt any **one:**---

(i) What is p - n junction? With the help of energy band diagram of an unbiased p-n junction explain the terms: Depletion region and Potential barrier. 10

(ii) Derive an expression for electron concentration in an intrinsic semiconductor, hence write the expression for hole concentration at absolute temperature (T). 10

(b) Attempt any **one:**---

(i) Draw the volt-ampere characteristics of the p-n junction diode. Explain how they depend on the temperature. 5

(ii) A germanium p-n junction diode has reverse saturation current of 2 μA at 27^0C. Find its static and dynamic resistance for an applied forward bias of 0.3 V at 27^0C. . 5

5. (a) Attempt any **one:**---

(i) The density of silver is 10^4 Kg / m^3, the atomic weight of silver is 107.9 a.m.u. The conductivity of silver at 20^0C is 7×10^7 Ω^{-1} m^{-1}. Calculate the collision time in silver. 4

(ii) Find the Fermi velocity and temperature of electron in sodium at 0 K for E_{F0} = 3.2 eV. 4

(b) Attempt any **one:**---

(i) Calculate critical current through Tungsten wire of diameter 2.8 mm and $H_C = 8.51\times 10^7$ A/m. 4

(ii) A two dimensional square lattice has side of 0.85 nm. Calculate momentum and energy of the free electron of first Brillion zone. 4

(c) Attempt any **one:**---

(i) Consider helium atom in its ground state. The mean radius is 0.528nm. Density of helium is 0.178kg/m^3. Calculate the diamagnetic susceptibility of the helium atom. Atomic mass of helium = 4.003u 4

(ii) A magnetic material made of steel has a magnetic moment of 3 Am^2 and a mass of 6 $x10^{-3}$ kg. If the density of steel is 7.9 x 10^3 kg m^{-3},find magnetic flux density when it is placed in magnetic field of 1000Amp/m. 4

(d) Attempt any **one:**---

(i) For an intrinsic semiconductor with gap width E_g = 0.7eV, calculate the concentration of intrinsic carrier at 300 K. Given $m_0 = 9.1 \times 10^{-31}$ kg, Nc = 5 x 10^{25} m^{-3}. 3

(ii) An electric field of 50V/m is applied to a sample of n-type semiconductor whose Hall coefficient is –($0.015m^3$/C). Determine the carrier charge density (n) in the sample. 3
