# PHYSICS

## PAPER - I

## SECTION A

1. Answer any four of the following (10 × 4 = 40)

(a) Distinguish between resolving power and dispersive power of a grating. What should be the resolving power of a grating to resolve two closely spaced wavelengths 4500 Å and 4510 Å?

(b) What is holography and how is it different from ordinary photography?

(c) The focal length of achromatic doublet made up of crown and flint glasses is 15 cm. Calculate the focal length of converging and diverging lenses of doublet if dispersive power of crown and flint glasses are 0.01506 and 0.02427 respectively.

(d) Explain the term phase velocity and group velocity. What is their significance?

(e) Deduce an expression for the moment of inertia of a diatomic molecule a distance 'γ' about an axis passing through the centre of mass and perpendicular to the bond length and also along the bond length.

2. (a) Discuss the motion of a particle under a central force field. Find the condition under which the orbit will be ellipse or parabola or hyperbola.

(20)

(b) An artificial earth satellite is travelling at an altitude of 150 km above the earth's surface, where g = 9.5 m/sec$^2$. Calculate the speed of the satellite. (radius of the earth- 6000 km)

(20)

3. (a) (i) Derive the formula for variation of mass with velocity.

(ii) A rod of length 1 m in a spaceship is moving with a velocity of 0.3 C relative to the earth. Calculate its length as measured by an observer first on the spaceship and on the earth.

(20)

(b) Deduce an expression for total energy of a simple harmonic oscillator. Show that total energy remains independent of time and displacement. Write a note on the effect of damping on the total energy of oscillator.

(20)

4. (a) Discuss the principle of Frenels' half period zones and explain how these are used in the construction of a zone plate. Show that zone plate has several foci.

(20)

(b) (i) Discuss briefly some application of Michelson enterferrometer.

(ii) Lycopodium spores which have an average diameter of 30 μm are dusted on a glass plate. If parallel light of λ = 589 nm is passed through the plate, what is the angular radius of first diffraction maximum ?

(20)

## SECTION B

5. Answer any four of the following:

(4 x 10 = 40)

(a) If in the LCR series circuit, a.c. voltmeter reads 30 volt across the resistor, 80 volt across the inductance, 40 volt across the condenser, what is the applied emf?

(b) A condenser of capacity 1 microfarad and inductance of 0.2 Henri and resistance 800 ohm are joined in series. Is the circuit oscillatory ?

(c) An electric dipole of two opposite charges of $10^{-4}$ coulomb separated by cm piece in an external electric field of strength $10^{-5}$ volts/m. Find the work required to turn the dipole in the reverse direction.

(d) What is the physical significance of poynting vector ? Deduce an expression for the intensity of electromagnetic wave propagating in free space.

(e) Two magnets having magnetic moments M and $\sqrt{3}M$ are joined to form a cross. If this combination is suspended freely in a uniform horizontal magnetic field, what will be its equilibrium orientation in this field?

6. (a) Write down the Poisson's equation for a homogeneous dielectric medium. What is the condition necessary to derive Laplace equation from Poisson's equation ?

A 50 volt AC source of frequency 500 Hz is connected to an LCR circuit with L = 8.1 millihenri; C = 12.5 μF; R = 20 Ω all connected in series. Find the potential across the resistance. (20)

(b) State Kirchhoffs laws for steady current and prove them.

Apply the Kirchhoffs laws to Wheatstones' network and show that $\frac{P}{Q}=\frac{R}{S}$ (20)

7. (a) Using Maxwell's equations obtain the velocity of an electromagnetic wave in vacuum. (20)

(b) What is Wien's displacement law ? Show that sun radiates maximum energy in the visible region whereas earth radiates in IR region. (20)

8. (a) (i) Derive the equation of state for a van der Wall's gas and calculate values of critical constants.

(ii) What is entropy? How is it related to disorder in the system ? (20)

(b) Discuss Einstein's Theory of specific heat of solids. Compare and contrast with Debye's theory. (20)

Useful constants:

h = 6.62 x $10^{-34}$ joule-sec

e = 1.65 x $10^{-19}$ coulomb

c = 3.0 x $10^{8}$ m/sec

1 eV = 1.6 x $10^{-19}$ joule

$\frac{1}{4\pi\varepsilon_0}$ = 9 x 109 $Nm^2$/coulomb

$\mu_0 = 4\pi \times 10^{-7}$ weber/amp.m.

# PHYSICS

## PAPER - II

## SECTION A

1 Answer any four of the following:

(a) Define angular momentum. Express it in the operator form and show that

$L_xL_y - L_yL_x = ih\,L_z$

(10)

(b) A photon and an electron have energy 15 keV each. Which of them will have a longer wavelength ?

(10)

(c) Write down the Schrodinger equation in three dimensions for a free electron and solve it for electrons confined to a cube of edge L and hence obtain an expression for the density of states.

(10)

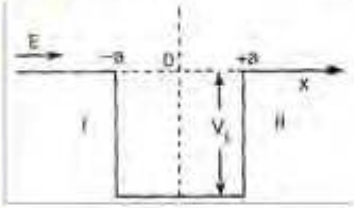
(d) State Franck-Condon principle and discuss its applications in molecular spectroscopy.

(10)

(e) If the magnetic moment of proton is 2.793 $\mu_N$, calculate, giving necessary steps, the radio frequency at which nuclear magnetic resonance occurs in water kept in a uniform magnetic field of 2.4T.

(10)

2. (a) Consider a one-dimensional square well potential, as shown below, which is attractive.




The potential is - $V_0$ in the region x = a to x = - a and zero elsewhere. A stream of particles of mass M and energy E is directed from the left, Set up time-independent Schrödinger equation and obtain an expression for the transmission ratio from region I to II.

(20)

(b) Write the Schrödinger equation for a free particle confined in a cube of edge L. Determine the energy eigenvalues. Show that for a single value of energy different quantum states are possible. Explain the term degeneracy.

(20)

3. (a) Set up the time-independent Schrödinger equation for an electron moving in a Coulomb field, $V(r) = -\frac{ze^2}{4\pi\varepsilon_0 r}$, in polar coordinates. Solve the radial equation to get the energy eigenvalues.

(20)

(b) What is Zeeman effect? How it can be understood on a quantum mechanical basis ? Obtain an expression for the energy splitting.

(20)

4. (a) Write the wave function for the ground state of the hydrogen molecule under the molecular orbital approximation. Estimate the energy of the electron in the ground state of $H_2^+$ moleculeion.

(20)

(b) Derive the combined vibration-rotation spectrum of a diatomic molecule. What are P and R branches ?

(20)

## SECTION B

5. Answer any four of the following:

(a) On the basis of binding energy curve explain why fusion is possible only for low mass nuclei whereas the fission takes place only in heavy nuclei. (10)

(b) A star converts all its hydrogen to helium, achieving 100% helium composition. It then converts the helium to carbon via the reaction.

$$_2^4He + _2^4He + _2^4He \rightarrow _6^{12}C + 7.27MeV$$

The mass of the star is $5.0 \times 10^{32}$ kg and it generates energy at the rate of $5 \times 10^{30}$ W. How long will it take to convert all helium to carbon at this rate ? (10)

(c) Indicate the interactions in which the following conservation laws are obeyed or violated:

(10)

(i) Hypercharge

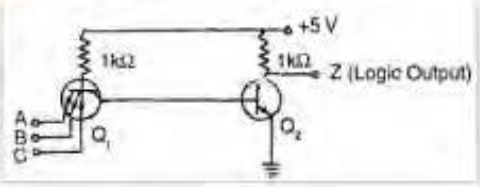
(ii) Charge conjugation

(iii) Isotopic spin

(d) Calculate the number of nearest neighbours and the packing fraction for an fcc lattice.

(10)

(e) Explain the operation of the following circuit as a gate. Draw the truth table and find the operation carried out by this gate.



6. (a) What are magic numbers? Discuss the shall structure of a nucleus. How this model is able to explain various properties of nuclei ? Discuss the limitations of this model.

(15)

(b) What is internal conversion ? Describe an experiment to determine internal conversion coefficients.

(c) What is Möasbauer effect? Describe an experimental arrangement employed for, the study of nuclear resonance scattering. Mention some applications of this phenomenon.

(15)

7. (a) Discuss various symmetry elements of a crystal lattice. Explain why five- fold rotation symetry is not observed.

(10)

(b) Consider the motion of electrons in a periodic potential of a crystal lattice. Show that the energy spectrum of electrons consists of bands of allowed and forbidden energies. How are the insulators, semiconductors and conductors discriminated on the basis of band structure ?

(20)

(c) Distinguish between a superconductor and a perfect conductor. Explain what is a Cooper pair.

(10)

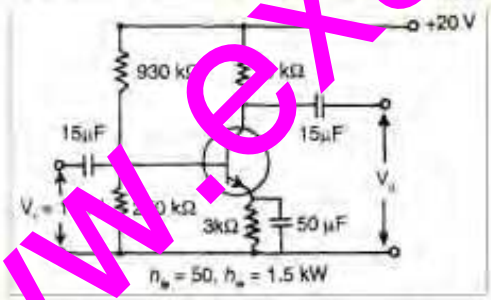
8. (a) Explain the working principle of a phase shift oscillator. Obtain an expression for the frequency of oscillations.

(15)

(b) Describe the constructional details of a MOSFET. Draw the drain current-drain voltage characteristics.

(15)

(c) A common emitter amplifier using n-p-n transistor is shown below:




Calculate the output signal for an input signal of 1 mV. Explain the functions of (i) 50 μF capacitor across 3 k Ω resistor in the emitter circuit and (ii) the resistors 930 kΩ and 250 kΩ

(10)