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H.P.A.S. (Main)—2011

PHYSICS

Paper I

Time : 3 Hours *Maximum Marks :* 150

Note :— Question No. 1 is compulsory. Attempt any *four* questions from the rest. *All* questions carry equal marks.

1. Answer the following :

   (*a*) Differentiate between stream line and turbulent flow of a liquid and explain the significance of the Reynolds number. 6

   (*b*) A rocket of mass 2500 kg is projected vertically. If the exhaust gases escape out with a velocity 250 m/sec, find the rate of consumption of fuel to overcome the weight of the rocket. 6

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(c) How can you change the internal energy of an ideal gas ? Give example of each. 6

(d) If a system absorbs heat Q from the surrounding at a constant temperature T in a reversible process, what are the changes in entropy of the system, surroundings and universe ? Justify your answer. 6

(e) What are the conditions for sustained interference pattern and how are they realized in Fresnel's biprism experiments ? 6

2. (a) State the Kepler's laws of planetary motion and derive them from Newton's law of gravitation. 10

(b) Using Newton's second law, find an expression for the relativistic velocity of a particle of charge 'q' moving in a circle of radius 'R', at right angles to a magnetic field 'B'. 10

(c) Show that the energy of a body moving under an inverse square force remains conserved. 10

3. (a) What do you mean by an ideal gas ? To what limit do the real gases obey the ideal gas law ? Explain the deviation on the basis of kinetic theory. 10

(b) What do you mean by the black-body spectrum ? Use Bose-Einstein's statistics to derive Planck's formula for the distribution of energy in the black-body spectrum. 10

(c) 'm' mass of liquid at a temperature 'T_1' is mixed with equal mass of same liquid at temperature 'T_2' ($T_2 < T_1$). The whole system is insulated. Calculate the change in entropy in this process and show that the entropy of universe increases in this process. 10

4. (*a*) Define phase and group velocities. Establish a relation between phase and group velocities in cases of dispersive and non-dispersive media. 10

(*b*) Write down the differential equation for a forced harmonic oscillator and explain the significance of each term in it. Obtain solution of this equation and discuss it. Write the condition of resonance and explain the sharpness of resonance. 10

(*c*) The amplitude of oscillation of a forced harmonic oscillator is initially 10^{-5} m when the driving frequency is very low. It acquires a maximum value equal to 5×10^{-3} m at the frequency of driving force equal to 250 Hz. Calculate quality factor of the oscillator, relaxation time and half width of the resonance curve. 10

5. (a) State the physical conditions under which Maxwell-Boltzmann and Fermi-Dirac statistics show the identical behavior. 10

(b) Write down the Planck's formula for the black-body spectrum and use it to derive Wien's law and Reyleigh-Jean's law as its limiting cases. 10

(c) Assume that a gas is composed of point molecules that make perfectly elastic collisions with the walls of its container. Show then that the pressure exerted on the wall of a rectangular box of volume V = *abc*, containing N identical molecules each of mass *m*, is given by :

$$p = \frac{2N}{3V}\left[\frac{1}{2}m\left(v^2\right)_{avg}\right].$$ 10

6. (a) What are fringes of equal thickness and fringes of equal inclination ? Explain the formulation of Newton's rings by reflected light. How can we get a bright centre in a set of Newton's rings observed by reflected light ? 10

(b) What do you mean by Fraunhoffer diffraction ? Describe the Fraunhoffer diffraction pattern obtained with a single slit illuminated by beam of monochromatic light. Deduce condition of maxima and minima. Calculate the intensity of secondary maxima as a function of principal maxima. 10

(c) Distinguish between normal and anomalous dispersion ? Describe briefly Wood's experiment for observing anomalous dispersion. 10

7. (*a*) In Young's double slit experiment, the fringe width is 1×10^{-4} m. If the distance of the screen from the slit is doubled and the distance between the slits is reduced to half and the wavelength of light is changed from 6.4×10^{-7} m to 4.0×10^{-7} m, calculate the new fringe width. 10

(*b*) A zone plate is constructed by taking the photograph of Newton's rings obtained in the reflected light of wavelength $\lambda = 5000$ Å from an air film formed by keeping a plano-convex lens in contact with a plane glass plate. The radius of curvature of the curved surface of lens is 1 m. Calculate the fundamental focal length of the zone plate and the radius of the first zone. 10

(c) What is meant by multiple beam interference ? Deduce an expression for intensity of fringes. 10

8. (a) Show that the interference fringes formed in reflected and transmitted part due to thin film with monochromatic light are complementary to each other. Distinguish these fringes. 10

(b) What do you understand by coherent sources ? Is it possible to see interference with two independent sodium light sources ? Give reason to your answer. How are two coherent waves obtained ? 10

(c) Find the energy stored in a 60 cm length of a laser beam operating at 5 mW. 10