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M.Sc. 4th Semester Examination 2014

PHYSICS

PAPER – PHS-401(Gr.-A + Gr.-B)

Full Marks : 40

Time : 2 hours

The figures in the right hand margin indicate marks

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

Use separate scripts for Gr.-A and Gr.-B

GROUP–A

[*Marks* : 20]

Time : 1 hour

Answer **Q.Nos.1 & 2** and any **one** from the rest

1. Answer any *two* bits : 2 × 2

(*a*) What is particle exchange operator ? What are its eigenvalues ? Show that it is a constant of motion for the Hamiltonian which are invariant under particle exchange.

(*Turn Over*)

(*b*) In a two particle spin system discuss the singlet and triplet state. Which of the two correspond to higher energy and what is the energy difference between the two states ?

(*c*) Obtain an expression for the phase shift δ_0 for *S* wave scattering by the potential

$$V(r) = \begin{cases} \infty & \text{for} \quad 0 \leq r \leq a \\ 0 & \text{for} \quad r > a \end{cases}$$

And hence find total scattering cross -section considering only *S* wave scattering.

2. Answer any *two* bits : 3 × 2

(*a*) Find an expression for phase shift of the scattered wave from a scatterer represented through a spherically symmetric potential.

(*b*) Write the Hamiltonian for an alkali atom in a magnetic field incorporating the spin orbit interaction term. Find the shift of the energy levels of the ground state and the first excited state due to (*i*) a weak magnetic field (Zeeman effect) and (*ii*) a strong magnetic field (Paschen-Back effect).

(*c*) What are the assumptions used in the Thomas Fermi model for estimating the central potential for the atomic electrons. Find the dimension less Thomas Fermi equation for estimating $V(r)$.

3. (*a*) Find the form of Greens function $G(\vec{r})$ which satisfy the equation

$$(\vec{\nabla}^2 + k^2)\, G(\vec{r}) = \delta(\vec{r}).$$

(*b*) Using the Greens Function, find an expression for the scattering amplitude in the first Born approximation.

(*c*) Find out the scattering cross-section for scattering by screened coulomb potential

$$V(r) = \frac{z_1 z_2 e^2}{4\pi \in_0 r} e^{-ar}$$ 10

4. Using semiclassical treatment of radiation with matter, find an expression for the transition probability per unit time for absorption or induced emission. Discuss the selection rules for electric dipole transition and the origin behind the doublet lines in the alkali atom exposed to a radiation field. l

GROUP—B

(*Statistical Mechanics*)

[*Marks* : 20]

Time : 1 hour

Answer **Q.No.1** and any **one** from the rest

1. Answer any *five* : 2 ×

(*a*) Write down the expression of grand partition function for B.E and F.D statistics.

(*b*) Draw the temperature dependance of chemical potential for ideal B.E and F.D. gas.

(*c*) In Rb^{87} atom, density of atoms is given by $n = 2{\cdot}5 \times 10^{18}/m^3$. Calculate the B.E. condensation temperature.

(*d*) Explain the term ' symmetry breaking' for para-ferro transition.

(*e*) Define long range and short range order parameter.

(*f*) How critical exponents are defined ?

(*g*) Why the concept of correlation function is important in magnetic susceptibility ?

(*h*) How Bragg William approximations predicts mean field theory ?

2. (*a*) For a 3-dimensional gas of bosons for which the single-particle energy is given by

$$\varepsilon_{\bar{p},n} = \frac{|\vec{p}|^2}{2m} + \propto n$$

where $\propto$ is a positive constant and $n = -j, \ldots, j$ is an integer. Find Expressions, valid in the thermodynamic limit, for the pressure P and the mean number of particles per unit volume in terms of the temperature T and the fugacity $z = e^{\mu\beta}$.

(*b*) Write down the condition for Bose-Einstein condensation.

(*c*) Find an expression of entropy density and specific heat per unit volume of a black body radiation in a 2-dimensional cavity at temperature T. 3 + 3 + 1 + 3

3. (*a*) Discuss Bragg-William approximations and show that the equilibrium value of long range order parameter is given by

$$m(T) = \tanh(\mu_0 H_{eff} \beta).$$

(*b*) Prove that in photoelectric effect, current density

$$J = \frac{2\pi k me}{h}(\gamma - \gamma_0)^r$$

where k = probability of absorption of photons in a metal. 5 + 5
