U.G. 4th Semester Examination 2022

PHYSICS (Honours)

Paper Code : DC - 9

(Elements of Modern Physics)

Full Marks : 25 Time : Two 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* questions : 2×5=10

(a) How the half life (τ) is related to the decay constant (λ) of a radioactive sample ? Which value does 'λ' assume at the end product of a radioactive series ? 1+1

(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. 2

(c) Which of the following is a possible solution of Schrödinger wave equation and why ?
(i) $A\cot x$ (ii) Ae^{-x^2}. 2

(d) On fission, U^{235} yields two fragments of A = 95 and A = 140 roughly. Assume that the two fragments are ejected with equal and opposit momentum. Prove that their energies will be approximately in the ratio 3 : 2. 2

(e) What do you mean by 'population inversion' ? How is it achieved in a ruby laser ? 1+1

(f) The normalised wavefunction of a particle moving in a region $0 \le x \le L$ is given by $\psi(x) = \sqrt{\frac{2}{L}} \sin \frac{n\pi x}{L}$, where '$n$' is an integer. Prove that the expectation value of the momentum of the particle is zero. 2

(g) The nuclear radius of Be^8 is 2.4 F. Find that of Al^{2+}. 2

2. Answer any *three* questions : 5×3=15

(a) Write down Planck's radiation formula, explaining the symbols used.

Obtain Stefan's law of radiation from Planck's formula. 2+3

(b) (i) From the kinetic energy of photoelectrons versus frequency of the incident radiation, comment on the slope of the curve and indicate the threshold frequency. 2

(ii) If $u(x) = e^{-x^2/2}$ is an eigenfunction of the operator $\left(\frac{d^2}{dx^2} - x^2\right)$, find the corresponding eigenvalue. 1

(iii) Show that uncertainty relation does not allow presence of electrons in the Nucleus. 2

(c) (i) What are magic numbers ? Why are they so called ? 1+1

(ii) Show from the semi-empirical mass formula, that $A \simeq 2z$ for light nuclei.

Take $\frac{a_c}{a_a} = 0.030$. 3

(d) (i) State Moscley's law of characteristic X-ray spectra. 1

(ii) A particle of mass 'm' is confined to a one-dimensional box of length L extending from $x = 0$ to $x = L$. Show that the probability of finding the particle in the region $0 \le x \le L/4$ for an arbitrary value of quantum number 'n' is $P = \frac{1}{4} - \frac{\sin\frac{n\pi}{2}}{2n\pi}$. 4

(e) (i) An electron of mass 9.1×10^{-31} kg is moving under a potential difference of 150 volt. Prove that the average wavelength of the corresponding de Broglie wave is nearly 1.0 Å.

(ii) Explain nuclear fission on the basis of liquid drop model. 2+3
