Total No. of printed pages = 12

63/2 (SEM-3) PHY 303,304(N/O)

2021

(held in 2022)

PHYSICS

(Theory Paper)

Paper Code : PHY-303 (NEW)

(Advanced Nuclear Physics–I)

Full Marks – 80

Time – Two hours

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

1. Choose the correct answer from the following : 1×5=5

(a) When a photon interacts with matter, pair production occurs if the energy E (in MeV) of the photon is

(i) $0.1 < E$ (ii) $0.1 < E < 10$

(iii) $E > 10$ (iv) None of the above

[Turn over

(b) In a typical range number-distance curve, the mean range is the thickness of the matter at which the number of particle absorbed is roughly

(a) 10 % (b) 1%

(c) 50% (d) 100%

(c) Which of the following statement is correct ?

(a) Λ is a baryon with positive charge.

(b) Intermediate vector bosons are composite in nature.

(c) *e*, μ and τ are known as mesons.

(d) Mesons and baryons are collectively known as hadrons.

(d) The range of electromagnetic force is

(a) $\leq 10^{-14}$ cm (b) $\leq 10^{-13}$ cm

(b) $\sim 10^{-5}$ cm (d) infinite

(e) Choose the particle with strangeness quantum number, s = 3 from the following

(i) $\bar{\Omega}^{+}$ (ii) Ξ^{-}

(iii) Ω^{-} (iv) Δ^{+}

2. Answer any *five* of the following : 2×5=10

(a) Neutron is chargeless but it has a non-zero magnetic moment. — Why ?

(b) What is Schmidt line ? Write its significance.

(c) What are the different modes of nuclear shape vibration ? What is the lowest possible mode of shape vibration ?

(d) Define Detector sensitivity. Mention on which factors does Detector sensitivity depend.

(e) What are Absolute efficiency and Intrinsic efficiency ?

(f) What are the role of magnetic field and electric field in a cyclotron ?

(g) Explain the consequences when heavy ions are used in cyclotron.

3. Answer any *five* of the following : 5×5=25

(a) Discuss the spin-parity of excited states of Te-120 nucleus in the light of vibrational model.

(b) Why parity in rotational model is assumed to be positive ? The first excited state of the rotational spectrum of the nucleus $^{238}_{92}U$ has an energy 45 KeV above the ground state. Calculate the energy (in KeV) of the second and third excited state. 1+4=5

(c) Why the lowest order of electric multipole moment that may arise from a non-spherical charge distribution is the electric quadrupole moment. With the help of single particle shell model calculate the quadrupole moment of $^{27}_{13}Al$.

(d) Write down the Bethe-Bloch equation and describe each term in details. Mention limitations of Bethe-Bloch formula. 4+1=5

(e) What do you mean by dead time of a detector? Discuss about the models of dead time detector. Why the concept of dead time is important in the context of particle detector. 1+3+1=5

(f) Write short note on Surface Barrier Detector. 5

(g) A fixed frequency cyclotron has an oscillation frequency of 12 MHz and a dee radius of 0.55 meter. It is used to accelerate deuterium, $m_d = 3.34245 \times 10^{-27}$ kg, and $e=1.6\times10^{-19}$ C. Calculate

(i) the Magnetic flux density

(ii) Energy to which deuterium is accelerated.

4. Answer any *four* of the following : 10×4=40

(a) Discuss how nuclear magnetic moment is calculated with the help of single particle shell model. Using single particle shell model calculate the nuclear magnetic moment of $^{13}_{6}C$ and $^{15}_{7}N$ and compare it with the experimental value : $\mu\left(^{13}_{6}C\right)_{exp} \sim 0.7\mu_N$; $\mu\left(^{15}_{7}N\right)_{exp} \sim -0.28\mu_N$. Discuss Schmidt's approach to calculate the magnetic moment of a nucleus by taking the example of $^{13}_{6}C$ and $^{15}_{7}N$. 2+4+4=10

(b) What are the different mechanisms by which a charged particle interacts when it passes through matter. Discuss the working of a scintillation counter and mention its advantages over other detectors. 4+6=10

(c) Write in detail the principle, working, and construction for Van de Graaff generator. Which type of particles can be accelerated using Van de Graaff generator ? 8+2=10

(d) Write in detail the principle, working and construction for the Betatron. How is the problem of "loss of resonance" resolved ? 8+2=10

(e) (i) A baryon X decays by strong interaction as $X \rightarrow \Sigma^+ + \pi^- + \pi^0$, where Σ^+ is a member of the isospin triplet $(\Sigma^+, \Sigma^0, \Sigma^-)$. What will be the third component of the isospin (I_3) of X ? 3

(ii) A particle is a composite state of three quarks u, d, and s. What will be the electric charge, spin and strangeness of the particle ? 3

(iii) Build up the structure of spin-1 mesons and spin 3/2 baryons in terms of quarks. 2+2=4

(f) (i) What is $\theta - \tau$ puzzle ? Discuss how Lee and Yang solved the mystery. 2+2=4

(ii) Describe C. S. Wu's experiment which lead to the discovery of parity violation in weak interaction. 6

(Theory Paper)

Paper Code : PHY-304 (OLD)

(Nuclear Physics–II)

Full Marks – 80

Time – Two hours

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1. Choose the correct answer from the following : 1×5=5

(a) When a photon interacts with matter, pair production occurs if the energy E (in MeV) of the photon is

(a) $0.1 < E$ (b) $0.1 < E < 10$

(c) $E > 10$ (d) None of the above

(b) In elastic scattering the incident particle after striking the target-nucleus leaves with

(i) less energy (ii) greater energy

(iii) same energy (iv) zero energy

(c) In nuclear reaction, the physical quantity, which is *not* conserved is

(i) total energy.

(ii) angular momentum.

(iii) charge.

(iv) electric quadrupole moment.

(d) Which of the following statement is correct ?

(a) A is a baryon with positive charge.

(b) Intermediate vector bosons are composite in nature.

(c) e, μ, and τ are known as mesons.

(d) Mesons and baryons are collectively known as hadrons.

(e) Choose the particle with strangeness quantum number, $s = 3$ from the following :

(i) $\bar{\Omega}^+$ (ii) Ξ^-

(iii) Ω^- (iv) Δ^+

2. Answer any *five* of the following : 2×5=10

(a) Neutron is chargeless but it has a non-zero magnetic moment. — Why ?

(b) What is Schmidt line ? Write its significance.

(c) What are the different modes of nuclear shape vibration ? What is the lowest possible mode of shape vibration ?

(d) What are Absolute efficiency and Intrinsic efficiency ?

(e) What are Stripping and Pick-up reactions ? Give one example of each.

(f) What is the necessity of nuclear collective models ?

3. Answer any *five* of the following questions : 5×5=25

(a) Write the success and failure of single particle shell model.

(b) Discuss the spin-parity of excited states of Te-120 nucleus in the light of vibrational model.

(c) Why parity in rotational model is assumed to be positive ? The first excited state of the rotational spectrum of the nucleus $^{238}_{92}U$ has an energy 45 KeV above the ground state. Calculate the energy (in KeV) of the second and third excited state. 1+4=5

(d) Why the lowest order of electric multipole moment that may arise from a non-spherical charge distribution is the electric quadrupole moment ? With the help of single particle shell model calculate the quadrupole moment of $^{27}_{13}Al$.

(e) Write down the Bethe-Bloch equation and describe each term in details. Mention limitations of Bethe-Bloch formula. 4+1=5

(f) What do you mean by dead time of a detector ? Discuss about the models of dead time detector. Why the concept of dead time is important in the context of particle detector ? 1+3+1=5

(g) Write short note on Surface Barrier Detector. 5

4. Answer any *four* of the following : 10×4=40

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(c) (i) A baryon X decays by strong interaction as $X \rightarrow \Sigma^+ + \pi^- + \pi^0$, where Σ^+ is a member of the isospin triplet (Σ^+, Σ^0, Σ^-). What will be the third component of the isospin (I_3) of X ? 3

(ii) A particle is a composite state of three quarks u, d, and s. What will be the electric charge, spin and strangeness of the particle ? 3

(iii) Build up the structure of spin-1 mesons and spin 3/2 baryons in terms of quarks. 2+2=4

(d) (i) What do you mean by nuclear reaction ? Explain briefly different types of nuclear reactions with example. 1+5=6

(ii) Discuss the mechanism of formation of compound nucleus. 4

(e) Write short notes on any *two* : 5+5=10

(i) G.M counter

(ii) Multi-wire proportional chambers

(iii)Multi-Channel Analyzer (MCA).