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PHYSICS

(Major)

Paper : 6.4

Full Marks : 60

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

*Write the answers to the two Groups in
separate books*

GROUP—A

(**Statistical Mechanics**)

(Marks : 30)

1. Answer the following questions : 1×4=4

- (a) How many dimensions of the phase space are required to describe a system of N particles?
- (b) Write down the expression for the ensemble average of a physical quantity.

(2)

- (c) What type of wave functions is required to describe a system of bosons?
- (d) What are the occupation numbers of a quantum state for fermions?

2. Answer the following questions : $2 \times 3 = 6$

- (a) State the postulate of equal a priori probability.
- (b) Write the Boltzmann relation which connects statistical mechanics with thermodynamics. Hence find the entropy of a system at the absolute zero temperature.
- (c) The relative probability of finding a system in the energy states E_1 and E_2 is e^2 . If $E_2 - E_1 = 4.83 \times 10^{-21}$ J, calculate the temperature of the system.

3. Answer any two of the following questions :

- (a) Establish Liouville's theorem and give its physical interpretation. $4+1=5$
- (b) Calculate the probability of finding two particles together in any one of three different quantum states if they are
- (i) classical particles, (ii) bosons and (iii) fermions. $2+2+1=5$

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(Continued)

(3)

- (c) Describe the phenomenon of Bose-Einstein condensation. Give one physical example of this phenomenon.

$4+1=5$

4. Answer any one of the following questions :

- (a) Deduce the Maxwell-Boltzmann energy distribution law

$$n(u)du = \frac{2\pi N}{(\pi kT)^{3/2}} u^{1/2} e^{-u/kT} du$$

Represent this distribution graphically.

$9+1=10$

- (b) What is the Fermi energy? Find an expression for the Fermi energy using Fermi-Dirac statistics.

Calculate the Fermi energy in copper provided number density of free electrons is 8.5×10^{28} electrons/m³.

$2+6+2=10$

GROUP—B

(Computer Applications)

(Marks : 30)

5. Answer the following :

$1 \times 4 = 4$

- (a) Write down the input and output statements used in either FORTRAN-95 or C or C++.

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(Turn Over)

- (b) Write down the FORTRAN-95 or C or C⁺⁺ expression for the algebraic expression $a = x + \frac{y}{z} - r^2 + c^3$.
- (c) How the following mathematical functions are invoked in FORTRAN-95 or C or C⁺⁺?
- (i) Absolute value of x
- (ii) y to the power z
- (d) What is nested loop?
6. Answer the following : 2×3=6
- (a) Briefly explain a statement use to implement looping in either FORTRAN-95 or C or C⁺⁺.
- (b) What is an array? Write down the syntax for declaration of a one-dimensional array in either FORTRAN-95 or C or C⁺⁺.
- (c) Write down the FORTRAN-95 or C or C⁺⁺ comparison operator corresponding to mathematical symbols (i) =, (ii) ≠, (iii) ≥ and (iv) ≤.

7. Answer either (a) or (b) : 5
- (a) Write down the flowchart and a program in either FORTRAN-95 or C or C⁺⁺ to find the sum of the following series :
- $$1+3+5+\dots+25$$
- (b) Write down the algorithm and a program in either FORTRAN-95 or C or C⁺⁺ to generate first fifteen numbers of the series
- $$0, 1, 1, 2, 3, 5, 8, \dots$$
8. Answer either (a) or (b) : 5
- (a) Prepare a program in either FORTRAN-95 or C or C⁺⁺ to compute the real as well as imaginary roots of the quadratic equation $ax^2 + bx + c = 0$.
- (b) Write down the flowchart and a program to compute the approximate value of the real root of the following equation :
- $$x^7 - 2x^4 + x - 8 = 0$$
9. Answer either (a) or (b) : 10
- (a) Write down the necessary relation to compute the numerical solution of a first-order differential equation using Runge-Kutta fourth order method.

Develop an algorithm and write a program in either FORTRAN-95 or C or C++ to compute the numerical solution of the equation

$$\frac{dy}{dx} = \frac{1}{2}(1+x)y^2$$

in the interval $[0, 1]$ having initial value $y = 1$ at $x = 0$ and step size $h = 0.1$ using Runge-Kutta fourth order method.

- (b) Give the mathematical relations used to compute numerical value of an integral using Simpson's one-third rule. Write the flowchart and a program in either FORTRAN-95 or C or C++ to compute the numerical value of the integral

$$\int_0^1 \frac{dx}{1+x^2}$$

using Simpson's one-third rule.
