WEST BENGAL STATE UNIVERSITY
B.Sc. Honours 4th Semester Examination, 2023

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: $2 \times 10 = 20$

(a) A pion at rest decays into a muon and a neutrino. Show that the kinetic energy of muon is $T_\mu = (m\pi - m\mu)^2 c^2 / 2m\pi$.

(b) What are "space-like interval" and "time-like interval"?

(c) Show that the Compton wavelength corresponds to the self-energy of an electron.

(d) Calculate the number of light quanta present in green light of 100 W per m^2 per second. Given $\lambda = 6000$ Å.

(e) Show that – "the particle and the associated wave packet move together, i.e., move with the same velocity".

(f) How does a nucleus resembles a liquid drop? Give two points.

(g) What do you mean by "Boltzmann weight factor"? Write down the relationship between Boltzmann distribution function and this weight factor.

(h) Calculate the ratio of stimulated to spontaneous emission rates for the wavelength $\lambda = 5900$ Å at 250°C.

(i) 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.

(j) Explain the 'ultraviolet catastrophe' in context of black body radiation.

(k) The half-life of radon is 3.82 days. What fraction of freshly prepared sample of radon will disintegrate in 10 days?

(l) Calculate the number of photons emitted per sec. by a 100 watt sodium lamp. ($\lambda = 5893$ Å for sodium).

(m) Calculate the energy of γ-rays emitted in the β-decay of $_{13}Al^{28}$. Given: the end point energy = 2.81 MeV ; $M\left(_{13}^{28}Al\right) = 27.9819\,u$; $M\left(_{14}Si^{28}\right) = 27.9769\,u$.

(n) A nucleus with $A = 235$ splits into two nuclei of mass numbers in the ratio 2 : 1. Find the radii of the new nucleus.

2. (a) What is 'proper time' and 'proper length'? `2`

(b) In a frame S, the following two events occur: `3`

Event 1: $x_1 = x_0$, $t_1 = \dfrac{x_0}{c}$, $y_1 = z_1 = 0$

Event 2: $x_2 = 2x_0$, $t_2 = \dfrac{x_0}{2c}$, $y_2 = z_2 = 0$

Find the relative velocity of S' frame relative to S in which the events occur at the same time and what is the t-value?

(c) The position and momentum of 1 keV electron are simultaneously measured. If its position is located to within 1A, find the percentage of uncertainty in its momentum. `3`

(d) Establish Bohr's quantization condition on the basis of de Broglie's concept of matter waves. `2`

3. (a) What is 'population inversion'? How the population inversion is achieved in the He-Ne gas laser? `1+3`

(b) If R be the radius of the nucleus and $\langle r^2 \rangle$ be the mean squared radius of nuclear charge distribution, show that $R^2 = \frac{5}{3}\langle r^2 \rangle$. `2`

(c) Calculate the α-disintegration energy for the α-particle with energy 5.76 MeV emitted from the nucleus $_{83}\text{Bi}^{212}$. `2`

(d) Prove mass of photon is zero. `2`

4. (a) Draw a graph indicating stability line. On this graph indicate the β^--active nuclei. Explain the role of neutrino hypothesis in understanding the β-ray spectrum. `1+1+2`

(b) Discuss the features of B.E./A vs. A curve. `3`

(c) What are the experimental evidences that suggest nuclear shell model? `3`

5. (a) Establish a relation between Einstein's Spontaneous and Stimulated coefficients. `3`

(b) Calculate the Surface energy and Coulomb energy for a $_{92}^{236}\text{U}$ nucleus. `1+1`

(c) Among $_3\text{Li}^7$ and $_4\text{Be}^9$ — Which nucleus is more stable? `2`

(d) How does pair production take place by a high energy γ-rays? Can pair production occur in free space? `2+1`

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