

**B.Sc. 6<sup>th</sup> 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  ${}_2^3He$  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)  $\alpha$ -particle emitted from  ${}_{88}^{226}Ra$  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  ${}^{14}N(\alpha, p){}^{17}O$  is exothermic or endothermic.  
(Mass of  ${}^{14}N=14.00753$  u, mass of  $\alpha$ -particle=4.0026 u, mass of  ${}^{17}O=17.0045$  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  $\pi^+$  and  $\Sigma^-$ .
- (n) According to QCD what are the colours of quarks?
- (o) What is the particle X in the nuclear reaction  ${}_{\text{6}}^{\text{13}}\text{C} + \nu_e \rightarrow {}_{\text{7}}^{\text{13}}\text{N} + \text{X}$ ? 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  ${}_{\text{6}}^{\text{13}}\text{C}$  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  $\beta$ -decay. Explain the continuous spectra in  $\beta$ -decay.  
(ii)  ${}_{\text{3}}^{\text{7}}\text{Li}$  and  ${}_{\text{4}}^{\text{7}}\text{Be}$  have atomic masses 7.016005 u and 7.0160929 u. Which of them shows  $\beta$ -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 advantages 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:**

$$10 \times 2 = 20$$

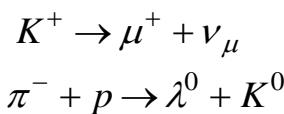
- (a) (i) Write down the similarity between a liquid drop and a nucleus.  
(ii) Write down the bethe-Weizesacker formula for nuclear binding energy. Discuss the various terms in the formula.  
(iii) Find the most stable isobar for a nuclide with mass number 25. ( $a_c = 0.71\text{Mev}$ ,  $a_a = 23.7\text{Mev}$ ). 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 a dee of diameter 2 m and a magnetic field of flux density  $0.72 \text{ Wb/m}^2$ . (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:  $e^+$ ,  $\Xi^-$ ,  $\Sigma^0$  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:



$$4+2+4$$

- (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  $60^0$  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

**B.Sc. 6<sup>th</sup> Semester (Honours) Examination, 2022 (CBCS)**  
**Subject: Physics**  
**Paper:DSE-3:(7)**  
**(Biophysics)**

**Time: 3 Hours**

**Full Marks: 60**

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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**

<b>3. Answer any two questions.</b>	<b>2×10=20</b>
(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 it's 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