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

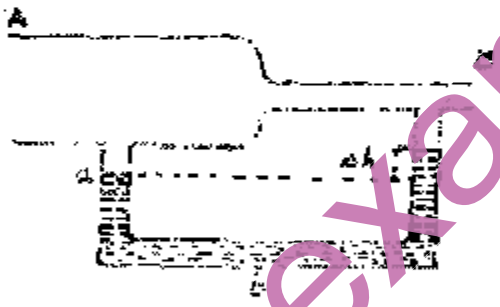
SECTION A

1. Attempt any three of the following:

(a) Find the linear acceleration of the center of gravity of a uniform disc which rolls down an inclined plane without slipping. The angle of inclination is 30°.

(b) A steel ball 1.00 mm in diameter falls at a constant speed of 0.176 $m\,s^{-1}$ in a large vessel filled with oil. Calculate the dynamic viscosity of the oil (Density of steel = 7800 kg/m^3 density of oil = 900) kg/m^3).

(c) Air is blown through a pipe AB, at a rate of 15 litres per minute. The area of cross-section at A is $2cm^2$ whereas at B it is 0.2 cm^2. A tube abc, containing some water, is connected as shown. Find the difference in height, Δh, between the levels of water in the tube abc.



(b) A muon (μ meson) is formed high up in the atmosphere and travels towards the earth with a speed of 0.992 c. It decays after travelling a distance of 6.0 km. In what time does the muon decay as measured

(i) by us and

(ii) in its own frame of reference? What is the distance covered the muon in its own frame of reference?

2.(a) Find the expression for the rise of a liquid between two parallel plates separated by a distance t and dipped vertically in the liquid.

(b) Derive the expression for the energy distribution of particles according to Bose-Einstein statistics.

(c) The mean distance of the Earth from the Sun is 1.496×10^{11} m, while that of Saturn is 1.427×10^{12} m. Find the time taken by Saturn to complete one revolution round the Sun.

3.(a) Starting from van der Waals equation for a gas, deduce expressions for its critical temperature, critical pressure and critical volume.

(b) For an isotropic solid define Young's modulus of elasticity Y, coefficient of rigidity η and Poisson's ratio α. Establish the relation.

$$\sigma = \frac{Y - 2\eta}{2\eta}$$

(c) Find the density of hydrogen gas at temperature of 25°C and pressure of 750 mm Hg.

4.(a) Derive an expression for the mean energy ε of a Planck oscillator in thermal equilibrium with the surroundings. Now does the ratio. *lk*T vary as the temperature T varies from ⩽hv/k to ⩽hv/k, the symbols having the usual meanings?

(b) For a Maxwell-Boltzmann gas derive the expression for

(i) the most probable speed

(ii) the average speed and

(iii) the root mean square speed and find their ratio (taking the most probable speed as unity).

(c) Show that the kinetic energy T of relativistic particle moving with momentum p is

$T = P^2 / m+m_0$

What m_0 its rest mass and m is its relativistic mass.

SECTION B

5. Attempt any three of the following:

(a) Mention sonic experiment which establishes that electrons in metals obey Fermi-Dirac statistics and justify your answer in some detail.

(b) The speeds v of waves on the surface of a liquid is given by

$$v = \sqrt{\frac{TK}{P} + \frac{g}{k}}$$

where T is the surface tension of the liquid of density P > K = 2π/λ, λ being the wavelength of the wave and g is acceleration due to gravity Find the wavelength and frequency of waves on water which move with minimum speed.

(c) A beam of light of wavelength 5.82×10^{-7} m falls normally on a glass wexge with the wedge angle of 20". If the refractive index of glass is 1.5, find the number of dark interference fringes per centimetre of the wedge length.

(d) State Huygen's principle and on its basis establish Snell's law of refraction of light. How does the result differ from what Newton's Corpuscular theory gave?

6.(a) Derive an expression for the resolving power of a diffraction grating.

(b) The equation for displacement of point on a damped oscillator is given by

$$x - 5e^{-0.25t} \sin\frac{\pi}{2}t \text{ metre}$$

Find the velocity of the oscillating point at $t = \frac{T}{4}$ and T_p where T is the time-period of the oscillator.

(c) Fourier analyse the step-function

$f(x) = 1$ for $0 < x < \pi$

$= -1$ for $\pi < x < 2\pi$

and hence prove that

$$1+\frac{1}{9}+\frac{1}{25}+\frac{1}{49}+\ldots\ldots=\frac{\pi^2}{8}$$

7.(a) Write down Maxwell s equations for the electromagnetic field in Free space and show that $\vec{E}$ satisfies the wave equation. Hence obtain the expression for the velocity of e.m. waves in free space.

(b) Plane waves pass through a slit whose plane is parallel to the wave fronts. Obtain an expression for the angular spread of the central maximum due to diffraction, and critically comment on the result.

(c) Monochromatic light of wavelength due to diffraction, and critically; comment on the result,

(d) Monochromatic light of wavelength 6.56×10^{-7} m falls normally on a grating 2.00 cm wide. The first order spectrum is produced at an angle of 18°15' from the normal. Deduce the total number of lines in the grating.

8. Write notes on any three of the following:

(a) Oscillations with two degrees of freedom.

(b) Coriolis force and its manifestations.

(c) Predictions of general theory of relativity and their experimental verification.

(d) Anomalous dispersion.

(e) Production of temperature below 1K.

PHYSICS

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PAPER - II

SECTION A

1. Answer any three of the following:

   (a) The series limit due Balmer series for hydrogen is given by 3.65×10^{-5} cm. and an element is found to give k-series wavelength down to 10×10^{-10} cm, Find the atomic number of the element.

   (b) In an oscillatory circuit L =0.30 herry and C =1.2 x 10 F, determine the value of maximum resistance so that the circuit may remain oscillatory.

   (c) Compare the energy of a photon with that of a neuron when both are associated with wavelength of 1Å.

   (d) Obtain an expression for the force exerted on unit volume of a paramagnetic substance in a non-uniform magnetic field. How could you experimentally distinguish and diamagnetic and paramagnetic substance?

2. What is dielectric susceptibility? Describe how you can determine the radius of an atom from the measurement of the dielectric constant of a gas.

   A parallel plate condenser consists of two plates of area 400 sq. cm. each separated by a sheet of material of 0.10 mm thickness. Find the capacity in microfarads when the dielectric constant of the material is 5.0.

3. Explain thermoionic emission. Discuss Richardson's derivation of the thermionic equation and show how the velocity distribution of the emitted electrons corroborates Fermi-Dirac distribution,

   Mention a few modern thermoionic emitters.

4. Draw the circuit diagrams suitable for measuring the voltage amplification of a triode valve with the following methods of connection:

   (a) Common cathode

   (b) Common grid

   (c) Common anode.

   Write down, without proofs, the expression for amplification in each case in terms of μ and the relevant resistance values.

   Which of the three methods is usually employed in high frequency circuit practices and why ?

SECTION B

5. Answer any three of the following:

(a) Some amount of a radioactive substance (half-life=30 days) spread inside a room and consequently the level of radiation becomes 50 times the permissible level for normal occupancy of the room. After how many days the room would be safe for occupation?

(b) Define Compton wavelength for an electron. Calculate in electron-volts the photon energy corresponding to radiations of the Compton wavelength. What light does the Compton effect throw on the nature of X-rays?

(c) Schematically draw the binding energy cone for atomic nuclei defining the parameters used. Explain how it indicates release of energy on fission of some nuclei and on fusion of other. Could one of these processes be the origin of solar energy?

(d) Interpret the nuclear process described by the equation

$$_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{92}n^{236} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3{}_{0}n^{1} + Q$$

The products of this kind of reaction vary widely, but the average Q is found to be 180 MeV. Compute the consumption rate of U^{235} per year if power generation is to be an average 100 MW. (Take efficiency = 1).

6. Define Fermi energy. Show that the Fermi level lays half-way between the top of the valence band and the bottom of the conduction band of an intrinsic semiconductor.

Explain why an extrinsic semiconductor, such as an N-type crystal, has more free electrons than holes but is found to be electrically uncharged.

7. State and explain Heisenberg uncertainty principle using situations where one of the parameters is

(a) liner distance x

(b) angle ϕ

(c) energy E.

Prove that according to the principal the presence of an electron within the a omic nucleus is not possible.

8. Attempt any two of the following:

(a) Write a brief note (about 200 words) on parity violation

(b) Write a shout note (about 200 words) on super-conductors and the nature of revolution that may come up if superconductors with critical temperature well above the room temperatures are developed.

(c) In observing the Raman spectrum of a sample, using 2537 Å as the exciting line, one gets a Stokes line at 2683 Å. Deduce the Raman shift in cm^{-1} units. What information does it give? Compute the wavelength in Å units, for the corresponding Stokes and anti-Stokes tines if the exciting line is 5461Å