Civil Services (Main) Examination, 1997

PHYSICS
(Paper II)

Time Allowed : Three Hours **Maximum Marks : 300**

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.
Candidate has to attempt FIVE questions in all.
Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.
All questions carry equal marks.
Wherever any assumptions are made for answering a question, they must be clearly indicated.
Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following:

(a) Using Gauss law find the electric field inside a cylindrical capacitor and hence derive the expression for its capacitance. Find the dielectric constant of the material inside a 50 mm long capacitor of capacitance 40 μF having inner conductor of radius 1 mm, outer conductor of radius 10 mm. Which of the materials has such a value of the dielectric constant?

(b) Calculate the magnetic moment of a coil having 100 turns, each of area 10 cm^2 carrying a current of 1 mA, flowing for 1 ms. The coil is placed in a magnetic field of 0.5 kg which is perpendicular to the magnetic moment. Calculate the torque acting on the coil and the angular momentum transferred to it.

(c) Assuming that for a paramagnetic material, the magnetic susceptibility is inversely proportional to temperature in Kelvin, obtain Curie-Weiss law for the paramagnetic phase of a ferro-magnetic material.

(d) Four silicon diodes are connected as shown in Fig. 1. A sinusoidal voltage of amplitude 2 V is applied in the input. What is the waveshape of the output and its amplitude? If the amplitude of the input voltage is reduced to 1 V, what will be the waveshape of the output and its amplitude? Threshold voltage of each diode is 0.6 V.

[Figure: Fig. 1: Two input terminals on the left (labelled “Input”) and two output terminals on the right (labelled “Output”). In the upper line a diode is in series, pointing to the right (anode towards the input terminal, cathode towards the output side); in the lower line an identical series diode, also pointing to the right. Between the upper and lower lines, on the output side, two diodes are connected in parallel as shunt elements: the first (left) points downwards (anode on the upper line, cathode on the lower line); the second (right) points upwards (anode on the lower line, cathode on the upper line). The output is taken across this anti-parallel pair.]

2. (a) An alternating voltage, $v=V_0\sin(\omega t+\phi)$ is applied to a series RL circuit through a switch. Find the sum total of the transient and steady currents. Find the conditions when transient current becomes (i) zero, and (ii) maximum

(b) The self inductance of primary and secondary coils of a R.F. transformer is 10 mH each. When the coils are connected in series self resonating frequencies are 132.6 kHz and 108.3 kHz. Calculate the mutual inductance between the coils and the winding capacitance.

3. (a) Write down maxwell’s equations in free space and hence show that the phase velocity of the electromagnetic wave is equal to the velocity of light in free space.

(b) Obtain the characteristic impedance of the vacuum. Derive the expression used.

4. (a) Draw the circuit of an emitter-follower and find its voltage gain.

(b) Simplify the following logic function and draw the corresponding logic gates:

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$$Y=A.B+B.\bar{C}+\bar{A}.B+\bar{A}.C+\bar{B}.C+\bar{A}.\bar{B}.\bar{C}+A.B.C.$$

SECTION 'B'

5. Answer any three of the following:

(a) Using Heisenberg Uncertainty principle, find the ground state energy and Bohr radius of hydrogen atom.

(b) Explain the origin of continuous X-rays. Compare the phenomenon with photoelectric effect.

(c) Mention the conservation laws violated in the following elementary particle reactions: (i) $\mu^- \rightarrow e^- + \nu_o$ (ii) $n \rightarrow p + e^-$ (iii) $k \rightarrow \pi^o + \pi^o$ (iv) $e^- + e^- \rightarrow \gamma$

(d) Explain the basic distinction between a perfect conductor and a superconductor.

6. (a) Draw the expression for Lande's g-factor for LS coupled state.

(b) Draw the energy level diagram and show the allowed transitions for Zeeman pattern for $n=3_1 \rightarrow 2_0$ transition line of a hydrogen atom placed in a uniform magnetic field of 1 kg. Calculate the doublet splittings.

(c) Write in brief the differences between the IR active and Raman active bands.

7. Write down the time independent Schrodinger equation for the x < 0 and x > 0 in case of a step potential

$$V(x)=\{[0, \quad x<0 \; ; \; V_o, \quad x\geq 0]$$

Discuss the solutions thus obtained for the case $E>V_o$. Obtain the following relations.

$$|R|^2=((1-\mu)/(1+\mu))^2 \text{ and } k/k_o|T|^2=\mu(2/(1+\mu))^2$$

Where $\mu=\sqrt{(1-V_o/E)}$, R and T are reflection and transmission coefficients respectively. Other symbols have their usual meaning. Plot the behaviour of $|R|^2$ and $k/k_o|T|^2$ with μ.

8. (a) Explain the physical meaning of each term, write semiempirical mass formula for a nucleus. Find the value of atomic number of most stable nucleus for a given mass number A.

(b) Explain the phenomenon of nuclear fission and obtain the expression for fissionability parameter. Show that the critical value of the fissionability parameter is 50.

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