RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2017

SECOND YEAR [BATCH 2015-18]

Date : 27/05/2017 **PHYSICS (General)**

Time : 11 am – 1 pm **Paper :** IV Full Marks : 50

[Use a separate Answer Book for <u>each group</u>]

Group – A

(***Answer <u>any four</u> questions***) [4×5]

1. a) Draw the circuit of a single stage CE amplifier. [2]
   b) Construct the load line equation at the output and explain voltage amplification qualitatively with the help of load line. [1+2]

2. a) Establish the currents relation $I_C = \beta I_B + I_{CEO}$ in CE mode configuration where I_C = collector current, I_B = Base current, β = DC current gain, I_{CEO} = Leakage current in CE mode. [3]
   b) How beta (β) of a transistor is related to its alpha (α) ? α = current gain in CB mode. [2]

3. a) Perform the following operations using 2's complement method.
   (i) 48 – 23 (ii) –48 – 23 (iii) 23 – 48 [3]
   b) Prove the following using De Morgan's theorem.
   i) $AB + CD = \overline{\overline{AB} \cdot \overline{CD}}$
   ii) $(A+B)\cdot(C+D) = \overline{\overline{(A+B)} + \overline{(C+D)}}$ [2]

4. a) What is a NAND gate? Write down its truth table. [1+1]
   b) Construct AND, OR and NOT gates from NAND gate. [1+1+1]

5. Given the logical equation, $Y = (A + BC)(B + \bar{C}A)$.
   a) Design a circuit using gates to realize Y. [2]
   b) Design a circuit using NAND gates only to realize the same function Y. [3]

6. a) Carry out the arithmetic sum and logical sum of the two binary number A = 1011 and B = 1100. [2]
   b) Draw the necessary circuit using Half-adder to carry out the arithmetic sum of A and B in (a). [3]

Group – B

(***Answer <u>any six</u> questions***) [6×5]

7. a) Write down Lorentz transformation relations. [1]
   b) What is time dilation? Derive an expression for time dilation. [2]
   c) From the concept of velocity addition, prove that maximum attainable velocity is the velocity of light. [2]

8. a) Derive an expression for relativistic kinetic energy from Work-Energy theorem. Show that for velocities v <<c, the relativistic kinetic energy reduces to classical kinetic energy. [2+1]
   b) If the kinetic energy of a body is twice its rest mass energy, find its velocity. [2]

9. a) What do you mean by blackbody? Why blackbody radiation is not visible at room temperature but become visible as temperature rises to sufficiently high value. [1+1]

   b) What do you mean by Raman effect? [1]

   c) A beam of X rays is scattered by free electrons. At 45° from the beam direction the scattered X-rays have a wavelength of 0·022Å. What is the wavelength of the X-rays in the direct beam? [2]

10. a) State De Broglie's hypothesis. [1]

    b) Show that the de Broglie wavelength of a particles of charge e, rest mass m_0, moving at relativistic speeds is given as function of the accelerating potential V as

$$\lambda = \frac{h}{\sqrt{2m_0 eV}}\left(1+\frac{eV}{2m_0C^2}\right)^{-\frac{1}{2}}.$$ [2]

    c) Show how this agrees with $\lambda = \frac{h}{p}$ in the nonrelativistic limit. [1]

    d) A particle moving with kinetic energy equal to its rest energy has a de Broglie wavelength of $1\cdot7898\times10^{-6}$ Å. If the kinetic energy doubles, what is the new de Broglie wavelength? [1]

11. a) State Heisenberg uncertainty Principle. [1]

    b) What do you mean by wavepacket? Explain briefly what happens when one try to localize a wavepacket by reducing the uncertainty in position. [2]

    c) A microscope using photons is employed to locate an electron in an atom to within a distance of 0·2Å. What is the uncertainty in the velocity of the electron located in this way? [1]

    d) The lifetime of an excited state of a nucleus is usually about 10^{-12} sec. What is the uncertainty in energy of the γ-ray photon emitted? [1]

12. The ground state wave function for a quantum particle trapped in a one-dimensional box of length L is given by $\psi_1(x,t) = A\sin\frac{\pi x}{L}e^{-\frac{i\pi^2\hbar t}{2mL^2}}$ for $0 < x < L$.

    a) Determine the normalization constant. [1]

    b) Find the probability of finding the particle in between $x = \frac{L}{2}$ to x = L. [1]

    c) Find the expectation value of position <x>, momentum <p_x> and energy <E>. [3]

13. a) What are Miller indices? How are they obtained? [2]

    b) Write Bragg's law for X-ray diffraction in crystal and prove it. [1+2]

14. a) Draw a graph for binding energy per nucleus (B/A) vs mass number (A) and explain the stability of nucleus. [2+1]

    b) Calculate the binding energy per nucleon of a Helium nucleus. Given the mass of a proton = 1·0028 a.m.u. mass of a neutron = 1·00867 a.m.u., mass of Helium nucleus = 4·00276 a.m.u. [2]

15. a) What is successive disintegration? [1]

    b) A is a radioactive element which decays into B. Again B decays into C. Obtain the number of atoms of B at any time t, considering λ_1, λ_2 and λ_3 are the decay constants of A, B and C respectively. [4]

16. How energies are formed in stars by thermonuclear fusion. [5]

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