Second Semester M.Sc. Physics Examination, January 2016

Classical Electrodynamics and Optics

Time: 3 Hours Max. Marks: 80

Instructions: *Answer all questions.*

1. (a) Arrive at the multipole expansion of the electrostatic potential due to an arbitrary charge distribution. (10)

   (b) Setup an expression for electric quadrupole moment. (5)

OR

2. (a) Setup an expression for Lienard-Wiechert potentials of a moving point charge. (10)

   (b) Show that charges travelling with uniform speed cannot radiate electromagnetic energy. (5)

3. (a) Deduce the Abraham-Lorentz formula for radiation reaction. Explain its significance. (10)

   (b) Show that acceleration assumes enormous proportion almost instantaneously, in terms of Abraham-Lorentz formula. (5)

OR

4. (a) Discuss the behaviour of plasma in a magnetic field in detail. (10)

   (b) Obtain an expression for Alfven velocity of a plasma wave. (5)

5. (a) Discuss the propagation of electromagnetic waves through a conducting medium. (10)

   (b) Obtain an expression for plasma frequency of an ionized gas. (5)

OR

6. (a) Derive Clausius- Mossotti equation for electric fields in solids. (10)

   (b) Write a note on crystal polarizers. (5)

7. (a) Obtain an equation for the intensity distribution due to superposition of light waves from two coherent sources. (10)

   (b) Note down the conditions for sustainable interference. (5)

OR

8. (a) Give a detailed description of diffraction at a circular aperture. (10)

   (b) Discuss briefly the Huygens' theory of light and Fresnel's correction to it. (5)

9. Answer **any four** of the following: (4X5=20)

(a) Obtain an expression for electric dipole moment.

(b) Show that when the velocity is zero, the Lienard-Wiechert potentials generate electrostatic potential.

(c) Obtain an expression for power radiated by an accelerated charge when its acceleration is collinear to its velocity (bremsstrahlung).

(d) Show that ρ and ϕ are the fourth components of $\vec{J}$ and $\vec{A}$ respectively.

(e) Write a note on Pinch effect.

(f) Starting from Fresnel's equations, obtain Brewster's law.

(g) Discuss about resolving power of Fabry-Perot etalon.

(h) Write a short note on temporal coherence.

Second Semester M.Sc. Physics Examination, January 2016

Quantum Mechanics-1

Time: 3 Hours Max. Marks: 80

Instructions: *Answer all questions.*

1. (a) State and prove Heisenberg's uncertainty principle. 10

   (b) Discuss the method of normalization of wave function with an example. 5

OR

2. (a) Discuss the matrix representation in Quantum mechanics. 10

   (b) Distinguish between bra space and ket space. 5

3. (a) Obtain solutions for the radial equation of hydrogen atom. 10

   (b) Discuss in detail the relativistic kinematics of two body collisions. 5

OR

4. (a) State and prove Ehrenfest's theorem for momentum operator. 10

   (b) Set up Heisenberg equation of motion for a free particle. 5

5. (a) What are Clebsch-Gordan coefficients? Deduce the recursion relations required for the evaluation of Clebsch-Gordan coefficients. 10

   (b) Obtain the commutation relation between rotation operations about different axes. 5

OR

6. (a) Discuss the discrete symmetry transformations by considering parity and time reversal operations. 10

   (b) Obtain the Liouville's equation for the density matrix of a quantum system. 5

7. (a) Discuss the stationary state perturbation theory for non-degenerate case. Obtain the first order correction to wave function and first and second order correction to energy. 15

OR

8. (a) Based on the variational principle, estimate the ground state energy of helium Atom. 10

(b) Write a note on emission and absorption of radiation giving selection rules. 5

9. Answer **any four** of the following 4X5=20

(a) Show that the eigenvectors corresponding to different eigenvalues are orthogonal.

(b) Prove that the operators $i\left(\frac{d}{dx}\right)$ *and* $\left(\frac{d^2}{dx^2}\right)$ are Hermitian.

(c) Evaluate $\left[x, p_x^2\right]$.

(d) A particle in a one dimensional box $0 \le x \le a$ is in the ground state. Find $\langle x \rangle$ *and* $\langle p \rangle$.

(e) Arrive at the eigenvalue spectrum of J^2 operator.

(f) Determine the total angular momentum that may arise when the following angular momenta are added: (1) $j_1 = 1, j_2 = 1/2$ (2) $j_1 = 2, j_2 = 1/2$.

(g) Calculate the first order perturbation correction to the energy of a harmonic oscillator with a perturbation $V = \frac{1}{2} bx^2$ where b is a constant.

(h) Show that under harmonic perturbation, only those transitions are allowed for which the Bohr frequency is equal to the frequency of the perturbation.

Second Semester M.Sc. Physics Examination, January 2016

Thermal Physics and Statistical Mechanics

Time: 3 Hours

Max. Marks: 80

Instructions: *Answer all questions.*

1. (a) Deduce Maxwell's relations in thermodynamics. 10

(b) Derive Clausius-Clapeyron equation. 5

OR

2. (a) State and explain Onsager reciprocal equation. 10

(b) Show that for an ideal gas, $C_p - C_v = R$. 5

3 .(a) State and prove Liouville's theorem. 10

(b) Write a note on Phase space of a molecule. 5

OR

4 .(a) Derive the distribution for a canonical ensemble. 10

(b) State and explain Gibbs paradox. 5

5. (a) Derive the expressions for BE and FD distribution functions starting from a grand canonical ensemble. 10

(b) Obtain the symmetric and anti symmetric wave functions for a system of two independent quantum particles. 5

OR

6 .(a) Obtain an expression for the average value of an observable using density matrix formalism. 10

(b) Derive an expression for rotational partition function at high temperature. 5

7. (a) Starting from Fermi energy equation derive an expression for zero point pressure of an electron gas in metals. 10

(b) Write a note on flux quantization. 5

OR

8. (a) Using BE statistics derive Planck's law of black body radiation. 10

(b) Define magnetic susceptibility. 5

9. Answer **any four** of the following: 4X5=20

(a) State and explain second law of thermodynamics.

(b) Given that the critical temperature, critical pressure and molar volume for a gas are 33.2K, 1.295×10^{6} Pa and 6.5×10^{-5} m^3mol^{-1}. Find the Van der waal's constants.

(c) Derive an expression for entropy of a system in terms of Partition function.

(d) Prove that for two systems to be in equilibrium, their chemical potentials must be constant.

(e) Under what condition does one get the classical limit of quantum statistical system?

(f) Deduce the vibrational contributions of the molecules of a gas to the specific heat.

(g) Calculate the Fermi energy in eV for sodium, assuming that it has 1 free electron per atom. Given: density of sodium= 0.97 gcm^{-3}, atomic weight of sodium is 23.

(h) How many photons are there in 1cc of radiation at 727^0C temperature?

Second Semester M.Sc. Physics Examination, January 2016

Spectroscopy

Time: 3 Hours Max. Marks: 80

***Instructions**: Answer all questions.*

1. (a) Explain the normal Zeeman effect and obtain an expression for the transition between the D_1, D_2 lines of sodium. Also deduce the expression for Lande's g_J factor. 10

(b) Explain the natural width of the spectral line. 5

OR

2. (a) Describe the Stark effect in weak and strong field. 10

(b) Explain the nuclear spin and obtain an expression for nuclear magneton. 5

3 .(a) Mention the principles involved in NMR spectroscopy and explain with neat diagrams the basic requirements in NMR spectrometer. 10

(b) Mention the applications of NMR in medicine. 5

OR

4 .(a) Explain the rotational spectra of rigid rotator and non- rigid rotator of diatomic molecules. 10

(b) Write a note on microwave spectroscopy. 5

5. (a) Explain the theory of diatomic vibrating rotator. 10

(b) Explain the working of FTIR spectrometer. 5

OR

6 .(a) Explain the quantum theory of Raman effect. Also explain the intensity of Raman lines. 10

(b) Explain the selection rules used in the IR spectroscopy. 5

7. (a) Describe the spectrofluorimeter and mention its applications. 10

(b) Write the qualitative applications of gas liquid chromatography. 5

OR

8. (a) Explain the stellar evolution and write a note on cosmic rays. 10

(b) Write the applications of mass spectroscopy. 5

9. Answer **any four** of the following. 4X5=20

(a) Using the isotopes $_1H^1$ and $_1H^2$, estimate the change of wavelength.

(b) A sample of a certain element is placed in a magnetic field of flux density 0.3 tesla. How far apart is the Zeeman component of a spectral line of wavelength 4500 Å? Given: e/m = 1.76×10^{11} C/kg, c = 3×10^8 m/s.

(c) For a given organic compound two kinds of protons exhibit signals at 50 and 200 Hz using a 60 MHz p.m.r spectrometer. What will be their relative position using 90 MHz spectrometer? And convert the position of signal at 50 Hz into δ *and* τ units.

(d) The rotational spectrum of HCl shows a series of lines separated by 20.6/cm. Find the moment of inertia and inter-nuclear distance.

(e) Using wavelength of 4000 Å, the first Stokes' line appears at a spacing of 350/cm from the Rayleigh line. Calculate the frequency of the first anti-Stokes line in wave number.

(f) The fundamental frequency of a molecule is 8.67×10^{13}/s. calculate the corresponding Raman lines of the molecule when irradiated with 435.8 nm wavelength.

(g) Calculate the energy in joules per quantum calories per mole and electron volts of photons of wavelength 3000 Å.

(h) Write a note on cosmic ray spectrum.