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63/2 (SEM-3) PHY 303

2022

(Held in 2023)

PHYSICS

(Theory Paper)

Paper Code : PHY-303

(Advanced Nuclear Physics – I)

Full Marks – 80

Pass Marks – 32

Time – Three hours

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

1. Choose the correct answers : 1×5=5

(a) Which of the following statement(s) is/are correct ?

(i) Λ is a baryon with zero charge.

(ii) Intermediate vector bosons are fundamental in nature.

(iii) e, μ, and τ are known as mesons.

(iv) Mesons and baryons are collectively known as leptons.

[Turn over

(b) Nuclear reaction cross-section has the dimension of

(i) velocity (ii) area

(iii) angular momentum (iv) energy

(c) Choose the particle(s) with strangeness quantum number, $s = 0$ from the following

(i) Ω^{-+} (ii) π^-

(iii) Ω^- (iv) Δ^+

(d) To avoid large dead time effects

(i) the counting rate of the detector must be sufficiently low

(ii) the counting rate of the detector must be sufficiently high

(iii) detection should be done at high temperature

(iv) detection should be done at low temperature

(e) In a betatron, electrons can gain energy during the _____ of the applied external AC field.

(i) first half cycle

(ii) first quarter cycle

(iii) second half

(iv) full cycle

2. Answer *all* the following questions : 2×5=10

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

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

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

(d) Define range of a charged particle. What do you mean by range straggling ?

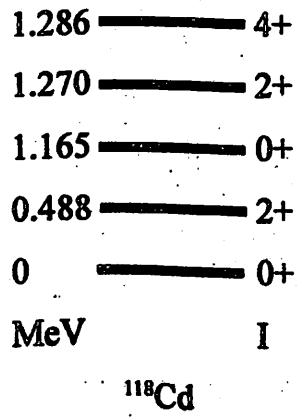
(e) Which factors limit the performance of cyclotron ?

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

(a) Why parity in rotational model is assumed to be positive ? The first excited state of the rotational spectrum of the nucleus $^{238}_{94}Pu$ has an energy 44 KeV above the ground state. Calculate the energy (in KeV) of the third and fourth excited state. 1+4=5

(b) What is CPT theorem ? Discuss the implications of CPT theorem and CP violation. 1+3+1=5

(c) Discuss the spin-parity of excited states of Cd-118 nucleus (shown below) in the light of vibrational model. 5



^{118}Cd

(d) Tabulate all the quarks in terms of its mass, charge, baryon number, isospin, and strangeness. 5

(e) Write the Bethe-Bloch formula for stopping power. Discuss about density and shell corrections in Bethe-Bloch formula. Mention the limitations of Bethe-Bloch formula. 1+3+1=5

(f) The r.f. potential applied between the dees of a cyclotron is 50 Kilovolts and magnetic field of 1.6 Tesla. Dee radius is 0.55 meter. It is used to accelerate proton ($m_p = 1.67\times10^{-27}$ kg and $e = 1.6\times10^{-19}$ C).

(i) Calculate the energy acquired by protons in this cyclotron.

(ii) Number of revolutions these protons make in attaining this energy.

(iii) Calculate the frequency and wavelength. 5

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

(a) (i) Write any two success of nuclear shell model. With examples show that the extreme single particle shell model cannot explain the spin-parity of the excited state nuclei. 1+4=5

(ii) 'The lowest order of electric multipole moment that may arise from a non-spherical charge distribution is the electric quadrupole moment' – Justify the statement. With the help of single particle shell model calculate the quadrupole moment of $^{41}_{20}Ca$. 2+3=5

(b) 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 : $\mu(^{13}_{6}C)_{exp} \sim 0.7\mu_N$; $\mu(^{15}_{7}N)_{exp} \sim -0.28\mu_N$. With the help of Schmidt's approach derive the expression for magnetic moment of odd-A nuclei. Also discuss how the CN Catastrophe was resolved by Schmidt's approach. 2+6+2=10

(c) (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

(d) (i) Draw a block diagram and explain the principle of pulse production in a Scintillation counter. 5

(ii) Discuss about the detection characteristics of semiconductors. 5

(e) 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

(f) Explain in detail the working of electron synchrotron. How does its working differ from proton synchrotron ? 8+2=10