

4/EH-24 (iv) (Syllabus-2020)

2 0 2 2

(May/June)

PHYSICS

(Elective/Honours)

**(Special Theory of Relativity,
Quantum Mechanics—I, Atomic Physics—I,
Nuclear Physics—I and Solid State Physics—I)**

[PHY04 (T)]

Marks : 56

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

Answer any eight questions

1. (a) State the fundamental postulates of the special theory of relativity. 2
- (b) A frame s' moves with respect to another frame s with a uniform velocity v . Derive transformation equations giving (x', y', z', t') in terms of (x, y, z, t) in Lorentz form; the moving frame coincides with the stationary one at $t' = t = 0$. Prove that when $v \ll c$, the velocity of light in vacuum, Lorentz transformations reduce to Galilean transformations. 4+1=5

(2)

2. (a) On the basis of Lorentz transformations, derive expressions for (i) length contraction and (ii) time dilation.

$$2\frac{1}{2} + 2\frac{1}{2} = 5$$

- (b) The half-life of a particular particle as measured in the laboratory comes out to be 4.0×10^{-8} s when its speed is $0.80c$ and 3.0×10^{-8} s when the speed is $0.60c$. Find its actual life-time.

2

3. (a) State and explain the Heisenberg's uncertainty principle.

2

- (b) Explain why free electrons cannot exist inside a nucleus.

3

- (c) "A beam of short wavelength gives accurately the position of a particle." Justify the statement.

2

4. (a) What is wave function of a moving particle? Give its physical significance.

$$1\frac{1}{2} + 1\frac{1}{2} = 3$$

- (b) Derive the one-dimensional time-dependent Schrödinger equation for a particle.

4

(3)

5. (a) Define excitation and ionization potentials of an atom.

$$1 + 1 = 2$$

- (b) Calculate the first excitation potential of hydrogen atom, given that its ionization potential is 13.6 eV.

2

- (c) Obtain an expression for the mean life of a radioactive sample.

3

6. (a) State Moseley's law and discuss the importance of the law.

$$1 + 1 = 2$$

- (b) What is Compton effect? Calculate the change in wavelength of the scattered X-ray beam in Compton scattering.

$$1 + 4 = 5$$

7. (a) What is artificial transmutation? What are the advantages of using neutrons as projectiles for effecting artificial transmutations? Give one example of (n, α) reactions.

$$1 + 1\frac{1}{2} + 1\frac{1}{2} = 4$$

- (b) What are nuclear reactions? Give the general scheme of a nuclear reaction. List the quantities that are conserved in a nuclear reaction.

$$1 + 1 + 1 = 3$$

8. (a) What is a nuclear reactor? What are the main elements of a nuclear reactor? 1+3=4
- (b) What is multiplication factor? Classify nuclear fission on the basis of this factor. 1+2=3
9. (a) What are cosmic rays? Distinguish between primary and secondary cosmic rays. 1+3=4
- (b) Give a broad classification of elementary particles. 3
10. (a) What are symmetry operations? Discuss any one of the symmetry operations. 1+2=3
- (b) Calculate the packing fraction of b.c.c. structure. 4
11. (a) What is band gap? Distinguish between semiconductors and insulators on the basis of the band gap. 2+2=4
- (b) What is Meissner effect? Show that a superconductor behaves as a perfect diamagnetic. 1+2=3

12. (a) What are Miller indices? Find the Miller indices of a plane having intercepts of $8a$, $4b$ and $2c$ on the \vec{a} , \vec{b} and \vec{c} axes respectively. 2+3=5
- (b) Explain primitive and unit cell. 1+1=2

★ ★ ★