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:

(20 x 3 = 60)

(a) A block of mass m, attached to an ideal massless spring of force constant k, is at rest on a smooth horizontal floor. A second block of mass 2 m, moving with an initial velocity strikes the free end of the spring. The collision is one dimensional and elastic.

(i) Calculate the maximum compression of the spring.

(ii) What are the velocities of the block long time after the collision?

(b) An observer S_1 sees two bodies A and B having equal rest mass approach each other with equal but opposite velocities 4c/5. To a second observe S_2, the body A is at rest. What us the velocity of the body B as seen by observe S_2? What are the kinetic energies of the body B in the frames of S_1 and S_2?

(c) Two transverse harmonic waves, each of amplitude 5mm, wavelength 1m and speed 3 m/s are travelling in opposite directions along a stretched string fixed at both ends.

Obtain an expression for the standing wave Produced. Locate the position at the nodes and antinodes.

(d) Two thin convex lenses of focal length 0.2 m and 0.1 m are located 0.1m apart on the axis of symmetry. An object of height 0.1m is placed at a distance of 0.2 m from the first lens. Find by the matrix method, the position and the height of the image.

2.(a) Write the Euler's equations for the rotational motion of a rigid body with one point fixed, under the action of torque. Apply these equations to discuss the rotational motion of a symmetrical top in the absence of any force other than the reaction at the fixed point.

(30)

(b) An ideal massless spring of force constant k has a mass m attached to one of its ends, the other and being fixed to a rigid support. The spring is horizontal floor, A resistive force –bv, proportional to the velocity v acts on the mass. Assuming the damping to be light, obtain the frequency of oscillation. When m = 0.1 kg and k = 10 N/m, it is found that the frequency of oscillation is $\sqrt{1/2}$ times the frequency in the absence of damping. Calculate the value of the constant b.

(30)

3.(a) Write the Lagrange's equation for a system of particles which is acted upon by Conservative forces. What is a cyclic coordinate ? Show that the generalized momentum conjugate to a cyclic coordinate is conserved.

(20)

(b) How does Doppler effect of light of relativistic physics qualitatively differ from its non-relativistic analogue ? Calculate the Doppleer shift in the frequency of a photon travelling along the y-axis. with respect to an observer moving along the x-axis with a constant speed v.

(20)

(c) Explain the phenomenon of pulse dispersion in a step index optical fibre.

(20)

4.(a) What is holography ? Describe the experimental set up for Gabor's on-line holographic recording. What are the limitations of Gabors experiments? How these were over come by Leith and Upatneiks?

(20)

(b) Obtain an expression for the intensity of light in the Fraunhofer diffraction pattern due to a circular aperture. What is Airy pattern ? Explain with a neat diagram.

(20)

(c) Explain the phenomenon of self focusing of laser beams.

(20)

SECTION B

5. Answer any three of the following

(20 x 3 = 60)

(a) A cylinder of length L and radius b has its axis coincident with z-axis. The electric held in th region is E = 100k. Find the electric flux through

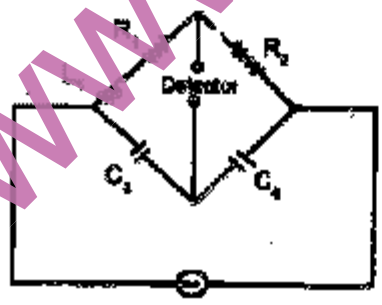
(i) the top circular end

(ii) the bottom circular end

(iii) the curved wall of the cylinder

(iv) the closed surface of the cylinder

(b)



A bridge network with resistance, capacitance and inductance is given in the above figure. Show that the conditions for balancing the bridge are independent of the frequency of applied voltage.

(c) Earth receives 1.3KW/m^2 of radiant energy from the Sun. Assuming Sun to be a spherical black body of radius 7 x 10^8m and Earth-sun distance to be 1.5 x 10^{11}m, Calculate the surface temperature of Sun. (Stefan-Boltzmenn constant $\sigma = 5.67 \times 10^{-8}$ $Wm^{-2}K^{-4}$].

(d) 100 particles at a temperature T and distributed among three energy levels $E_0 = 0$, $E_1 = kT$ and $E_2 = 2kT$. What is the total energy of the system ?

6.(a) Consider an infinite grounded conducting plane. If a point charge is held at a distanced d from the plane, compute by method of images, the electric potential above the plane and the induced charges on the conductor.

(20)

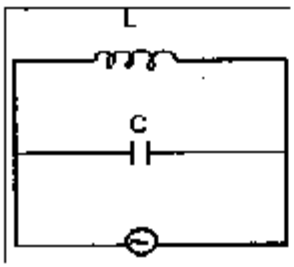
(b) Define Poynting vector and explain its significance. The electric field vector for an electromagnetic field travelling in vacuum is given by

$$\vec{E} = E_0 \cos(kz - \omega t)\hat{i}$$

Calculate the Poynting vector for the wave and show that its magnitude is equal to the energy density of the wave time the velocity of light.

(20)

(c)



A parallel LC circuit is operated at a frequency ω, which is less than the resonant frequency ω_0 of the LC circuit. Explain whether the reactance is inductive or capacitative.

(20)

7.(a) What is Laplace equation ? Determine the average electric potential over a spherical surface, due to a point charge q placed at a distance r from the centre of the sphere. Assume r to be greater than the radius of the sphere.

(30)

(b) A plane wave of frequency ω, which into two linear dielectric media. It has a normal incidence at the interface of the media. Giving appropriate for the intensities of reflected and transmitted rays.

(30)

8.(a) Two bodies A and B have the same mass m each and are made of the same material with specific heat C per unit mass. A is at a temperature T and B is at a temperature 4T. What will be the entropy change of the universe when the bodies are brought into diathermic contact with each other?

(20)

(b) Describe the Otto cycle and obtain an expression for the efficiency of the cycle, Show that the efficiency is lower than that of a Carnot cycle operating between the highest and the lowest temperature of Otto cycle.

(20)

(c) Define Fermi energy. For an ideal Fermi gas of N particles at absolute zero temperature, show that the total energy of is 3/5 NE_F, where E_F is the Fermi energy.

(20)

PHYSICS

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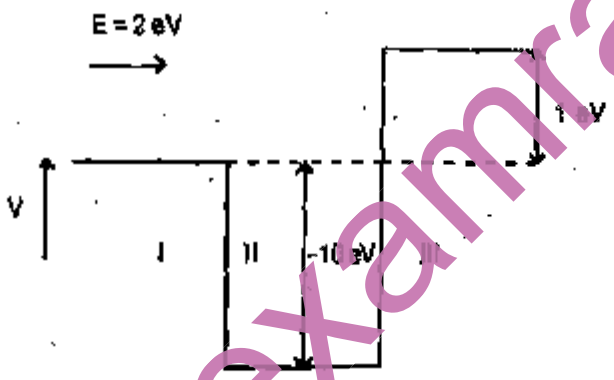
PAPER - II

SECTION A

1. Attempt any three of the following:

(a) (i) Explain what do you understand by Heisenberg uncertainty principle. Using this principle, determine the energy of the ground state of a one dimensional simple harmonic oscillator.

(ii) An electron having an energy 2 eV is travelling in the region where V(x) varies as shown below:



Calculate the de Broglie wavelength of the electron in regions I, II and III.

(10 + 10)

(b) (i) Express the Cartesian components of the angular momentum L in operate form. Show that $[L^2, L_z] = 0$. What is the significance of this commutation relation ?

(ii) Show that the Pauli Matrices anti-commute.

(15+5)

(c) (i) What are the typical energies (eV) of the radiations, required to excite

(i) electronic transitions.

(ii) vibrational transitions and

(iii) rotational transitions in a molecule ?

(ii) The rotational spectrum of HI consists of equidistant lines with a separation of 12.8 cm^{-1}. Calculate the (a) M.I. and (b) bond length of HI molecule.

(6 + 14)

(d) (i) Show that the radial probability density of the ground state of the hydrogen atom has a maximum at r = a. The ground state wave function of the hydrogen atom is given by

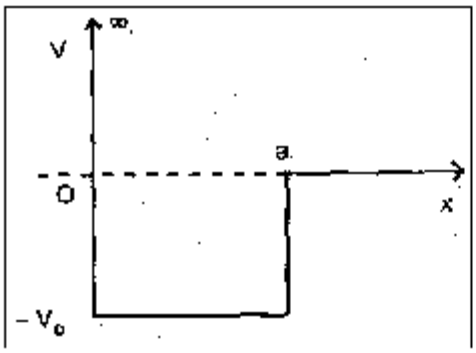
$$\psi(r) = \frac{1}{\sqrt{\pi} a^{3/2}} . e^{-r/a}$$

where a is the Bohr radius.

(ii) Calculate the Larmor frequency of a spin 1/2 particle in a magnetic field B.

(10 + 10)

2. A particle of mass m, with energy E such that $-V_0 < E < 0$, is trapped in a potential wall as shown below :



(a) Write time independent Schrodinger equation in regions

(i) $0 < x < a$ and

(ii) $x > a$.

(b) Obtain an expression from which the energy eigen values can be determined.

(c) Show that for at least one bound state to exist

$$a^2 V_0 \geq \frac{h^2 \pi^2}{8m}$$

(15+15+30)

3.(a) Number at non-interacting electrons are confined in a cube of volume L^3. Obtain an expression for the Fermi energy.

(b) Define the gyromagnetic ratio and obtain an expression for the Lande g factor. What is the importance of g factor in spectroscopy?

(30 + 30)

4.(a) Discuss the salient features of O, P, Q, R and S branches of electronic spectrum of diatomic molecules. Which spectrum contains only branches, both branches and bands, branches and progressions ?

(b) Show that a sprining nucleus precesses in a magnetic field. Explain the underlying principle of NMR spectroscopy.

The magnetic moment of a position is 2.793 μN. Calculate the radio frequency at which nuclear magnetic resonance occurs in water kept in a magnetic field of T.

(25+35)

SECTION B

5. Answer any THREE of the following:

(a) Sketch carefully the binding energy per nucleon curve for stable nuclei. Explain its salient features. On the basis of this curve explain why fusion is possible only for low mass nuclei, whereas fission takes place in heavy nuclei.

(20)

(b) (i) State the conservation law which is violated in each of the following processes:

(1) $n \rightarrow p + e^- + r$

(2) $\pi^- + p \rightarrow K^+ + K^-$

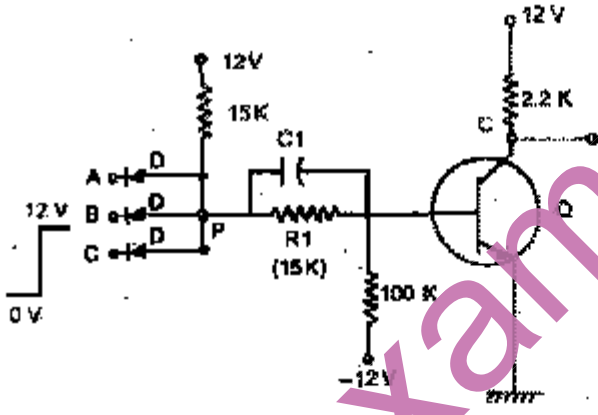
(3) $\pi^- + p \rightarrow \sum^+ + K^-$

(4) $\sum^- \rightarrow K^- + p + \overline{p}$

(ii) Draw a bcc lattice. Determine its primitive lattice vectors and calculate the packing fraction.

(8 + 12)

(c) Explain the operation of the following circuit is a gate. Draw the truth table and find the operation carried out by this gate neglecting the source impedance.



junction saturation voltages and diode voltages in forward direction. Find the minimum value of h_{fe}.

(20)

(d) (i) What are high T_c superconductors ? Give two examples indicating their transition temperatures. Differentiate between the conventional and high T_c super conductors.

(ii) Explain the principle of feedback in an amplifier. What are the advantages & negate feedback?

(12 + 8)

6.(a) List some of the important properties of deuteron and show that it is a loosely bound system and has only one bounded state.

(b) Distinguish between a nuclear reaction and decay. Which conservation laws are obeyed in nuclear reactions ? Explain the significance of Q value.

Calculate the Q value for the following nuclear reaction:

$${}_1^2H + {}_1^2H \rightarrow {}_2^3H + n.$$

(30 + 30)

7.(a) Give two characteristics properties of strange par- tides which distinguish them from non-strange ones. Write the Gellmann-Nishijima relation and show how it is used for the classification of elementary particles.

(b) What is a Josephson junction ? Discuss dc and ac Josephson effects and obtain the relation.

$$V = \frac{2eV}{h}$$

where the symbols have their usual meaning.

(30 + 30)

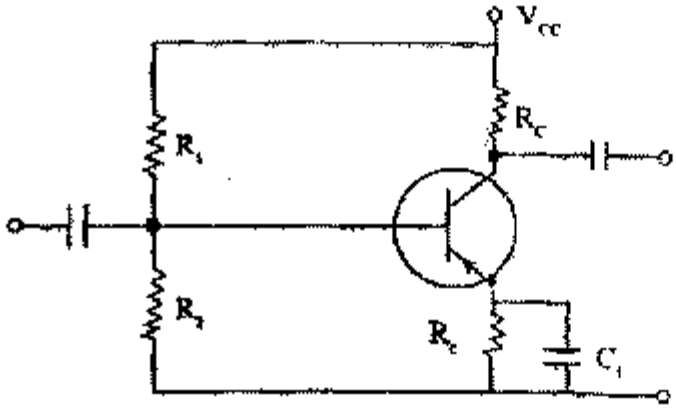
8.(a) Derive the various current components in a p-n-p transistor when it is actively biased. Using Ebers-Moll model, show that for the common-emitter configuration

$$I_C = -\alpha I_E - I_{CO}\left(E^{V_C/V_T} - 1\right)$$

where the symbols have the usual meaning.

(b) In the following circuit,

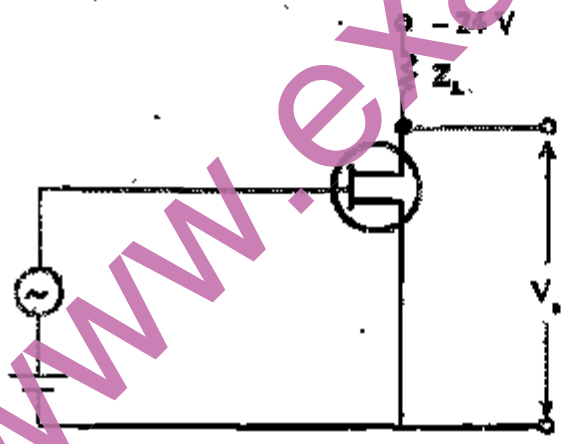
Show that the stability factor, S, is given by



$$S = \frac{1+\beta}{1+\dfrac{\beta R_e}{R_e + R_b}}$$

Where $R_b = \dfrac{R_1 R_2}{R_1 + R_2}$

(c) Calculate the gain of the following amplifier circuit :



Given that $g_m = 10$ mV/A, $r_d = 1\,\Omega$ and $Z_L = 10$ kΩ.

(30 + 20 + 10)