2020

PHYSICS — HONOURS

Paper : DSE-B-2

(Nuclear and Particle Physics)

Full Marks : 65

The figures in the margin indicate full marks.

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

Group - A

1. Answer ***any five*** questions : 2×5

(a) Find the distance of closest approach of 1 MeV proton incident on gold nucleus (z = 79) with zero impact parameter.

(b) What do you mean by 'charge independence' and 'charge symmetry' of nuclear force?

(c) Find the ground state spin parity of $_{12}Mg^{25}$.

(d) Explain why a Geiger Counter cannot measure the energy of moving charge particle.

(e) What are the limitations of a fixed frequency cyclotron?

(f) A hadron has a quark content ddu. Find the charge and strangeness of this hadron.

(g) Are the following processes allowed in strong interaction?

(i) $\pi^- + n \rightarrow \Sigma^- + K^o$

(ii) $\pi^- + p \rightarrow \wedge^o + K^o$.

Group - B

Answer ***any three*** questions. 5×3

2. The density of iron is 8×10^3 kg/m^3. The neutron capture cross-section of iron is 2.5 barn. What fraction of a normally incident neutron beam is absorbed by an iron sheet of 0.01 m thick? Explain the formula used. 3+2

3. (a) Calculate the minimum energy required to be given to the neutron in order that the following nuclear reaction may occur

$$_0n^1 + {}_{15}P^{31} \rightarrow {}_{14}Si^{30} + {}_1H^1$$

Given the masses (in a.m.u.)

$$M\left({}_0n^1\right) = 1.008665 \qquad M\left({}_{15}P^{31}\right) = 30.973766$$

$$M\left({}_{14}Si^{31}\right) = 30.975349 \qquad M\left({}_1H^1\right) = 1.007825$$

(b) What do you mean by thermal neutrons? Indicate their key role in nuclear reaction. 3+(1+1)

Please Turn Over

4. (a) Draw the characteristic curve of G.M. counter. Define threshold voltage.

(b) An organic quenched GM tube operates at 1000 V and has a wire having diameter 0.2 mm. The radius of the cathode is 2 cm. What is the maximum radial field? (2+1)+2

5. Explain working principle of semiconductor detector. What is the major advantage of this detector over others? 3+2

6. Explain why the following processes are not allowed. 2+2+1

(a) $p + \pi^o \rightarrow p^- + \pi^+ + \pi^-$

(b) $n \rightarrow p + e^-$

(c) $e^- \rightarrow \nu_e + \gamma$.

Group - C

Answer ***any four*** questions. 10×4

7. (a) Write down the Bethe-Weiszäcker formula for binding energy of a nucleas, explain all the terms therein.

(b) Exlain graphically how the binding energy per nucleon varies with mass number on an average, as a result of the various terms mentioned.

(c) What is meant by saturation of nuclear force?

(d) Show that $\gamma \rightarrow e^+ + e^-$ process cannot take place in vacuum. 3+3+1+3

8. (a) Define threshold energy and derive an expression for the threshold energy of an endoergic reaction.

(b) Write down an expression for the cross-section of a nuclear reaction, clearly explaining all the terms therein.

(c) A 0.01 mm thick $_3Li^4$ target is bombarded with 10^{13} protons per second. As a result 10^6 neutrons per second are produced. What would be the cross-section for the reaction?
(Density of $_3Li^4$ = 500 kg / m^3) (1+4)+2+3

9. (a) Derive the Bethe-Block formula for the energy loss of a moving charged particle inside a matter due to ionisation.

(b) Explain the Compton wavelength shift.

(c) Compute the maximum energy of the Compton recoil electrons resulting from the absorption of Al of 2.19 MeV γ-rays. 4+3+3

10. (a) What is the dead time of a GM counter? A GM counter has dead time of 200 μs. What are the true counting rates when the observed rates are 1000 per minute?

(b) Explain the basic principle of photomultiplier tube (PMT).

(c) What is scintillation process? Why is photomultiplier tube used in a scintilation detector? (2+2)+3+(1+2)

11. (a) Briefly explain the working principle of a cyclotron.

(b) Calculate the maximum energy of protons obtainable from a cyclotron having dees of diameter 1.2 m each and 1.5 T magnetic field. At what frequency must the cyclotron be operated? If the average energy gain per dee passage is 50 k_0V, how many revolutions do the proton make?

5+(2+1+2)

12. (a) What is meant by Eightfold way? Explain with referrence to the octate symmetry of particle physics.

(b) Define lepton number and baryon number. Write down the equation for muon decay. How is lepton number conserved in this process?

(c) The decay $\equiv^- \rightarrow \wedge^0 + \pi^-$ is observed in nature, whereas the apparently similar decay $\equiv^- \rightarrow n^0 + \pi^-$ is never observed. Why? (1+3)+(2+1+1)+2
