2019

PHYSICS

[Honours]

PAPER – II

Full Marks : 90

Time : 4 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

Illustrate the answers wherever necessary

GROUP – A

Answer any **two** questions : 15 × 2

1. (*a*) A mass is projected vertically upward from O with initial velocity V_0. Find the maximum height reached, assuming that resistance of air is proportional to velocity. 4

(*b*) The equation of a orbit of a particle moving under a central force is $r = a(1 + \cos\theta)$, a being constant. Find the nature of the force. 3

(*c*) Find the gravitational attraction between the two hemispherical halves of a solid sphere. 4

(*d*) Calculate the moment of inertia of a solid hemispherical object about an axis passing through its centre of mass and parallel to one of its principal diameter. 4

2. (*a*) Write down Maxwell's velocity distribution law of gas molecules. Deduce the energy distribution law from it. 1 + 3

(*b*) What do you mean by most probable velocity ? Expressing the velocity C as a fraction of the most probable velocity, deduce the reduced form of Maxwell's velocity distribution law. 1 + 4

(*c*) Give Einstein's analysis of Brownian motion and derive Einstein's equation. 6

3. (*a*) A point charge $q/2$ is placed at the centre of a spherical cavity of radius r inside a neutral spherical conductor of radius $4r$. Find the surface density of induced charge on the boundary of cavity. 4

(*b*) Using Biot-Savart's law prove that $\vec{\nabla} \cdot \vec{B} = 0$. 4

(*c*) What do you mean by polarization of dielectrics ? Obtain the modified Gauss's law in dielectric medium. 2 + 3

(*d*) What are the importances of Laplace's equation in electrostatics. 2

4. (*a*) Establish the boundary conditions satisfied by $\vec{B}$ and $\vec{H}$ at the interface of two media of different permeabilities, assuming that there is no free surface current. 6

(*b*) Determine the force between two equal parallel circular coaxial coils which are a small distance apart in free space and carry the currents I_1 and I_2. Assume that each of the coils has a single turn. 3

(*c*) Define emissive and absorptive power of a black-body. State Kirchhoff's law of thermal radiation. 2 + 2 + 1

(*d*) What do you mean by black-body radiation. 1

GROUP – B

Answer any **five** questions : 8 × 5

5. (*a*) Prove that for a system of particles, the total external torque is equal to the rate of change of angular momentum of the system, provided that the internal force between the particles is central. 5

(*b*) Show that the angular momentum of a body moving under a central force is conserved. 3

6. Find the relation between the time rates of change of a vector in a fixed and a rotating frame. Hence find an expression of Coriolis acceleration. (2 + 2) + 4

7. (*a*) Prove that for a gm-mole of a van der Waal gas,

$$C_p - C_v = R\left[1 + \frac{2ap}{R^2T^2}\right]$$ 5

(*b*) Establish Clausius-Clapeyron equation for first order phase transition. 3

8. Prove the relation $K = \eta C_v$, where the symbols have their usual meanings. 8

9. Set up the differential equation for the flow of heat through a metal bar of uniform cross -section considering the loss of heat by radiation from its surfaces. 8

10. (*a*) A charge q coulomb is distributed uniformly throughout a non conducting spherical volume of radius R metre. Show that the potential at a distance r from the centre ($r \leq R$) is given by

$$\phi = \frac{1}{4\pi \epsilon_0} \frac{q(3R^2 - r^2)}{2R^3}$$ 5

(*b*) Find the expression for average power dissipation in an a.c. circuit. 3

11. (*a*) Derive expressions for current and impedance when an alternating e.m.f. is applied to a circuit having capacitor, inductor and resistor in series. 6

(*b*) Define magnetomotive force and reluctance in a magnetic circuit. 2

12. (*a*) Derive an expression for the moment of inertia of a rigid body about an axis having direction cosines l, m, n. 3

(*b*) What is a compound pendulum ? Find the condition of minimum time period of a compound pendulum. 1 + 2

(*c*) A planet of mass M moves around the sun along an ellipse so that its minimum distance from the sun is equal to r and maximum distance is R. Using Kepler's laws, prove

that the period of revolution around the sun is

$$T = \pi\sqrt{\frac{(r+R)^3}{2GM}}.$$ 2

GROUP – C

Answer any **five** questions : 4×5

13. Consider the motion of two masses M_1 and M_2. Show that the kinetic energy of the particles in the centre of mass frame is equal to

$$\frac{1}{2}\left(\frac{m_1 m_2}{m_1 + m_2}\right)\dot{r}^2$$

where $\vec{r}$ is the relative position vector of the two masses. 4

14. Show that the path of a planet in a gravitational force field is an ellipse. 4

15. Obtain the radial and transverse components of

velocities and acceleration of a particle moving in a plane with the polar coordinates $r = A \sin Bt$ and $\theta = ct$, where A, B and C are constants. 4

16. An ideal gas (diatomic) expands adiabatically so that its volume is doubled. How many times will the number of collisions per second of moles decrease ? 4

17. What is physical significance of 'entropy' of a system ? Deduce an expression for the change in entropy of one gm-mol of a perfect gas when the temperature changes from T_1 to T_2 and volume changes from V_1 to V_2. 1 + 3

18. Show that at critical temperature, the departure of van der Waal's gas laws from the perfect gas is 62.5%. 4

19. (*a*) A plane electromagnetic wave with $\vec{B}$ field amplitude $3 \times 10^{-6}\,T$ travelling in vacuum falls on a surface and is totally reflected. Calculate the pressure exerted on the surface. 2

(*b*) What do you mean by retarded potential ? 2

20. A dipole of moment p is placed with its axis vertical at a distance 'd' from an infinite conducting horizontal grounded plane. Calculate the force exerted on the plane by the dipole with proper explanation. 4