3 (Sem–6) PHY M1

2020

PHYSICS

(Major)

Paper : 6·1

(Nuclear Physics)

Full Marks : 60

Time : Three hours

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

1. Give short answers to the following questions : 1×7=7

   (a) Why do heavier nuclei tend to have larger neutron number to proton number ratio ?

   (b) Select the pairs of 'isobars' and 'isotones' from ${}_7N^{15}$, ${}_8O^{15}$, ${}_6C^{13}$, ${}_7N^{14}$.

(c) What is the unit of radioactivity which is defined as $3{\cdot}7 \times 10^{10}$ disintegrations per *sec* ?

(d) Explain why a single photon cannot be produced from the annihilation of electron and positron.

(e) What does form the basis for detection of nuclear radiation ?

(f) Why are the nuclei so small as compared to the atoms ?

(g) On what behaviour of nucleous, liquid drop model is based ?

2. Briefly answer the following questions : 2×4=8

(a) Calculate the nuclear radius of Te^{125}, if that of Al^{27} is 3·6 fermi.

(b) Why should anode-wire be thin in a proportional counter ?

(c) Calculate the energy released when three $_2He^4$ nuclei fuse to form a $_6C^{12}$ nucleus.

Given, $m\left(_2He^4\right) = 4{\cdot}002603\ a.m.u$.

(d) What is the reason for variation of cosmic ray intensities in the equatorial and polar region of earth ?

3. Answer ***any three*** of the following : 5×3=15

(a) (i) Name the factors required for the selection of a carrier gas in a gas-filled detector. 2

(ii) Draw a curve relating total ion-collection and applied voltage for gas-filled detector of electrical radiation, and identify the ionization, the proportional and the Geiger-Müller region. 3

(b) What is meant by self-sustained chain reaction ?

$200 MeV$ energy is released per fission of $_{92}U^{235}$ nucleus. What would be the mass of $_{92}U^{235}$ consumed per day in the fission reactor of power $1 MW$?

2+3=5

(c) How are range, velocity and energy of alpha particle related ?

How did Geiger and Nuttall arrived at an interesting conclusion relating range of alpha particle and half-life of alpha-emitter.

2+3=5

(d) Discuss how a high energy cosmic ray particle incident on the top of the atmosphere loses its energy in successive collisions as it propagates down producing own cascades.

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(e) Using semi-empirical mass formula, predict for what elements stable isobars should exist for *(i)* $A = 97$ *(ii)* $A = 80$

5

4. Answer ***any three*** of the following questions : 10×3=30

(a) An ion of charge 'q' and mass 'M' is accelerated using a cyclotron. If 'B' is the magnetic induction field and 'R' is the radius of the Dess, derive an expression for the final energy of the ion. Hence show that the radii of successive paths of the ion increase as '$N^{1/2}$' where 'N' is the number of accelerations. 7+3=10

(b) (i) Explain three terms of Bethe-Weizsäcker mass formula which contribute to the binding energy of a nucleus. 6

(ii) With the help of the curve drawn between binding energy per nucleon and mass numbers of different nuclei, explain in a qualitative manner the reason for alpha decay by heavy nuclei, also energy release in nuclear fission and nuclear fusion processes. 4

(c) Classify different types of nuclear reactions. Give an account of the experimental determination of Q-value of nuclear reaction.

Give the unit of nuclear reaction cross-section. 3+6+1=10

(d) Write short notes on ***any two*** of the following : 2×5=10

(i) Gamma rays and their origin

(ii) Nuclear stability

(iii) Pauli's neutrino hypothesis

(iv) Cosmic ray primaries

(v) Liquid drop model of nucleus.

(e) (i) What are magic numbers ? "There are strong reasons to believe that the nucleons in nuclei are arranged in certain discrete shells" — Explain with supporting evidences. 1+6=7

(ii) Distinguish between "liquid drop model" and "shell model" of nucleus. 3

(f) (i) Why is alpha-decay a classically forbidden phenomenon ?

Discuss quantum mechanical tunnel effects in a qualitative manner. 2+3=5

(ii) Describe a method for determination of the range of alpha particle. 3

(iii) What are nuclear energy levels ? 2
