Thapar University
School of Physics & Materials Science
B. E., Second Semester, 2006-2007
End Semester Examination

Course Code: PH 202 | Date: May 30, 2007
Course Name: Modern Physics | Time Allowed: 3 hr
Instructor: S. D. Tiwari | Maximum Marks: 45

Note: This paper contains five questions. Attempt all questions. Show all steps in your derivations/calculations. Symbols have their usual meanings.

1. (a) Consider a 1000 kg car moving at a velocity of 100 km per hour with a velocity error of 1 μm per hour. Calculate the error in specifying the position of the car.

   (b) An excited atom gives up its excess energy by emitting a photon of characteristic frequency. If life time of the process is 1.0×10^{-8} s then calculate the uncertainty in the frequency of the emitted photon.

   (4.5 + 4.5)

2. (a) What is physical significance of expectation value?

   (b) A particle is limited to move along x-axis has the wave function $\psi = A \sin(\pi x/3)$ between x = 0 and x = 3; $\psi = 0$ elsewhere. Find the value of constant A.

   (c) A particle is limited to move along x-axis has the wave function $\psi = A x$ between x = 0 and x = 1; $\psi = 0$ elsewhere. Find the value of constant A and the expectation value $\langle x \rangle$ of the particle position. Also find the probability of finding the particle between x = 0.45 and x = 0.55.

   (1 + 2 + 6)

3. (a) Consider a system of two identical particles. We want to distribute these two particles between two different energy states. Find the number of ways in which these two particle can be distributed between the two different energy states if system follows (i) Maxwell-Boltzmann statistics, (ii) Bose-Einstein statistics and (iii) Fermi-Dirac Statistics.

   (b). Consider a system of N molecules of an ideal gas obeying Maxwell-Boltzmann statistics. The Maxwell-Boltzmann distribution function is $A\, e^{-(\varepsilon/kT)}$. For this system the number of energy states between energies ε and $\varepsilon + d\varepsilon$ is $B\, \varepsilon^{1/2}$. Calculate the value of product of A and B in terms of known constants.

   (c) Using results of 3 (b) or otherwise, show that average molecular energy of an ideal gas is (3/2) k T.

   (3 + 3 + 3)

4. Number of molecules of an ideal gas having energy between ε and ε + dε is given by relation

$$n(\varepsilon)\, d\varepsilon = C\, \varepsilon^{1/2}\, e^{-(\varepsilon/kT)}\, d\varepsilon.$$

Where C is a constant independent of ε. Using this relation find another relation which gives number of molecules of an ideal gas having speed between v and v + dv. Using this new relation find expressions for average and most probable speed.

(9)

5. (a) Derive Einstein's formula for specific heat of solids. Also write the assumption made by Einstein for the derivation of this formula. Using this formula show that at high temperature the specific heat of solid is independent of temperature.

(b) Write difference among Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac Statistics. Also give examples (at least one for each) of systems following the three different statistics.

(4.5 + 4.5)

Useful constant

(i) Plank's constant $h = 6.63 \times 10^{-34}$ J s

Useful integrals:

(i) $$\int_0^\infty \sqrt{x}\, e^{-ax}\, dx = \frac{1}{2a}\sqrt{\frac{\pi}{a}}$$

(ii) $$\int_0^\infty x^{3/2}\, e^{-ax}\, dx = \frac{3}{4a^2}\sqrt{\frac{\pi}{a}}$$

(iii) $$\int_0^\infty x^3\, e^{-ax^2}\, dx = \frac{1}{2a^2}$$