BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: IMSc **SEMESTER : V**
BRANCH: PHYSICS **SESSION : MO/2024**

SUBJECT: PH318 INTRODUCTION TO NUCLEAR AND PARTICLE PHYSICS

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Find the expression for the binding energy of a nucleus of mass number A and atomic number Z based on the liquid drop model.	[5]	1	1,2
Q.1(b)	Using the semi-empirical mass formula, determine the mass difference between two "mirror nuclei" whose N and Z differ by 1 unit and both have the same odd mass number A.	[5]	1	3
Q.2(a)	Define Q-value for a nuclear reaction. Obtain the expression of (non-relativistic) Q-value for the reaction X(x, y)Y.	[5]	2	1,2
Q.2(b)	In a 2 step radio-active decay series: $P \rightarrow Q \rightarrow R$, where R is stable and the decay constants of parent (P) and daughter (Q) are λ_P and λ_Q respectively, prove that the daughter population (N_Q) maximizes at a time: $$t_{max} = \frac{log_e\left(\lambda_Q / \lambda_P\right)}{(\lambda_Q - \lambda_P)}$$	[5]	2	3,4
Q.3(a)	Explain the various mechanisms of energy loss for a heavy charged particle as it traverses through an amorphous monoatomic medium. Which mechanism is the dominant one ?	[5]	3	2
Q.3(b)	Define critical energy (E_c) in relation to an electromagnetic shower. Find the critical energy (E_c), Radiation length (L_{Rad}) and Molière radius (R_M) for Pb^{208} and Cu^{64}.	[5]	3	1
Q.4(a)	Explain the working of a Van-de-Graaf generator with diagram. What are the differences between cyclotron, synchrotron and synchro-cyclotron ?	[5]	4	1,2
Q.4(b)	Deutrons (^2H) are accelerated in a fixed frequency cyclotron to a maximum dee orbit radius of 88 cm. The magnetic field applied is 14000 Gauss. (i) Determine the energy of the emerging deutron beam (in MeV). (ii) Determine the frequency of the dee voltage (in Hz). (iii) What change in magnetic field (in Tesla) is necessary if alpha particles (^4He) are to be accelerated by this same cyclotron ? (Given: m(^2H) = 2.014102 a.m.u; m(^4He) = 4.002603 a.m.u; 1 a.m.u = 1.67 x 10^{-27} Kg)	[5]	4	3
Q.5(a)	Briefly describe the fundamental interactions/forces of nature. Classify the elementary particles of Standard Model and explain their basic properties (e.g. mass, charge, spin, ..etc).	[5]	5	1,2
Q.5(b)	Identify the forbidden reaction (if any) and state which conservation law(s) it violates: (i) $\Lambda^0 \rightarrow K^+ + K^-$ (ii) $\mu^- \rightarrow e^- + \overline{\nu_e} + \nu_\mu$	[5]	5	3

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