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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

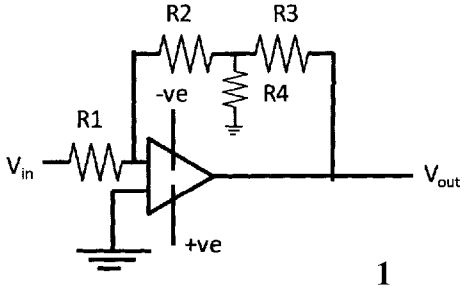
(Each question is of **12** marks and each sub part **(a)** and **(b)** are of **6** marks each)

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 α = 1/137

Planck's constant (h) = 6.547×10^{-27} erg.sec

Electron charge (e) = 4.77×10^{-10} abs. esu

Electron mass (m) = 9.035×10^{-28} 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 $^{27}Si_{14}$ and $^{27}Al_{13}$ 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) $\pi^- + p \rightarrow \pi^\circ + n$

(ii) $\pi^\circ \rightarrow \gamma + \gamma + \gamma$

(iii) $p + \bar{p} \rightarrow \Lambda + \Lambda$

(iv) $\Omega^- \rightarrow \Xi^\circ + \pi^-$

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?