PHYSICS

PAPER-I

SECTION A

1. Answer any four of the following:

   (a) Calculate the speed of an artificial earth satellite, assuming that it is travelling at an altitude h of 20 kms above the surface of the earth, where g = 9 m/sec^2. Take the radius of earth R as 6000 kms.

   (b) Prove that the expression $x^2 + y^2 + z^2 - c^2t^2$ is invariant under Lorentz transformation.

   (c) The period of small oscillation of a disk of radius 10 cms, pivoted at its rim is measured to be 0.78 sec. Find the value of g, acceleration due to gravity at that location.

   (d) Show that for an ideal gas undergoing an adiabatic process, pV^γ = a constant, where $\gamma = C_p/C_v$ (Ratio of specific heats at constant pressure and volume).

   (e) The lenses are normally coated with thin films of transparent substances like MgF_2 (with refractive index it = 1.38) in order to reduce the reflection from the glass surface, using interference. How thick a coating is needed to produce minimum reflection at the centre of visible spectrum (5500 $\mathring{A}$)?

2. (a) Explain the precession of a spinning top and show that precessional velocity is independent of angle of inclination.

   (b) Use the theory of damped harmonic oscillator to show that the quality factor of an LCR circuit is $Q = W_0L/R$, where $W_0 = 1/\sqrt{LC}$.

3. (a) What is First Law of Thermodynamics ? Calculate the entropy change that an ideal gas undergoes in a reversible isothermal expansion from a volume V_i to V_f.

   (b) What is entropy and how is it related to the disorder in the system?

   Calculate the entropy change when 1 kg of ice at 0°C melts (reversibly) to water at the same temperature. The latent heat of melting is 79.6 cal/gm.

4. (a) Derive an expression for Rutherford scattering cross-section for scattering of an electron by a heavy nucleus.

   (b) Explain the theory of Fabry-Perot interferometer and the formation of fringes by it. What finesse separation will be needed to resolve two spectral lines 0.05 nm apart if the average wavelength is 488 nm and reflectance 64 per cent?

SECTION B

5. Answer any four of the following:

   (a) Show that electronic contribution to the specific of solids varies as T at low temperatures.

   (b) Light from a star, of wavelength 600 nm is found to be shifted by 0.01 nm towards the red when compared with the same wavelength from a laboratory source. If the velocity of light is 3×10^5 m/sec, show that the earth and the star are separating at velocity 5 km/sec.

(c) What is Lorentz-Fitzgerald contraction in special theory of relativity? Derive an expression for this contraction.

(d) A 75 gin block of copper, taken from a furnace is dropped into a 300 gm glass beaker containing 200 gm of water. The temperature of water rises from 12° to 27°C. What was the temperature of furnace?

(e) What requirements must be met for the central maximum of the envelope of the double slit Fraunhofer pattern to contain exactly eleven fringes?

6. (a) What is Stefan-Boltzmann law of black-bodyradiation? Derive an expression for the Stefan-Boltzmann constant.

(b) Calculate the Moment of Inertia of a solid cylinder about a central diameter. R is the radius and l is the length of the solid cylinder.

7. (a) Write down the expression for the energy distribution function for the black-body radiation at temperature T.

(b) What is spatial coherence? Considering Young's two-slit experiment, prove that the distance between the slit must be sufficiently less than (λ/θ) for obtaining fringes of good contrast, where λ is the wavelength of light used and θ is the angle subtended by the source at the slits.

8. (a) The maximum pressure variation P that the ear can tolerate in loud sounds is about 28 m/metre^2. Normal atmospheric pressure is about 100,000 nt/metre^2. Find the corresponding maximum displacement for a sound wave in air having frequency 1000 cycles/sec. Give a brief derivation of the formula used.

(b) Deduce van der Waal's equation of state of a gas. Mention its defects by drawing pressure volume plot at different temperatures.

Some Useful Data

Density of Air	=	1.22 kg/metre^3
Sound vel. in Air	=	331 metres/sec
Sp. heat of copper	=	0.093 cal/gm°C
Sp. heat of glass	=	0.12 cal/gm°C
Sp. heat of water	=	1 cal/gm°C

PHYSICS

PAPER-II

SECTION A

1. Answer any four of the following:

(a) Where in the electromagnetic spectrum does the wavelength of a 10 eV electron appear?

(10)

(b) Give the schematic diagram of an integrating circuit. Describe how the input is modified and appears in the output in a different waveform. Find the output waveform if the input is a square wave.

(10)

(c) The exciting line in a Rama scattering experiment is 546.0 nm and the Stokes' line in the spectrum of a material is found at 552.0 nm. Find the wavelength of the corresponding anti-Stokes' line.

(10)

(d) Find the Thevenin's equivalent for the current flowing form the left of terminals A and B. Find the current in R and voltage across the resistance R_L.

(10)

(e) Write a short explanatory note on a Fast Breeder Reactor.

(10)

2. (a) State the salient features of the Langevin theory of paramagnetism.

(15)

(b) Explain how the concept of effective magnetic moment arises from the comparison of classical result with the quantum mechanical expression.

(12)

(c) Discuss the paramagnetism of free electrons.

(13)

3. (a) State the differential set of four equations governing the static electric field due to steady charges and the static magnetic field due to steady currents.

(20)

(b) How are these equations changed for time-varying fields?

(20)

(c) State Maxwell's equations in electromagnetic field. Give the word statement of the field equations.

(10)

4. Derive an expression for the frequencies at which light is absorbed by hydrogen atom in their ground state, using the atomic model of Bohr. Why should these frequencies be slightly different for positronium?

(40)

SECTION B

5. Answer any four of the following:

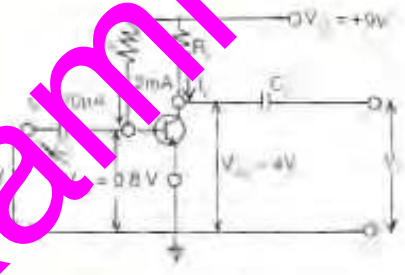
(a) A body of mass 1 g falls through a height of 1 cm. If all of the energy acquired in the fall were converted to light of 600 nm wavelength, how many photons would be emitted?

(10)

(b) Consider the uncertainty principle. Calculate the minimum energy of a particle in an infinite potential well, with boundaries $-a < x < a$. (Assume $\Delta x = a$)

(10)

(c) A bipolar junction transistor is used as a voltage amplifier whose circuit is given in the figure below:



Given:

$I_B = 20\mu A, I_C = 2mA, V_{CC} = 9V, V_{BE} = 0.8V, V_{CE} = 4V$

Find the values of the elements R_B and R_L.

(10)

(d) Given two switches A and B, a battery, a resistor R and a light bulb. Illustrate the NAND gate and construct its Truth Table.

(10)

(e) The critical field B of lead at the boiling point of liquid Helium (4.2 k) is 5.3×10^{-2} T. What is the maximum current that can flow in a wire of lead with a radius of 4.0 mm if it is to remain superconducting at this temperature?

(10)

6. (a) What are oscillators ? How many types of oscillators are there? What is the basic principle of operation?

(10)

(b) Describe a phase shift oscillator.

(10)

(c) Describe a Wein bridge oscillator and compare it with a phase shift oscillator.

(15)

7. (a) Define a Hermitian operator $\hat{Q}$ of a physical system.

(5)

(b) Prove that for well-behaved functions of a physical system having a Hermitian operator $\hat{Q}$, the eigen values q are all real.

(15)

(c) Show that the momentum operator $\hat{P}_z$ is Hermitian.

(20)

8. (a) State the various contributions to the mass M(Z, A) of a nucleus in the semi-empirical mass formula.

(15)

(b) Calculate the Q-value of the fission(symmetric) reaction $_{92}U^{235} + {}_0n^1 \rightarrow X + Y$, where X and Y are fragments with A values 119 and 120, respectively, and Z values 45 and 46.

(10)

(c) What is Bohr-Wheelercriterion for nuclear fission? Briefly describe the theory of fission.

(15)

The following physical constants may be used:

Mass of electron, $m_e = 9.11 \times 10^{-31}$ kg

Charge of electron, $e = 1.6 \times 10^{-19}$ Coul

Planck's constant, $h = 6.63 \times 10^{-34}$ Js

$h = 1.054 \times 10^{-34}$ Js

Velocity of light, $c = 3.0 \times 10^{8}$ m/s

Permeability of vacuum, $\mu_0 = 8.85 \times 10^{-12}$ F/m

Permittivity of vacuum $\mu = 4\pi \times 10^{-7}$ H/m

$k = 1/4\pi\varepsilon_0 = 9 \times 10^9$ Nm^2/ Coul^2

Acceleration due to gravity, $g = 9.8$ m/s^2

1 eV = 1.6×10^{-19} J

$= 1.6 \times 10^{-12}$ erg

1 amu = 931 MeV/C^2

Neutron rest mass $M_n = 1.008665$ amu

Proton rest mass $M_p = 1.007825$ amu

Binding energy per nucleon at A = 120 is 8.5 MeV

Binding energy per nucleon at A = 240 is 7.6 MeV