
PHYH-C IX: ELEMENTS OF MODERN PHYSICS
Department of Physics, Hooghly Women's College

Semester - IV
Assignment - 4, Marks: 25

Today: April 28, 2019
Submit on: 8th May, 2019

Answer all the questions

1. The mean momentum \bar{p} of a nucleon in a nucleus of mass number A and atomic number Z depends on A , Z as

(A) $\bar{p} \propto A^{1/3}$ (B) $\bar{p} \propto Z^{1/3}$ (C) $\bar{p} \propto A^{-1/3}$ (D) $\bar{p} \propto (AZ)^{-2/3}$

JAM-2018; Marks: 2

2. For an atomic nucleus with atomic number Z and mass number A , which of the following is/are correct?

- (A) Nuclear matter and nuclear charge are distributed identically in the nuclear volume.
(B) Nuclei with $Z > 83$ and $A > 209$ emit α - radiation
(C) The surface contribution to the binding energy is proportional to $A^{2/3}$
(D) β - decay occurs when the proton to neutron ratio is large, but not when it is small.

JAM 2017; Marks: 2

3. For a proton to capture an electron to form a neutron and a neutrino (assumed massless) the electron must have some minimum energy. For such an electron find the de Broglie wavelength in picometers. (Specify your answer to two digits after the decimal points)

JAM 2017; Marks: 2

4. Plot Binding energy per nucleon with respect to mass number of nuclei.

A nucleus has a size of 10^{-15} m. Consider an electron bound within a nucleus. The estimated energy of this electron is of the order of

(A) 1 MeV (B) 10^2 MeV (C) 10^4 MeV (D) 10^6 MeV

JAM 2015 ; Marks: 1+1 = 2

5. Consider the nucleons are bound within a harmonic potential trap. (i) Write down the form of energy of the nucleons in that bound state. (ii) Express the energy in terms of principal quantum number (n) and angular momentum quantum number (l). (iii) Comment about the degeneracy (Hint: degeneracy meaning same energy but different values of quantum numbers, i.e., different states!). (iv) Plot the discrete energy level diagram for different n and l values.

Marks: 1+1+1+2=5

6. Let us come back to the above problem again. Due to spin-orbit coupling ($\vec{L} \cdot \vec{S}$) each energy level is split into two sub-levels depending on their j values. Thus $j = l + 1/2$ and $j = l - 1/2$ have different energy values. (higher j value has lower energy, opposite to the atomic cases.) Using this information, plot the energy levels and sub-levels and show how the magic numbers 2, 8, 20, 28, 50 etc are coming.

Marks: 6

7. Using shell model of nucleus, draw schematic diagram of ground state of (a) $^{15}_8\text{O}$ (b) $^{39}_{19}\text{K}$ and (c) $^{20}_{10}\text{Ne}$. Then show that total ground-state angular momentum for the Oxygen, Potassium and Neon is $J = 1/2$, $J = 3/2$ and $J = 0$ respectively.

Marks: 3 x 2 = 6