RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2016

SECOND YEAR [BATCH 2014-17]

Date : 30/05/2016 **PHYSICS (General)**

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

[Use a separate Answer Book for each group]

Group – A

Answer any two questions from question nos. 1 to 4 : [2×10]

1. a) What is the difference between an ordinary junction diode and a zener diode? 2
   b) Write down the working principle of a zener diode as voltage regulator. 5
   c) The half wave rectified current through a load resistance is given by
   $$i_L = I_m \text{ Sin } \omega t \quad \text{for } 0 \le \omega t \le \pi$$
   $$= 0 \qquad \text{for } \pi \le \omega t \le 2\pi$$
   Calculate the ripple factor. 3

2. a) Draw the circuit diagram to have the input and output characteristics of a NPN transistor in CE mode. 2
   b) Sketch the schematic input and output characteristics curves with proper labelling. Discuss about the input and output resistances of the transistor in CE mode. 2+2
   c) Derive the relation $I_C = \beta I_B + I_{CEO}$ for a transistor in CE mode. (Symbols have their usual meaning) 4

3. a) Convert the following binary number into decimal and hexadecimal number: 2
   $(101010101.10101)_2$
   b) Convert the following hexadecimal number into binary number: 2
   $(2AB7)_{16}$
   c) Do the subtraction of two binary numbers 10110 & 10010 using 1's complement and 2's complement method. 3
   d) Simplify the Boolean expressions: 3
   (i) $A\cdot(B+C\cdot(\overline{A\cdot B+A\cdot C}))$
   (ii) $\overline{\overline{\overline{A}+\overline{B}}+\overline{A+B}}$

4. a) What is Half-adder? Write down the truth table for Half-adder. Then write down the Boolean expressions for Sum bit(s) and Carry bit(c). 1+1+2
   b) Draw a circuit diagram for *S* and *C* of Half-adder using NAND gate only. 6

Group – B

Answer any three questions from question nos. 5 to 10 : [3×10]

5. a) What do you mean by an space time interval between two events? What are the different types of space time intervals possible? In light-cone diagram indicate the regions of different space time intervals. 1+1+1
   b) An event occurs at the origin of an inertial frame *S* at $t = 0$. Another event occurs at $x = 4c$, $y = 0$, $z = 0$ at $t = 5$ sec relative to *S*. What is the space-time interval between these events. Determine the velocity of the inertial frame S' in which the two events are recorded at same point in space. 2

c) Find an expression for relativistic kinetic energy from work energy theorem. Show that at low speeds the relativistic expression reduces to the classical expression of kinetic energy. Also, show that the total energy E can be expressed as $E = mc^2$, where m is the mass of the particle and c is the velocity of light. 2+1+1

d) An electron in a television picture tube typically moves with a speed u = 0.25 c. Find its total energy and kinetic energy in electron volts. 1

6. a) State the basic postulates of Bohr's model. 2

b) Derive an expression for the energy of an electron moving in the nth orbit round a nucleus of charge Ze. 5

c) How many revolutions does an electron make in the n = 2 state of a hydrogen? Average life-time in this state is 10^{-8} s. 3

7. a) What do you mean by Compton effect? Deduce an expression for Compton shift in terms of scattering angle. 1+3

b) Molybdenum K_α X-rays of wavelength 0.709 Å are allowed to suffer Compton scattering from a carbon target. Calculate the wavelength of the photons scattered at $\phi = 30^o$. 1

c) Find the expression of velocity of a relativistic particle by assuming its velocity is equal to the group velocity and hence deduce the de Broglie relation. 3

d) Calculate the de Broglie wavelengths of electrons of kinetic energy 0.1 MeV using both relativistic and non-relativistic expressions for λ. 2

8. a) What do you mean by uncertainty principle? An electron is confined to a box of length 1.1×10^{-8} m; calculate the minimum uncertainty in its velocity. Given $m = 9.1\times10^{-31}$ kg $\hbar = 1.05\times10^{-34}$ joule sec. 1+2

b) Calculate the expectation value of $\hat{p}^2$ for the wave function $\psi(x) = \sqrt{2/L}\sin\frac{\pi x}{L}$ in region 0 < x< L, where $\hat{p}$ is the x-component of the momentum operator. 2

c) A quantum particle of mass m is confined in one dimensional box of length a extending from $x = -\frac{a}{2}$ to $x = \frac{a}{2}$. The potential energy inside the box is zero, which outside the box is infinity. Using time independent Schrödinger equation, find the normalized wave functions and energies of the particle. Sketch the ground state and first excited state wave function. 5

9. a) For X-ray diffraction write Bragg's equation and then explain. 1+2

b) The first order Bragg reflection is formed when X-rays of wave length 0.842 AU is made incident on a crystal at glancing angle 8º35'. What will be the glancing angle for third order reflection? 4

c) Draw the plane for miller indices (1,1,1) and (1,0,0). 3

10. a) Find out the binding energy and binding fraction for the $_2He^4$ atom. 2+2

Atomic mass = 4.003874 a.m.u.

m_H = 1.008145 a.m.u.

m_n = 1.008986 a.m.u.

b) What is nuclear fission? 3

c) Draw atomic mass (A) Vs binding energy per nuclear (B/A) curve and explain nuclear stability. 1+2

———— × ————