B.Sc. Semester-IV Examination, 2022-23

PHYSICS [Honours]

Course ID : 42412 Course Code : SH/PHS/402/C-9(T9)

Course Title : Elements of Modern Physics

Time : 1 Hour 15 Minutes Full Marks : 25

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

SECTION–I

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

   a) The half-life of a radioactive substance is 15 years. Calculate the period in which 2.5% of the initial quantity will be left over.

   b) What is the physical significance of probability current density?

   c) Write down time-dependent Schrödinger equation.

   d) What are semi-magic and double-magic number?

   e) What is the fundamental difference between the nature of electron-photon scattering in case of photoelectric effect and in case of Compton effect?

   f) In Michelson Interferometer experiment, it is found that for source S, as one of the mirrors is moved away from the equal path length position by a distance about 5 cm, the fringes disappear. What is the coherence time of the radiation coming out of the source?

   g) Find the energy of a 700 nm photon.

   h) What do you mean by Eigen function and Eigen value?

SECTION–II

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

   a) Find the de Broglie wavelength of 0.01 kg pellet having a velocity 10 m/s. Explain whether this wave character of the particle can be experimentally observed or not. Show that velocity of the particle is equal to the group velocity of the associated de Broglie wave. 2+1+2

   b) In the fission of a nucleus of mass number A_0 into the two nuclei A_1 and A_2, the energy release is $Q = M_0C^2 - M_1C^2 - M_2C^2$. Estimate Q for symmetric fission of a nucleus with A_0=240.

c) i) How does the uncertainty principle rule out the possibility of electron being inside the nucleus?

ii) What are the ground state angular momentum of the following nuclei as predicted by the Shell model?

$_{8}O^{17}$ and $_{16}S^{33}$ 3+(1+1)

d) Explain the lasing action of a typical three-level laser with proper energy level diagram.

SECTION–III

3. Answer any **one** of the following questions: 10×1=10

a) Calculate the transmission co-efficient (T) of a particle through a rectangular potential barrier to an energy less than the barrier height. Sketch the variation of T with energy. Apply the above result to explain α-decay of radioactive nucleus.

[Given potential function, $V(x) = 0, \quad \text{at } x < a$
$= V_0, \quad \text{at } 0 < x < a$
$= 0, \quad \text{at } x > a$]

6+2+2

b) i) Establish the Semi-empirical mass formula,

$$M(A, Z) = ZM_P + (A-Z)M_N - a_v A + a_s A^{\frac{2}{3}} + a_c \frac{z(z-1)}{A^{\frac{1}{3}}} + a_a \frac{(A-2z)^2}{A} \pm \frac{\delta}{A^{\frac{3}{4}}},$$

where symbols have their usual meaning.

ii) Calculate the binding energy in MeV of He^4 from the following data: 8+2

Mass of He^4 = 4.003875 u

Mass of H^1 = 1.008145 u

Mass of neutron = 1.008986 u.

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