

B.Sc. 6th Semester (Honours) Examination, 2022 (CBCS)

Subject: Physics

Paper:DSE-3:(6)

(Nuclear and Particle Physics)

Time: 3 Hours

Full Marks: 60

The figures in the margin indicate full marks.

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

Group-A

1. Answer any ten questions from the following: 2x10=20

- (a) Assuming the constancy of nuclear charge density show that radius of a nucleus is proportional to $A^{1/3}$ where A is mass number of the nucleus.
- (b) Mention two characteristics of nuclear force.
- (c) What is the Coulomb energy of the two protons in ${}^3_2\text{He}$ if they are separated by a nuclear radius R_0 ? (Here $R_0 = 1.4$ fm).
- (d) Explain the stability of magic nuclei using shell model.
- (e) α -particle emitted from ${}^{226}_{88}\text{Ra}$ has kinetic energy 4.7845 Mev. What is the recoil energy of daughter nucleus?.
- (f) Show that pair production cannot occur in empty space.
- (g) State whether the reaction ${}^{14}\text{N}(\alpha, p){}^{17}\text{O}$ is exothermic or endothermic. (Mass of ${}^{14}\text{N} = 14.00753$ u, mass of α -particle = 4.0026 u, mass of ${}^{17}\text{O} = 17.0045$ u and mass of proton = 1.00814 u)
- (h) A massive particle X in free space decays spontaneously into two photons. What will be the charge and spin of X?
- (i) What is Cerenkov radiation?
- (j) In a photoelectric effect experiment, ultraviolet light of wavelength 320 nm falls on the photocathode with work function of 2.1 eV. What will be the stopping potential?

- (k) Write one advantage and one disadvantage of linear accelerator.
- (l) Highly energetic electrons cannot be obtained in cyclotron. Why?
- (m) Write down the quark content of π^+ and Σ^- .
- (n) According to QCD what are the colours of quarks?
- (o) What is the particle X in the nuclear reaction ${}^{13}_6\text{C} + \nu_e \rightarrow {}^{13}_7\text{N} + X$? Mention the quantum number in support of your conclusion.

Group-B

2. Answer any four questions from the following: 5x4=20

- (a) What is the binding energy of a nucleus? Draw the curve of binding energy per nucleon against mass number of nuclei. Discuss the main features of the curve. 1+1+3
- (b) (i) Write two evidences for the shell structure of the nuclei.
 (ii) What is the origin of $p_{3/2}$ and $p_{1/2}$ nuclear energy levels in the shell model?
 (iii) The spin-parity of low lying levels of ${}^{13}_6\text{C}$ are $1/2^+$ for first excited state and $3/2^-$ for second excited state. Write down the configuration of these states. 2+1+2
- (c) (i) Draw the energy spectrum of β -decay. Explain the continuous spectra in β -decay.
 (ii) ${}^7_3\text{Li}$ and ${}^7_4\text{Be}$ have atomic masses 7.016005 u and 7.0160929 u. Which of them shows β -activity and of what type? (1+2)+2
- (d) (i) What is the necessity of quenching in the G-M counter? Describe the quenching process.
 (ii) Write down two advantageous of semiconductor detector over gas detectors. (1+2)+2
- (e) (i) Bethe-Bloch formula for interaction of charged particles with matter is not applicable for electrons. Give three reasons.
 (ii) Discuss the basic principle of neutron detector. 3+2
- (f) Obtain the expression of Q-value of the following reaction $a+X=Y+b$ in terms of kinetic energies of the product particles and the projectile. Show that exoergic reaction is possible even if the projectile has no kinetic energy. 4+1

Group-C

3. Answer any two questions from the following:

10x2=20

- (a) (i) Write down the similarity between a liquid drop and a nucleus.
(ii) Write down the bethe-Weizesacker formula for nuclear binding energy. Discuss the various terms in the formula.
(iii) Find the most stable isobar for a nuclide with mass number 25. ($a_c = 0.71\text{Mev}, a_a = 23.7\text{Mev}$). 2+(2+4)+2

- (b) (i) Briefly describe the working principle of a cyclotron with a schematic diagram.
(ii) Derive the frequency of voltage at resonance condition.
(iii) What is the energy to which protons can be accelerated in a cyclotron with dee of diameter 2 m and a magnetic field of flux density 0.72 Wb/m^2 . (Mass of proton = $1.673 \times 10^{-27} \text{ kg}$) 5+3+2

- (c) (i) Write down the relative strength and mediating particles in different types of interactions.
(ii) Mention the category (lepton, meson & baryon) of following particles: e^+ , Ξ^- , Σ^0 and K^0 .
(iii) Mentioning the quantum numbers of individual particles show that whether the z-component of isospin (I_3) and strangeness are conserved in following reactions:



- (d) (i) What is Compton effect? Obtain the expression of wavelength-shift in Compton scattering.
(ii) X-rays of wavelength 0.24 nm are Compton scattered and the scattered beam is observed at an angle of 60° relative to the incident beam. The Compton wavelength of the electron is 0.00243nm. Find the kinetic energy of scattered electrons in eV.
(iii) What is internal conversion? (1+4)+3+2

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(Biophysics)

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Group-A

1. Answer any ten questions from the following:

2x10=20

- (a) Write any two functions of Cell-wall.
- (b) What are the differences between Cell-wall and Cell- membrane?
- (c) What is Allometric scaling law?
- (d) Define cellular reproduction.
- (e) What are the main types of cellular reproductions?
- (f) What are the approximate sizes of typical proteins found in human body?
- (g) What is the size of a nucleic acid?
- (h) What type of energy is required to form bacterial cells?
- (i) Define DNA replication process.
- (j) What are the steps of protein replication?
- (k) What do you mean by transcription of DNA?
- (l) How many genes are there in a typical human cell?
- (m) What is the number of genes present in a RBC cell?
- (n) Define ecosystem .
- (o) What is a biosphere?

Group-B

2. Answer any four questions.

5x4=20

- (a) How the process of the exchange of energy with its environment occurs in a living cell? 5
- (b) Draw neat labeled diagram of any two very small genetic circuits. 5
- (c) What are the stages of RNA-Transcription process? 5
- (d) What is the structure and function of Mitochondria in a living cell? 5

- (e) Discuss briefly about molecular evolution. 5
- (f) Discuss any one model of Cellular Dynamics. 5

Group-C

3. Answer any two questions. 2×10=20

- (a) Define random walk. Discuss with proper derivation the process of random walk. 10
- (b) (i) Write a short note on Convergent Evolution.
(ii) Discuss briefly about Metabolic networks. 5+5
- (c) (i) What is genotype-phenotype map? Write its two applications
(ii) Draw the structure of a human brain indicating the main three parts. (3+2)+5
- (d) Draw the labeled diagram of a neuron. Explain the salient features of the prominent parts. 4+6