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335402

May, 2019

B.Sc.(H) PHYSICS SEMESTER-IV

ELEMENTS OF MODERN PHYSICS (BPH-402)

Time : 3 Hours] [Max. Marks : 75

Instructions :

1. *It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.*
2. *Answer any four questions from Part-B in detail.*
3. *Different sub-parts of a question are to be attempted adjacent to each other.*
4. *Use of non-programmable simple calculator is allowed.*

PART–A

1. (a) What are the postulates of Planck's quantum theory of blackbody radiations? (1.5)

(b) Calculate the group velocity of ocean waves whose phase velocity is given by $V_p = \sqrt{\frac{g\lambda}{2\pi}}$; where λ is the wavelength of ocean wave and g is the acceleration due to gravity. (1.5)

(c) What is the physical interpretation of a wave function ψ ? (1.5)

(d) The wave function for a particle confined in one dimensional box of length L is given by $\psi(x) = A\sin\left(\frac{n\pi x}{L}\right)$; normalize the wave function. (1.5)

(e) Determine the ratio of nuclear radii of ${}_6C^{12}$ and ${}_8O^{16}$. (1.5)

(f) Write any three main assumptions of liquid drop model. (1.5)

(g) How do you explain the emission of Beta-particles from radioactive nuclei even though they are not contained in them? (1.5)

(h) What kind of observations on the energy spectrum of Beta-rays led 'Pauli' to propose the neutrino hypothesis in 1930? (1.5)

(i) A positron and an electron with negligible kinetic energy meet and annihilate each other producing two Gamma-rays of equal energy. What is the wavelength of these gamma-rays? (1.5)

(j) What is population inversion and why is it needed in lasers? (1.5)

PART–B

2. (a) Why is the classical wave theory unable to explain the observations of the photoelectric effect? How does Einstein's photoelectric equation resolve these difficulties? (10)

(b) How does the uncertainty principle rule out the possibility of electron being inside the nucleus? (5)

3. (a) Explain the de-Broglie hypothesis for matter waves. Describe the Davisson-Germer experiment in detail. What are the outcomes of the experiments and how it established the wave nature of electrons? (10)

(b) Calculate the de-Broglie wavelength for an electron with kinetic energy of (i) 1 eV and (ii) 1 MeV, provided the rest mass energy of electron is 0.511 MeV. (5)

4. (a) Obtain the energy eigen values and normalized wavefunctions for a free particle of mass m trapped in a one dimensional box of length L. (12)

(b) Explain the quantum mechanical tunnelling in one dimension across a step potential. (3)

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5. (a) Write the main properties of nuclear forces. (3)

(b) Write the semi-empirical mass formula for a nucleus of mass number 'A' containing 'Z' protons and 'N' neutrons explaining each term used in the expression. (9)

(c) Calculate binding energy in MeV per nucleon for $_5B^{10}$ with mass number 10.0161 a.m.u. Given that mass of a proton in 1.0081 a.m.u. and that of neutron is 1.0089 a.m.u. (3)

6. (a) What are the laws of the radioactive decay. Explain the mean life and half life of a radioactive material. (5)

(b) Describe in detail the theory of beta-decay. Discuss the spectrum of energy released and Pauli's neutrino hypothesis. (10)

7. (a) Differentiate between spontaneous and stimulated emission. (3)

(b) Define and derive the Einstein coefficients? (7)

(c) What is optical pumping? Discuss two methods of optical pumping. (5)
