लक्ष्यं विश्वमानम्

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 4th Semester Examination, 2021

PHSACOR09T-PHYSICS (CC9)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Question No. 1 is compulsory and answer any *two* from the rest

1. Answer any ***ten*** questions from the following: 2×10 = 20

(a) Discuss Heisenberg's uncertainty principle as a consequence of wave-particle duality.

(b) A hydrogen atom is 5.3×10^{-11} m in radius. Use the uncertainty principle to estimate the minimum energy an electron can have in this atom.

(c) Compare the wavelengths of an electron (m_e) and a muon (m_μ) each with kinetic energy 15 keV. Given, $m_\mu = 207m_e$

(d) 'Although the efficiency of a four level laser is less than that of a three level laser, still the four level laser is better than the three level laser.' Why?

(e) Compute the coherence length of yellow light with 5893Å in 10^{-12} second pulse duration. Find also the bandwidth.

(f) Write down the important characteristics of nuclear force.

(g) Assuming spherical shape of atomic nucleus, show that density of nuclear matter is constant.

(h) When light of a given wavelength is incident on a metallic surface, the stopping potential for the photoelectrons is 3.2 V. If a second light source whose wavelength is double that of the first is used, the stopping potential drops to 0.8 V. Find the cut off frequency of the metal. (Given, Speed of light in vacuum $c=3\times10^8$ m/s and charge of an electron $e=1.6\times10^{-16}$ C).

(i) A muon is travelling through the laboratory at a speed of $(3/5)c$. How long does it last?

(j) A 45 kW antenna emits radio waves at a frequency of 4 MHz. How many photons are emitted per second? (Given, Planck constant $h=6.63\times10^{-34}$ Js)

(k) The Davisson-Germer experiment that first demonstrate the wave nature of matter used non relativistic electrons accelerated to 54 V. Determine the energy of the electrons in joules. Also calculate the speed of the electrons moving in this experiment.

(l) Ra-226 decays by α -particle emission with $T_{1/2} = 1590$ years and produces radon. Calculate the volume of radon at STP evolved from 1g of radium in 50 years.

(m) Write down some points of resemblance between the nucleus of an atom and a liquid drop.

(n) What is space-time interval? What is the value of space-time interval when two events can be connected with a light signal only?

2. (a) Explain the difference between group velocity and phase (wave) velocity. Which of these is associated with the particle velocity? The velocity of ocean waves is $u = \sqrt{\frac{g\lambda}{2\pi}}$, where g is the acceleration due to gravity and λ is the wavelength. Find the group velocity of ocean waves. 2+1+2

(b) An electron has a de Broglie wavelength of 2×10^{-12} m. Find its kinetic energy, group and phase velocities (given, rest mass energy of electron = 511 keV, Planck constant $h = 4.136\times10^{-15}$ eV/s, velocity of light in air $c = 3\times10^{8}$ m/s). 2+2+1

3. (a) What is 4-momentum? Write down the conservation law of 4-momentum. 3

(b) Draw the β -decay energy spectrum and describe the necessity of existence of a new particle to explain the discrepancies in the spectrum. 4

(c) A particle of rest mass M_1 decays into a particle of rest mass m_2 and a photon. What are the 4-momenta of the decaying particle and produced particle in their respective rest frames? In the rest frame of the produced particle what is the energy E_γ of the photon in terms of M_1, m_2 and the speed of light in vacuum c? 3

4. (a) Using semi-empirical mass formula show that α-decay can occur only for nuclei with mass number, $A > 160$. [Given that $a_1 = 0.016919\text{u}$, $a_2 = 0.019114\text{u}$, $a_3 = 0.0007626\,\text{u}$, $a_4 = 0.02544\text{u}$, $a_5 = 0.036\text{u}$, $E_B({}^4_2\text{He}) = 28.3\,\text{MeV}$] 4

(b) Show that for a normal optical source with temperature about 10^3K and wavelength 6000Å, the emission is predominantly due to spontaneous transitions. 3

(c) Event A happens at point $(x_A = 5, y_A = 3, z_A = 0)$ and at time t_A given by $ct_A = 15$; event B occurs at (10, 8, 0) and $ct_B = 5$. Both in system S. 3

(i) What is the invariant interval between A and B?

(ii) Is there an inertial system in which they occur simultaneously? If so, find its velocity relative to S.

(iii) Is there an inertial system in which they occur at the same point? If so, find its velocity relative to S.

5. (a) Find the total angular momentum and parity for the ground state of ${}_{16}S^{33}$ and ${}_{6}C^{13}$ nuclei. 2+2

(b) Derive Rayleigh-Jeans' formula from Wien's formula in case of blackbody radiation. 2

(c) A blackbody of surface area 1cm^2 is placed inside an encloser. The encloser has a constant temperature 27ºC and the blackbody is maintained at 327ºC by heating it electrically. What electric power is needed to maintain the temperature? 2

[Given $\sigma = 6.0 \times 10^{-8}\ \text{Wm}^{-2}\text{K}^{-4}$]

(d) Discuss Wilson-Sommerfeld quantization rule. 2

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

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