Raj BVR

Dr. SP

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MANIPAL UNIVERSITY, MANIPAL

FOURTH SEMESTER M.Sc. [Physics]
END SEMESTER EXAMINATION, MAY, 2016

SUBJECT: NUCLEAR PHYSICS-II

PHY-706.6

Time: 3 Hours **Max. Marks : 50**

Note:

- **Answer any FIVE Full questions**
- **Missing data, if any may suitably be assumed.**

1. (a) Assuming a central square well potential to the deuteron and extending the calculations for the ground state to the case where the orbital angular momentum is greater than zero $(l \neq 0)$, show that deuteron cannot exist in these states.

   (b) Assume the S-state of the deuteron to arise from a spherical square well potential of width 2.4 fm and depth V_0 If the binding energy of the deuteron is 2.226 MeV, calculate the depth of the potential, assuming that $V_0 >> 2.226$MeV. (6 +4 =10)

2. (a) Give an account of effective range theory of n-p scattering at low energies and show that the scattering cross section besides being a function of energy depends upon the scattering length and effective range.

   (b) 1.5 MeV neutrons are scattered on a target. The angular distribution of neutrons in the center of mass is found to be isotropic and the total cross section is measured to be 0.1b. Using the partial wave representation, calculate the phase shifts of the partial waves involved. [Use $mc^2 = 940$ MeV, $(hc/2\pi) = 197.3$Mev-fm]

   (6+4 =10)

3. (a) Discuss the basic features of the nuclear shell model including the effects of spin-orbit coupling. (b) Predict the ground state spins and parities of the following nuclei using the shell model. (i) ${}_8O^{15}$ (ii) ${}_8O^{19}$ (iii) ${}_9F^{17}$ (iv) ${}_{20}Ca^{41}$ (6+4 =10)

4. (a)Derive Breit- Weigner formula for reaction cross section. (b)From this obtain expressions for elastic and inelastic scattering cross sections. (c)How these gets modified near resonance? (5+3+2=10)

5. (a) Mention the evidences for the collective motion of nucleons in the nucleus. (b)Discuss the collective vibration of the nucleons within a nucleus.

   (3+7=10)

6. (a) What are direct reactions? Explain the types of direct reactions.

   (b) Distinguish between Compound Nuclear model and direct reaction model.

   (5+5=10)

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(1) ${}_8O^{15} \rightarrow J^\pi = \frac{1}{2}^-$ (2) ${}_8O^{19}$ $J^\pi = \frac{5}{2}^+$ (3) ${}_9F^{17}$ $J^\pi = \frac{5}{2}^+$

(4) ${}_{20}Ca^{41}$ $J^\pi = \frac{7}{2}^-$

General Data:

1 unified mass unit (u) = 931.5 MeV/c^2

Planck's constant h = 6.63 x 10^{-34} Js

Boltzmann's constant k = 1.38 x 10^{-23} JK^{-1}

Avogadro's number = 6.022 x 10^{23} (g-mole)$^{-1}$

Permittivity constant ε_o = 8.85 x 10^{-12} Fm^{-1}

Fundamental charge unit e = 1.60 x 10^{-19} C

speed of light (vacuum) c = 3.0 x 10^8 m/s

electron mass = 9.11 x 10^{-31} kg = 5.4858 x 10^{-4} u = 0.511 MeV/c^2

neutron mass = 1.6749 x 10^{-27} kg = 1.008665 u = 939.573 MeV/c^2

proton mass = 1.6726 x 10^{-27} kg = 1.0072765 u = 938.280 MeV/c^2

1 year = 3.156 x 10^7 s

1(b) $V_0 = \frac{\pi^2\hbar^2}{4Mr_0^2} = \frac{(3.14)^2(1.0545\times10^{-31})^2}{4(1.67\times10^{-27})(2.4\times10^{-15})^2\times(1.6\times10^{-13})}$ MeV $\simeq$ 36 MeV

2(b) for s-wave scattering $l = 0$ $\sigma = \frac{4\pi\sin^2\delta}{k^2}$, $k^2\hbar^2 = p^2 = 2mE$

$\sin^2\delta_0 = \frac{2mE\sigma}{4\pi\hbar^2} = \frac{2mc^2E\sigma}{4\pi^2\hbar^2c^2}$ $mc^2 = 940$ MeV $E = 1.5$ MeV, $\sigma = 0.1b = 10^{-25} cm^2 = 10 fm^2$

$\hbar c = 197.3$ MeV

on substitution we get $\sin^2\delta_0 = 0.1$ $\sin\delta_0 = 0.2$ or $\delta^0 = 13.9$