	Utech
Name:	
Roll No.:	The Description and Explana
Invigilator's Signature :	

CS/B.TECH(EE-NEW/EEE-NEW/EIE-NEW/ICE-NEW)/ SEM-4/PH(EE)-401/2012

2012

PHYSICS - II

Time Allotted: 3 Hours Full Marks: 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP - A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any ten of the following:

 $10 \times 1 = 10$

- i) He^3 and muon are
 - a) fermions
 - b) bosons
 - c) fermions & bosons respectively
 - d) bosons & fermions respectively.
- ii) The degrees of freedom for a system of N particles with K constraint relations is given by
 - a) N K

- b) N 3K
- c) 3N K
- d) 3K N.

4158 [Turn over



- iii) The coordination number for FCC structure is
 - a) 6

b) 8

c) 12

- d) 5.
- iv) The dielectric constant of a conductor is
 - a) 0

b) 1

c) - 1

- d) infinity.
- v) Fermi-Dirac distribution approaches Maxwell-Boltzmann distribution at
 - a) low temperature & high density
 - b) high temperature & low density
 - c) low temperature & low density
 - d) high temperature & high density.
- vi) If E_1 is the energy of the ground state of a one-dimensional potential box of length l and E_2 be the energy of the ground state when the length of the box is halved, then
 - a) $E_2 = 2E_1$
- b) $E_2 = E_1$
- c) $E_2 = 4E_1$
- d) $E_2 = 3E_1$.
- vii) The reciprocal lattice of a body centered cubic (bcc) lattice is
 - a) bcc

b) fcc

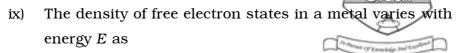
c) sc

- d) hcp.
- viii) The wave function of a particle is $\Psi = A \cos^2 x$ for $-\frac{\pi}{2} < x < \frac{\pi}{2}$. Then, the value of A is
 - a) $\sqrt{\frac{8}{3\pi}}$

b) $\sqrt{\frac{3}{8\pi}}$

c) $\sqrt{\frac{1}{2\pi}}$

d) $\sqrt{\frac{3}{2\pi}}$.



a) \sqrt{E}

b) E²

c) E^{0}

d) $\frac{1}{E}$.

x) Curie-Weiss law is obeyed by

- a) paramagnetic materials
- b) anti-ferromagnetic materials
- c) ferromagnetic materials above the Curie temperature
- d) ferromagnetic materials below the Curie temperature.

xi) The Miller indices of a plane parallel to XY plane is

- a) (100)
- b) (010)

c) (001)

d) (110).

xii) If σ and k be the electrical and thermal conductivities in a solid, then according to Widemann-Franz law,

- a) $\frac{\sigma}{kT}$ = const.
- b) $\frac{k\sigma}{T} = \text{const.}$
- c) $\frac{k}{\sigma T} = \text{const.}$
- d) $\sigma kT = \text{const.}$

(where T is the temperature)

xiii) The product of generalized force (\mathcal{Q}_i) and generalized displacement ($\delta\,q_j$) must have the dimension of

a) force

b) work

c) power

d) length.



- xiv) The spacing between the *n*th energy state and next energy state in a one-dimensional potential box increases by
 - a) 2n 1

b) 2n + 1

c) n-1

- d) n + 1.
- xv) In an n-type semiconductor, donor level
 - a) is nearer to conduction band
 - b) is at the middle between valence and conduction bands
 - c) is nearer to valence band
 - d) is not formed at all.

GROUP - B

(Short Answer Type Questions)

Answer any *three* of the following.

 $3 \times 5 = 15$

- 2. a) Describe briefly micro-state and macro-state with suitable examples.
 - b) Show that the average energy of electrons at T=0K is given by $\frac{3}{5}$ E_F (where E_F is the Fermi energy) . 2 + 3
- 3. a) What do you mean by cyclic coordinate? Explain with an example.
 - b) Show that if a given coordinate is cyclic in Lagrangian, it will also be cyclic in Hamiltonian. 2+3
- 4. a) Define atomic polarizability. Establish a relation between polarization and atomic polarizability.
 - b) Calculate the induced dipole moment per unit volume of He gas if it is placed in an electric field of 6000 V cm $^{-1}$. The atomic polarizability of He is 0.18×10^{-40} Fm 2 and density of He is 2.6×10^{25} atoms per m 3 . 3+2

- 5. a) Derive Curie's law of paramagnetism in the framework of Langevin's theory.
 - b) Are all orientations of the magnetic dipoles possible in quantum theory? Explain. 4 + 1
- 6. a) Explain what you mean by degeneracy of an eigenstate with an example.
 - b) The eigenvalue equation for the momentum operator is $\left(\frac{1}{i}\right)\left(\frac{\partial\Psi}{\partial x}\right) = \lambda\Psi.$

Solve the above equation and hence show that for Ψ to be a physically admissible eigenstate, the eigenvalue λ must be real. 2+3

7. Derive the Bragg's law of X-ray diffraction from Laue equation and deduce the vector form of Bragg's law of X-ray diffraction in reciprocal space. 2+3

GROUP - C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

- 8. a) A free particle of mass m is confined within x = 0 and x = L.
 - i) Write down Schrö dinger time-independent equation for such a system.
 - ii) Solve the equation to find out the normalized eigenfunctions.
 - iii) Show that the eigenfunctions corresponding to two different eigenvalues are orthogonal. 1 + 4 + 3



b) If \hat{P} and \hat{L} be the momentum and angular momentum operators, find the values of $[\hat{L}_x, \hat{x}]$ and $[\hat{L}_x, \hat{y}]$.

2 + 2

- c) Find the expectation value of x for the wave function given by $\Psi(x) = Ae^{-bx^2}$.
- 9. a) The energy wave vector dispersion relation for a one-dimensional crystal of lattice constant a is given by $E\ (\ k\) = E_o\ -\alpha 2\ \beta\ \cos\ ka, \ \text{where}\ E_o\ ,\ \alpha,\ \beta\ \text{are}$ constants.
 - i) Find the value of k at which the velocity of an electron is a maximum.
 - ii) Find the difference between the top and the bottom of the energy band.
 - iii) Obtain the effective mass m^* of the electron at the bottom and at the top of the band. 2 + 2 + 2
 - b) What do you mean by density of states ? Show that the density of states of free electrons vary with energy (E) as \sqrt{E} . 1 + 4
- 10. a) Define Hamiltonian of a dynamical system. When does it represent the total energy of the system? Explain.

2 + 3

b) The Lagrangian of a particle of mass m in one dimension is given by

$$L = \frac{1}{2} m \left(\dot{x}^2 - \omega^2 x^2 \right) e^{bt}$$

Obtain the canonical momentum and equation of motion. Is the Hamiltonian constant of motion? 3 + 3

c) Deduce D'Alembert's principle from the principle of virtual work.

4158

- 11. a) What do you mean by symmetric and anti-symmetric wave function? How does Fermi-Dirac (FD) statistics differ from Bose-Einstein (BE) statistics?
 b) Explain graphically the Fermi distribution at zero and non-zero temperature.
 3
 - c) Derive Planck's radiation law from BE statistics. State clearly the assumptions made in the theory. 3 + 2
 - d) Compute the specific heat of a free electron gas using classical statistics. Using FD statistics, argue that the specific heat of electrons should vary linearly with temperature (T). 2+3
- 12. a) What is Larmor frequency?
 - b) With the help of Weiss molecular field theory of ferromagnetism, derive the Curie-Weiss law. 5

2

- c) Draw the B-H curve for a ferromagnetic material and identify the retentivity and the coercive field on the curve. What is the energy loss per cycle?

 3 + 1
- d) Explain the reason behind the negative susceptibility of diamagnetic material.
- e) Calculate the effective Bohr magneton for Gd $^{+3}$. The electronic configuration for Gd $^{+3}$ is 4 f 7 5s 2 5p 6 .2

4158 7 [Turn over