BACHELOR OF SCIENCE EXAMINATION, 2022

(2nd Year, 2nd Semester)

PHSYICS

[ELEMENTS OF MODERN PHYSICS]

PAPER – CORE 09

Time : Two hours Full Marks : 40

Answer *any **four*** questions.

1. a) What is de Broglie's hypothesis of wave-particle duality?

   b) Discuss in brief how the Davisson-Germer experiment could establish the wave-particle duality.

   c) An electron has a de Broglie wavelength equal to that of a photon. Show that the corresponding kinetic energy of the electron is: $\left(m^2c^4 + h^2v^2\right)^{1/2} - mc^2$.

   (2+5)+3

2. a) Explain using the uncertainty principle why electrons cannot reside within the nucleus.

   b) Examine whether the following operator: $\hat{L}f(x) = f(x) + x^2$ is linear or not.

   c) Evaluate the commutator: $[x, p]$ in momentum representation. 4+3+3

3. a) Prove that Hermitian operators have orthogonal eigenfunctions.

b) Prove that the operator: $i\frac{d}{dx}$ is Hermitian.

c) Calculate the expectation values of position $\langle x \rangle$ and momentum $\langle p_x \rangle$ of a particle trapped in a one-dimensional infinite well of width, a and hence comment on the results. 3+3+(2+2)

4. a) How do you explain the nuclear spin and parity of nuclei?

b) Draw the N-Z plot and hence explain the stability of nucleus.

c) How do you interpret the nuclear fission and fusions from the binding energy per nucleon curve?

d) The binding energy per nucleon for C^{12} is 7.68 MeV and that for C^{13} is 7.47 MeV. Calculate the energy required to remove a neutron from C^{13}. 2+2+3+3

5. a) State and explain Geiger-Nuttal law.

b) Explain why classical physics fails to explain α-decay. What are the basic notions of the quantum mechanical theory of α-decay?

c) A sample of Radium-E contains 4.0 mg. If the half-life is 5.0 days and the average energy of the β particles emitted is 0.34 MeV, at what rate in watts does the sample emit energy?

d) What do you understand by electron-positron pair production? 3+2+3+2

6. a) Discuss about the spin and magnetic moment of neutron.

b) Why do very light atoms reduce the energy of neutrons more than heavy atoms do?

c) Why is it possible to produce fission of U^{235} with slow neutrons whereas it is necessary to use fast neutrons to produce fission of U^{238}?

d) Show that the mass of Ra^{226} (half-life 1600 years) with an activity 1 Currie is almost 1 gm. 3+2+2+3