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)* $A = 80$

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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.

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(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
