

2021

PHYSICS

[HONOURS]

Paper : VIIA

Full Marks : 50

Time : 2 Hours

*The figures in the right-hand margin indicate marks.**Candidates are required to give their answers in their own words as far as practicable.*

1. Answer any **five** questions: $2 \times 5 = 10$
- What do you mean by nuclear magneton? How does it differ from Bohr magneton?
 - What is the energy of the γ -rays emitted in the β -decay of ${}_{13}^{28}\text{Al}$? Given $M({}_{13}^{28}\text{Al}) = 27.9819\text{u}$; $M({}_{14}^{28}\text{Si}) = 27.9769\text{u}$.
 - ${}_{8}^{212}\text{Po}$ α -particles have kinetic energy 8.776 MeV. Assuming the mass of the α -particle to be $6.67 \times 10^{-27}\text{kg}$. Calculate their velocity.
 - What is anti-particle? Give an example of an anti-particle which exist in nature.
 - What do you mean by 'soft' and 'hard' component of cosmic ray?

- Explain the causality and simultaneity in different inertial frames.
- What do you mean by "light cone"?
- A train moves at $0.8c$. A passenger fires a bullet which moves at $0.6c$ relative to the train. How fast does it move relative to the ground?

GROUP-A

(Nuclear & Particle Physics)

- Answer any **three** questions: $5 \times 3 = 15$
- Define mass defect and packing fraction. Derive the relation between packing fraction and binding energy of an atom ${}_Z X^A$. $2+3$
 - Write down the basic assumptions of the shell model for the nucleus. 2
 - Compare shell model and liquid drop model. 3
 - What apparent inconsistencies in β -decay did lead Pauli to propose a new particle called neutrino? What are its properties? How the neutrinos are detected? $2+2+1$
 - Define isotopic spin and strangeness quantum numbers. State whether below reactions are allowed and explain them by their conservation rules.

i) $\pi^- + n^0 \rightarrow \Sigma^- + k^0$

ii) $k^- + p \rightarrow \pi^+ + \Sigma^-$

iii) $\pi^- + p \rightarrow \Sigma^+ + k^-$ 2+3

6. What are secondary cosmic rays and what is their composition at sea level? Write down the general properties of cosmic rays and discuss the altitude effect. 2+1+2

Answer any **one** question: 10×1=10

7. a) Obtain Bethe-Weizsäcker semi-empirical mass formula clearly explaining the significances of the terms involved. 7

b) For odd A, there is a single mass parabola for each A and for even A, there are two mass parabolas for same A—why? 3

8. a) What is Geiger-Nuttal law and write down the importance of this law. 2+2

b) Using the relation $\log(\lambda) = 56.13 - 105.07/v$, calculate the half-life of ^{234}Th emitting α -particle of energy 7.33 MeV. 3

c) What are inverse β -decay and K-capture? 1 $\frac{1}{2}$ + 1 $\frac{1}{2}$

GROUP-B
(Relativity)

Answer any **one** question: 5×1=5

9. a) What do you mean by 'inertial frame'? State the principle of relativity. 1+1

b) What is Minkowski space? 1

c) Explain the 'space-like' and 'time-like' four vectors. 1+1

10. Derive the velocity addition theorem and prove that it can be written in the form of

$$\beta = \frac{\beta_1 + \beta_2}{1 + \beta_1 \beta_2} \text{ where } \beta_i = \frac{v_i}{c} \quad \text{3+2}$$

Answer any **one** question: 10×1=10

11. a) Deduce the Lorentz transformation formulae for \vec{E} and \vec{B} and prove that $\vec{E} \cdot \vec{B}$ is Lorentz invariant. 5+3

b) Prove that the four dimensional volume element $dx dy dz dt$ is invariant under Lorentz transformation. 2

12. a) Define "World Point" and "World line".

b) Deduce Einstein's mass-energy equivalence relation.

c) A relativistic particle of rest mass m_0 is moving with a kinetic energy T. Show that its de-Broglie wavelength is given by

$$\lambda = \frac{hc}{\sqrt{T(T + m_0 c^2)}} \quad \text{2+3+5}$$