PHYSICS

Time Allowed: 3 Hours ***Maximum Marks: 300***

Candidates should attempt Question 1 and 5 which are compulsory, and any three of the remaining questions selecting at least one question from each Section. All questions carry equal marks.

PAPER - I

SECTION A

1. Attempt any three of following :

(a) The orbit of the earth is an ellipse wite eccentricity 0.0167. Determine the ratio of the maximum speed of the earth to its minimum speed.

(b) A rocket is fired vertically up. During the burning of the engine, which lasts for 50 s, a constant acceleration of 2.0 g is observed. What is the speed of the rocket at the end of 50 s? Calculate the maximum height to which the rocket will rise before it begins to fall back. Take = g = 9.80 ms^{-2} and neglect the variation of g with height.

(c) Water is observed to flow through a capillary of diameter 1.0 mm with a speed of 3 ms^{-1} viscosity of water in c.g.s. units is :

0.018 at 0°C

0.008 at 30°C

0.004 at 70° C

Calculate he Reynolds numbers, and test at which of these three temperatures is the flow likely to be streamlined.

(d) Find the Fermi energy in eV of electrons in sodium $\left({}^{23}_{11}C\,Na\right)$, given its density to be 0.97 g cm^{-3}. Treat the electrons as a free gas.

2.(a) A neutron having kinetic energy E collides head on with a ${}^{12}_{6}C$ nucleus and rebounds perfectly elastically in the direction from which it came. Determine the kinetic energy of the neutron after collision.

(b) Calculate the mass of the Sun, given the distance of the Earth from the sun to be 1.5 x 10^8 km.

(c) Calculate the velocity of an electron having kinetic energy 1 MeV.

3.(a) A solid sphere of mass 6 kg, diameter 20 cm, and uniform density rolls over a surface with a speed of 2 ms^{-1}. Calculate its kinetic energy.

(b) n identical drops of water, each of radius r_2, coalease to form a large drop of radius R. Calculate the energy released in the process and the consequent rise in temperature of water.

(c) Explain clearly why Young's modules Y of a material determines the resistance to bending of a thin rod made of that material.

Derive the expression for the work done when a wire of length *l* and cross-sectional area A is stretched by an amount x(≤1) under a given load corresponding to equilibrium at stretching x.

4.(a) Calculate the root-mean-square speed of smoke particles of mass 5x10^{-14} g in air 0°C.

(b) Write down the expression for the energy distribution of a black body radiation at temperature T and deduce. Wien's displacement law.

$$\frac{h\omega m}{kT} = \text{const.}$$

Taking the constant to be equal to 3-ε, where ε is small (so that ε can be neglected in comparison to 1). Find the value of ε.

(c) Consider the following equation of state for a gas:

$$P = \frac{RT}{v-b} - \frac{a}{Tv^2}$$

where a and b arc constants and other symbols have their usual meaning. Find the values of P_e, T_e and V_e in terms of a and h at the critical point.

SECTION B

5. Answer any three of the following:

(a) Parallel light is incident normally on diffraction granting having 6,000 lines per cm. Find the angular separation between the maxima for wavelengths 5,890 Å and 5,896 Å in the second order.

(b) The angular frequency, ω, of a wave is related to the wave vector, k, by the relation

$$\omega = \omega_0 \sin\frac{ka}{2} \text{ for } 0 < k > \frac{\pi}{a}$$

Determine the phase and group velocities of this wave and draw a rough sketch to show their variation with

$$k\left(0 < k < \pi / a\right)$$

(c) Calculate the power radiated by a tungsten filament 10 cm long and 0.010 mm in diameter, when it is heated to 2,500 K in an evacuated bulb. Assume that the filament radiates at 30% of the rate of a black body at the same temperature.

(d) The earth receives from the Sun $1.37\text{x}10^3$ W/m^2 of power on the top of the atmosphere. Calculate the mass of the Sun that is converted into energy in one second.

6.(a) Out of die following three functions only one can be Fourier analysed in the range $-\pi \leqslant x \leqslant \pi$. Choose the correct function and obtain its Fourier series expansion:

(i) $f(x) = x^2$ for $0 < x < \pi$

(ii) $f(x) = 0$ for $-\pi < x < 0$

$= \pi$ for $0 < x < \pi$

(iii) $f(x) = 1/x^2$ for $-\pi < x < \pi$

(b) How can one produce

(i) left-handed circular motion, and

(ii) right-handed circular motion

by combining two simple harmonic motions? Justify, your answers.

(c) What is stimulated emission of light? How does it differ from spontaneous emission? Name any device basal on the stimulated emission of light and explain its working.

7.(a) Define and explain the terms resolving power and magnifying power of an optical instrument. For a telescope, on that parameter do these depend? For a given resolving power, what is the optimum magnifying power?

(b) Using Huyghens' construction, discuss the propagation of O and E waves in a biaxial crystal when the optic axis is perpendicular to the plane of incidence and parallel to the boundary surface. Take the incident ray to be oblique.

(c) Two homogeneous isotropic dielectric media have a common plane boundary and ale otherwise infinite in extent. An electromagnetic wave is incident on the boundary. Establish the laws of reflection and refraction.

8. Write notes on any three of the following:

(a) Super fluidity, explaining why it is a quantum phenomenon.

(b) Brownian motion and the importance of its study.

(c) Thermal ionization and its application.

(d) Uses of multiple beam interferometry.

(e) Bernoulli's theorem and its applications.

(f) Physical significance of each of the four Maxwell's equation.

PHYSICS

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PAPER - II

SECTION A

1. Answer any three of the following:

(a) Two cells of emf 2 volts each and internal resistance 2 ohms rich are connected in parallel with each other and with a load resistance. Calculate the maximum power that can be dissipated in the load.

(b) The parallel plates of a capacitor have an area of 2000 cm^2 each and are 1 cm apart. They are originally at a potential difference of 3.000 volts. When a dielectric is introduced covering the whole space between the plates, the potential difference becomes 1000 volts. Calculate the capacitance of the capacitor before and after insertion of the dielectrical. What is the dielectric constant of the dielectric?

(c) A triode has a transconductance (g_m) of 1,600 micromhos. The following table gives two sets of the plate voltage (E_b), the grid voltage (E_c) and the plate current (I_b).

E_b	E_c	I_b
250V	–22V	12.6 mA
180	–16.5	12.6

Define the terms amplification factor and plate resistance and calculate them for the above case.

(d) Draw a complete circuit for common emitter (small signal) amplifier for low frequencies and explain briefly its working.

2. Distinguish between dia-. para- and ferromagnetism. Give an account of Weiss theory of ferromagnetism.

3. Obtain an expression for the impedance of an LCR circuit for the following cases:

(a) L and R in series and C in parallel to them.

(b) L. C and R in series.

Discuss the factors that determine sharpness of resonance in these cases.

4. Give an account of the basic principles of radio transmission and reception. Detailed circuits are not necessary but schematic diagrams indicating functions of various units may be shown.

SECTION B

5. Answer any three of the following:

(a) The stopping potential for electrons emitted from a metal, due to photoelectric effect, is found to be 1 volt for light of 2,500 Angstrom units. Calculate the work function of the metal in electron volts.

(b) Which of the following reactions are forbidden and why?

$$p \longrightarrow n + e^+ + v_e$$
$$\pi^+ \longrightarrow \mu^+ + v_u$$
$$H^2 \longrightarrow He^3 + e^- + e$$

(c) The number of alpha particles emitted per gm of radium each second is 3.71×10^{10}. Atomic weight of radium is 226. Calculate its half-life in years.

(d) Write a brief note (about 200 words) on X-ray absorption edges.

6. Construct solutions of Sehrodinger equation for a particle moving the potential

$V(x) = 0$ for $x < 0$

$= V_0$ for $x > 0$

Deduce the reflection coefficient for particles incident from left to right (i.e. from negative to positive x regions) with energy $E > V_0$. Do you expect any reflection for particles of same energy incident from right to left? Explain qualitatively.

7. Give an account of Pauli's exclusion principle. Show how it leads to the building up of the Periodic Table of elements. The description must particularly emphasize shell structure and the placing of alkali metals, helogens and inert gases in the Periodic Table.

8. Explain, on the basis of bond structure, the behaviour of insulators and conductors. Describe the effect of adding donor or acceptor impurities on conduction in a semi-conductor. Explain the action of a p-n junction as a rectifier.

Mass of electron $= 9.1 \times 10^{-31}$ kg

1 a.m.u $= 931$ MeV

Avogadro's numbers $= 6.1 \times 10^{23}$ (gm-mole)$^{-1}$

$\varepsilon_0 = 1/36\pi \times 10^{-9}$ f/m

$h = 6.6 \times 10^{-27}$ erg sec

$c = 3.0 \times 10^{10}$ cm/sec

I eV $= 1.6 \times 10^{-19}$ erg

$= 1.6 \times 10^{-19}$ joule.