'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL
B.Sc. Honours 4th Semester Examination, 2023

CC9-PHYSICS

ELEMENTS OF MODERN PHYSICS

Time Allotted: 2 Hours   Full Marks: 40

The figures in the margin indicate full marks.
All symbols have their usual significance.

GROUP-A

1. Answer any *five* questions from the following: $1 \times 5 = 5$

    (a) Explain population inversion in lasers.

    (b) Give the quantum operators for energy and position.

    (c) Write two differences between β-rays and α-rays.

    (d) What do you mean by work-function?

    (e) Prove that $[\hat{x}, \hat{p}_x] = -i\hbar$.

    (f) Give two differences between nuclear reaction and radioactive disintegration.

    (g) Write down the semi-empirical mass formula.

    (h) Write two sources of stellar energy.

GROUP-B

Answer any *three* questions from the following $5 \times 3 = 15$

2. (a) Can two independent laser beams produce an interference pattern? Explain.   2

    (b) A laser beam of wavelength 720 nm has a coherence time of 4×10^5 sec. Deduce the order of magnitude of its coherence length and spectral half width.   3

3. (a) What was the significance of Davisson-Germer experiment?   2

    (b) Derive a relation between group and phase velocities.   3

4. (a) Prove $[\hat{x}, P_x^n] = in\hbar \hat{p}_x^{(n-1)}$.   3

    (b) What do you mean by the eigenvalue of a dynamical variable?   2

5. (a) What do you mean by nuclear force? What are their characteristics?   1+1

  (b) Explain which is the most stable among $_2^6\text{He}$, $_2^6\text{Be}$ and $_3^6\text{Li}$.   3

6. (a) Find the angular momentum of the electron in the ground state and first excited state of hydrogen atom.   3

  (b) Give two differences between Compton and Photo-electric effect.   2

GROUP-C

Answer any *two* questions from the following $10 \times 2 = 20$

7. (a) Find the normalized wave-function for a particle trapped in one-dimentional box of infinite height.   4

  (b) Show that the De-Broglie wavelength associated with a particle of rest mass m_0 and kinetic energy E is given by $\lambda = \dfrac{hc}{(E^2 + 2Em_0c^2)^{\frac{1}{2}}}$.   3

  (c) How can you explain the continuous nature of β-ray spectrum?   3

8. (a) Why only α-particles are emitted by radioactive nucleii while protons and neutrons are not?   3

  (b) How much energy in MeV is required to remove one neutron from $_8\text{O}^{16}$?   3

  (c) Explain the phenomenon of nuclear fission.   2

  (d) Calculate using shell model, the spin and parity of each nucleus N^{15}, O^{16}.   2

9. (a) Explain the concept of a four level Laser system with an example.   4

  (b) Obtain the expression for the probability current density for the wavefunction $\psi = \dfrac{e^{ikr}}{r}$.   3

  (c) Energy required to remove an electron from sodium is 2.3 eV. Does Sodium show photo electric effect for orange light with wavelength 6800 Å?   3

10.(a) Explain why electron can not reside in the nucleus, with proper calculations.   4

  (b) A nucleus emits an α-particle followed by two β-particles. Show that the final nucleus is an isotope of the original one.   2

  (c) The wave-function of a metal is 2.2 eV. Calculate the threshold wavelength and maximum kinetic energy of the photoelectron when light of wavelength 2000 Å is incident on it.   3

  (d) Explain stimulated emissions in Lasers.   1

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