

CGPDTM
Patent
Examiner

Previous Year Paper
(Mains) (Physics)
Oct, 2015



108

Physics

TIME : 3 HOURS

MAXIMUM MARKS : 300

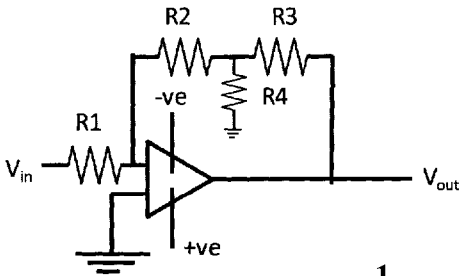
INSTRUCTIONS :

- 1. All questions are compulsory.
- 2. Question Paper may be divided into 4 (four) Sections from Section-A to Section-D and carry marks as under :
 - a. Section - A - Total 3 Questions having two parts, i.e. (a) and (b) each questions carries 12 marks × 3 Questions = Total 36 Marks.
 - b. Section - B - Total 3 Questions having two parts, i.e. (a) and (b) each questions carries 20 marks × 3 Questions = Total 60 Marks.
 - c. Section - C - Total 3 Questions having two parts, i.e. (a) and (b) each questions carries 28 marks × 3 Questions = Total 84 Marks.
 - d. Section - D - Total 3 Questions having two parts, i.e. (a) and (b) each questions carries 40 marks × 3 Questions = Total 120 Marks.

SECTION - A

(Each question is of 12 marks and each sub part (a) and (b) are of 6 marks each)

- 1
 - (a) What do you mean by transducers? Discuss the important parameters of transducers? Give any three type of transducers.
 - (b) Discuss temperature transducer in brief. Can we use semiconductors for temperature sensing? How can we estimate very high temperatures i.e., above 150°C ?
- 2
 - (a) Why do you need modulation in communication? How can you generate pulse width modulation (PWM) signal using IC555 timer circuit?
 - (b) Why do we prefer operational amplifier? Calculate the output voltage in the circuit given below :



- 3 (a) Electrons with energies of 1 eV and 2 eV are incident on a barrier of 5 eV height and 0.5 nm width. Find their respective transmission probabilities. How are these affected if the barrier width is doubled?
- (b) Write four Maxwell equations describing propagation of electromagnetic waves in free space with no charges and currents. Hence obtain the wave equation satisfied with electric field in this space.

SECTION - B

(Each question is of **20** marks and each sub part (a) and (b) are of **10** marks each)

- 4 (a) What is Cooper pair? Find the average separation of electrons in Cooper pair in Hg. Show that the wavelength of photon to destroy the pair in microwave region.
- (b) Where is the position of Fermi level in n-type semiconductor? Draw and explain Fermi level variation with respect to (i) dopant concentration (10^{13} to 10^{23} cm^{-3}) and (ii) temperature from 300 K to 500 K .
- 5 (a) Let $|e_1\rangle, |e_2\rangle$ be two vectors in a two dimensional vector space with the property, $\langle e_1|e_1\rangle=2$, $\langle e_2|e_2\rangle=2$ and $\langle e_1|e_2\rangle=1$.
- (i) Construct an orthonormal basis with one of the vectors parallel to $|e_1\rangle$.
- (ii) Find how the basis vectors transform if both of them are rotated by an angle π in the plane.
- (b) An $N \times N$ matrix has all its elements equal to one : $(A)_{ij}=1$ for all i, j .
- (i) Determine all its eigen values of A and hence its rank.
- (ii) Find an eigen vector that belongs to the lowest eigen value.
- 6 A free quantum mechanical particle of mass m is constrained to move on the surface of a sphere of radius R .
- (a) Determine the energy and its degeneracy if it is in the second excited state.
- (b) If a photon is emitted when it makes a transition to the first excited state, find its energy.

SECTION - C

(Each question is of **28** marks and each sub part **(a)** and **(b)** are of **14** marks each)

- 7 (a) Point out the limitations of the Bohr-Sommerfeld model of an atom. How were they sorted out in the quantum mechanical model? Calculate, to six significant figures, the wave numbers (in cm^{-1}) of the first two members of the Balmer series (common level $n_1 = 2$) in the spectrum of ionized He-atom. Convert these to wavelengths, in nm.

Useful constants:

Rydberg constant (R) = 109737 cm^{-1}

Fine structure constant $\alpha = 1/137$

Planck's constant (h) = $6.547 \times 10^{-27} \text{ erg.sec}$

Electron charge (e) = $4.77 \times 10^{-10} \text{ abs. esu}$

Electron mass (m) = $9.035 \times 10^{-28} \text{ g}$

- (b) For linear molecules CO and N_2 draw the rotational energy diagram assuming the molecules as rigid rotators. Show all possible absorption transitions up to a state with $J = 5$. How does the population distribution curve behave at temperature T ? If the molecules have elastic bonds (nonrigid rotator), what is the expected rotational energy diagram.
- 8 (a) Find the electric potential at the edge of a thin disk of radius r , one side of which carries a uniform surface density σ .
- (b) Calculate the self inductance for a length l of a long wire because of magnetic flux within the wire when a current passes through it.
- 9 (a) Given the complex function $f(z) = \frac{1}{(z-2)}$, determine $\oint_C f(z) dz$ where the contour is a circle of unit radius centered at $z = 5$.
- (b) Determine the real integral $\int_{-\infty}^{\infty} \frac{dx}{x^2 + a^2}$ using contour integral techniques.

SECTION - D

(Each question is of 40 marks and each sub part (a) and (b) are of 20 marks each)

- 10 (a) Calculate the electrostatic energy of a charge Q distributed uniformly throughout a sphere of radius R . Given that the mass difference of $^{27}\text{Si}_{14}$ and $^{27}\text{Al}_{13}$ as 6 MeV, estimate their radius. Assume that the mass difference between a pair of mirror nuclei is entirely due to the difference in the Coulomb energies.
- (b) If the surface of a nucleus has the equation $x^2 + y^2 + 1.2z^2 = R^2$ where R is the radius of a nucleus with $A = 200$, calculate its quadrupole moment. Assume that its total charge Ze is uniformly distributed through the volume.
- 11 (a) Assuming that the neutron and proton in a deuteron interact through a square well potential of width $b=2$ fermis, and depth $V_0 = 35$ MeV in the $l = 0$ state, (i) calculate the probability that the proton moves outside the range of the force of the neutron, given that $E = -2.2$ MeV. The deuteron, however, has an admixture of D-state ($l=2$). (ii) Given that the magnetic moments of the deuteron in the $l=0$ and $l=2$ states are 0.8798 nm and 0.3101 nm and the experimental value of deuteron as 0.8325 nm, calculate the probability of finding the deuteron in the D-state.
- (b) Indicate if the following processes are allowed or not ? Give reasons.
- (i) $\pi^- + p \rightarrow \pi^0 + n$
- (ii) $\pi^0 \rightarrow \gamma + \gamma + \gamma$
- (iii) $p + \bar{p} \rightarrow \Lambda + \Lambda$
- (iv) $\Omega^- \rightarrow \Xi^0 + \pi^-$
- 12 A particle of mass m is oscillating in a potential $V(x) = kx^8$
- (a) How does the period of the oscillation change if the amplitude is doubled?
- (b) How does amplitude of the oscillation change if the mass is halved and the speed at $x=0$ is held constant?

