2017

M.Sc.

3rd Semester Examination

PHYSICS

PAPER – PHS-301 (Gr. – A + B)

Full Marks : 50

Time : 2 Hours

(Quantum Mechanics III – PHS 301A)

Answer Q1 and any one from Q2 and Q3

1. Answer any five bits: 5X2 = 10

(a) Write down the conditions for central field approximations.

(b) Why ground state of a two-electron atomic system is always a singlet?

(c) Explain the origin of the spin-orbit interaction term (H_{SO}) for a hydrogen-like atom.

(d) Show that transitions between $2p_{3/2}$, $2p_{1/2}$ and $1s_{1/2}$ result in 10 different lines for weak-field Zeeman effect.

(e) With the help of one electron spin functions **α** and **β**, construct two-electron spin functions and hence show that $s^2\chi_1(1,2) = 2\chi_1(1,2)$ [symbols have their usual meanings]

(f) State and explain the Fermi Golden rule for transition to a group of closely spaced final state.

(g) State when partial wave method and Born approximation are applicable.

(Turn Over)

(h) What do you mean by 'equivalent and non-equivalent' electrons?

2. (a) Using $f_k(\theta) = \frac{1}{K}\sum_{l=0}^{\infty}(2l+1)sin\delta_l \,.\, e^{i\delta_l}.\ p_l(cos\theta)$, show that total scattering cross section is independent from the interference between different partial waves. (4)

(b) State and explain optical theorem for scattering. (2)

(c) Calculate the 1st order energy correction (ΔE_{MV}) due to perturbation of $H_{MV}(= -\frac{p^4}{8m^3c^2})$. (4)

3. (a) Write the wave function of the 2^3S (s=1) level of He in the central field approximation. Also express them in the form of Slater determinants. (1+2)

(b) Calculate the ground state energy of the two-electron atomic system. (4)

(c) Calculate the first Born amplitude for the potential $V(r) = -V_0 e^{-r/a}$ where V_0 and a are constants. (3)

(Statistical Mechanics II – PHS 301B)

Answer Q1 and any one from Q2 and Q3

1. Answer any five bits: 5X2 = 10

(a) A system consists of two identical, non-interacting, spinless particles. The system has only three single-particle states ψ_1, ψ_2, and ψ_3 with energies $\varepsilon_1 = 0 < \varepsilon_2 < \varepsilon_3$ respectively. List in a vertical column all the two-particle states available to the system, along with their energies, if the particles are Fermions.

(b) For a canonical ensemble derive the expression for entropy in terms of partition function.

(c) Compute the mean number of particles ($\langle n_s \rangle$) in a single particle state (s) for photons.

(Continued)

(d) What is Gibbs paradox?

(e) Consider N distinguishable and non interacting particles. The single particle energy spectrum is $\varepsilon_n = n\varepsilon$, with $n = 0, 1, 2, ..., +\infty$ and degeneracy $g_n = n+1$ ($\varepsilon > 0$ is a constant). Compute the internal average energy $\langle U \rangle$.

(f) Give a short account on the negative temperature of a magnetic system.

(g) Calculate density of states of free electrons in two and one dimensions.

(h) A classical particle of mass m is in one dimensional motion lying between $x = 0$ and $x = L$. The energy of the particle is between E and $E+\Delta E$. What is the area of the region of phase space accessible to the particle?

2. (a) A physical system is composed of N distinguishable spins assuming two possible values ±1. These two values correspond to the energy levels $\pm\varepsilon$, respectively. Compute the total energy E using the Boltzmann formula and the microcanonical ensemble. (5)

(b) Explain the fact of fluctuation in a thermodynamic system. How can one reduce the energy fluctuation in a canonical ensemble? (3)

(c) A canonical system has two distinct energy levels $+\Delta$ and $-\Delta$. What is the average energy? (2)

3. Evaluate the density matrix ρ_{mn} of an electron spin in the representation that makes $\hat{\sigma}_x$ diagonal. Calculate $\langle \sigma_z \rangle$, resulting from this representation. (5+5)

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Internal Assessment-10