B.SC. 4th Semester (Honours) Examination, 2019 (CBCS)

Subject : Physics

Paper : CC-IX

Full Marks: 40

Time: 2 Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

1. Answer *any five* of the following questions: 2×5=10

(a) Calculate the de Broglie wavelength of an electron of Kinetic energy $500eV$ is Å unit. $[h = 6.626 \times 10^{-34}\, J.S, 1eV = 1.602 \times 10^{-19} J, m_e c^2 = 0.5MeV]$

(b) Life time of a nucleus in the excited state is $10^{-12}S$. Calculate the probable uncertainty in the frequency of a γ-ray photon emitted by it.

(c) Can $\psi(x) = A \tan x$ be a solution of the Schrödinger equation for all value of x? Justify your answer.

(d) The wave function $\psi(x) = A\, e^{-|x|} \sin \alpha x$ is normalized. Find the normalization constant A.

(e) Find the ratio of the sizes of ${}_{82}Pb^{208}$ and ${}_{12}Mg^{26}$ nuclei.

(f) Find the angular momentum and parity of ${}_{8}O^{17}$ nucleus according to nuclear shell model.

(g) Give an estimate of the typical energies released in nuclear fission and nuclear fusion reactions.

(h) Distinguish between spontaneous and stimulated emissions of radiation.

2. Answer *any two* of the following questions: 5×2=10

(a) Write down Einstein's photoelectric equation explaining each term. Ultraviolet light of wavelength 350nm and intensity 1 watt/m^2 falls on a surface of potassium. Find the maximum kinetic energy of the emitted photoelectrons. (work function of potassium = 2·1 eV) 2+3=5

(b) The electron in a hydrogen atom may be thought of as confined to a nucleus of radius 5×10^{-11}m. Calculate the minimum uncertainty in the momentum of the electron and the minimum kinetic energy of the electron. Given mass of an electron = $9{\cdot}1 \times 10^{-31}$kg. 3+2=5

(c) Following liquid drop model, write down an expression for the total binding energy of a nucleus explaining each term. Using this expression, find the atomic number of the most stable isobar for a nucleus having odd number of nucleons. 2+3=5

(d) Discuss the principle and working of a He-Ne laser with the help of a diagram. 2+3=5

10×2=20

3. Answer *any two* of the following questions:

(a) Explain by a curve, the distribution of intensity of radiation emitted by a blackbody as a function of wavelength. How does the curve change with temperature? Discuss Planck's hypothesis to explain energy distribution of black-body radiation. Deduce Planck's radiation formula. 2+1+2+5=10

(b) Write down the expressions for probability density (ρ) and probability current density $(\vec{J})$ for a particle represented by the wave function $\psi(x,t)$. Show that ρ and $\vec{J}$ are related by the equation of continuity. Determine $\rho(x)$ and $\vec{J}(x)$ for $\psi(x) = A\, e^{\left(\frac{-\alpha x^2}{2} + ikx\right)}$. 3+3+4=10

(c) Set up the Schrödinger equation for a particle is an infinite square well potential

$$V(x) = 0 \quad \text{for} \quad -a < x < a.$$
$$= \infty \quad \text{for} \quad |x| > a$$

Solve the equation to find the energy eigenvalues and eigenfunctions. 2+8=10

(d) (i) How many α and β particles are emitted when $_{92}U^{238}$ decays to $_{82}Pb^{206}$. When a nucleus emits a gamma ray photon, what happens to its atomic number, mass number and the actual mass?

(ii) Define half-life of a radioactive substance. The half-lives of two radioactive substances *A* and *B* are respectively 1 hour and 2 hours. If initially the number of nuclei of both substances are the same, compare their rate of disintegration after 2 hours.

(3+2)+(2+3)=10

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