This question paper contains **5** printed pages]

Code No. : 18(I) *Roll No. .....*

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PHYSICS

Paper : I

Time Allowed : 3 hours] *[Maximum Marks : 300*

*Note : (i) Answers must be written in **English**.*

(ii) Number of marks carried by each question are indicated at the end of the question.

(iii) Part/Parts of the same question must be answered together and should not be interposed between answers to other questions.

*(iv) **The answer to each question or part thereof should begin on a fresh page.***

*(v) **Your answers should be precise and coherent.***

*(vi) **Questions No. 1 is compulsory**. Attempt any **four** other questions, selecting at least **one** question from each Section.*

1. Answer any *six* of the following :

(a) Calculate the speed and momentum of an electron whose kinetic energy is 3 times its rest mass energy. 20

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(b) Find the value of the constant c so that the force $\vec{F} = \hat{i}xy + \hat{j}cx$ is conservative. 20

(c) Two particles of masses m_1 and m_2 undergo simple harmonic motion of amplitudes A_1 and A_2 respectively. If the total energy of particle 1 is twice that of particle 2, find the ratio of their time periods, T_1/T_2. 20

(d) Calculate the change in entropy when 1 mole of an ideal gas expands isothermally at temperature T = 300K to double its volume. 20

(e) A geyser heats water flowing at the rate of 3.0 litres per minute from 27°C to 77°C. If the geyser operates on a gas burner, what is the rate of consumption of the fuel if its heat of combustion is 4.0×10^4 J/g ? 20

(f) The mean free path of nitrogen molecules at 0°C and 1 atm. is 0.80×10^{-5} cm. At this temperature and pressure there are 2.7×10^{19} molecules/cm^3. What is the molecular diameter ? 20

(g) A beam of light consisting of two wavelengths 6500Å and 5200Å, is used to obtain interference fringes in a Young's double slit experiment. The distance between the slits is 2 mm and the distance between the plane of the slits and the screen is 120 cm. Calculate the least distance from the central maximum where the bright fringes due to both the wavelengths coincide. 20

(h) A single slit is illuminated by light whose wavelengths are λ_a and λ_b, so chosen that the first diffraction minimum of λ_a coincides with the second minimum of λ_b. What relationship exists between λ_a and λ_b ? 20

(i) A transverse wave is represented by

$$y = y_0 \sin\left[\frac{2\pi}{\lambda}(vt - x)\right]$$

Find the value of λ so that the maximum particle velocity is twice the wave velocity. 20

SECTION – A

2. (a) A particle of mass m is projected from infinity with a velocity Vo and impact parameter b_o with respect to the fixed centre of a inverse-square repulsive force of magnitude k/r^2, k is constant. Find an expression for the distance of closest approach of the particle. 30

(b) Show that Kepler's second law is a result of any central force motion. 15

3. (a) A particle of mass m moves under a conservative force with potential energy $V(x) = \frac{cx}{x^2 + a^2}$, where c and a are positive 'constants. Find the position of stable equilibrium. 20

(b) Three particles of masses 3, 2 and 1 MeV/c^2 have linear momenta $10\hat{i}, -5\hat{j}, +5\hat{j}$ MeV/c respectively in the lab system. Find (i) the magnitude and direction of the total momentum in the lab system, (ii) total momentum of the particles in the centre of mass system, (iii) velocity of the centre mass in the lab system. 15

(c) The ceiling of a long hall is 24m high. What is the maximum horizontal distance that a ball thrown with a speed of 40 m/s can go without hitting the ceiling? 10

SECTION – B

4. (a) State and explain the law of equipartition of energy and use it to calculate the values of γ for mono, dia and polyatomic gases. 20

(b) Using the first law of thermodynamics, show that for an ideal gas undergoing an adiabatic process PV^{γ} = constant, where $\gamma = C_p/C_v$. 25

5. Write the Maxwell's formula for speed distribution of molecules of a gas. Derive expressions for mean speed $(\bar{v})$, the root-mean-square speed (v_{rms}) and the most probable speed (v_p) of the molecules. 45

Draw curves showing the speed distribution of molecules at two temperatures T_1 and T_2 $(T_2 > T_1)$. Describe the important features of the plots.

SECTION – C

6. (a) Describe the analogy between the oscillations of a mass-spring system and the oscillations of a LC circuit. 25

   (b) A beam of circular polarized light falls on a polarizing sheet. Describe the emerging beam. 20

7. Distinguish between a damped and an undamped harmonic motion. Give one example of each.

   Establish the differential equation for a damped harmonic motion. Obtain its solutions and discuss the important features of the motion. 45
