Tutorial 3:

- Shell model of the nucleus – successes and limitations;

Q1:

(b) Write down the nucleonic configuration of, ^{7}Li, ^{12}C, ^{17}O and ^{27}Al in the ground state of the nuclear shell model and hence calculate the corresponding ground state angular momenta and parities. How do the observed ground state angular momenta and parities agree with those predicted on the basis of shell model ?

(c) State the quantum numbers L, Y and S for the [illegible] 10

2013

Q2:

What are the magic numbers in nuclei ? List the experimental evidences indicating their existence. 20

2014

Q3:

Stable light nuclei have equal number of protons and neutrons, whereas heavy nuclei have excess of neutrons. Explain why. 10

2014, 2019

Q4:

(i) How does liquid drop model explain fission ? 10

(ii) What are the limitations of shell model ? 10

2014

Q4:

State the basic assumption of single particle shell model. How do the centrifugal and spin-orbit terms remove the degeneracy of a three-dimensional spherical harmonic oscillator ? *10+15=25*

2016

Q5:

Show that in the nuclear shell model, the level spacing between major oscillator shells is approximately $\hbar\omega = 41\ A^{-1/3}$ MeV. *15*

2016, 2021

Q6:

Predict the spin and parity of ground states of the following nuclei on the basis of shell model : *10*

(i) ${}_{8}O^{15}$

(ii) ${}_{8}O^{16}$

(iii) ${}_{17}Cl^{38}$

2016

Q7:

Obtain an expression for the magnetic moment of a nucleus having one nucleon outside the closed core. Use this to calculate the magnetic moment of ${}_{8}O^{17}$ nucleus. 20

2018

Q8:

Given that the single particle energy separation between $1d_{5/2}$ and $1d_{3/2}$ in ${}^{17}O$ is 5 MeV. Calculate the strength of spin-orbit interaction. It is observed that $1d_{5/2}$ level is lower than $1d_{3/2}$ level. 15

2019

Q9:

(i) Explain the origin of the nuclear magnetic moment. Deduce expression for the magnetic dipole moment with the help of the Schmidt single particle model. 10

(ii) For a system consisting of one proton and one neutron (not necessarily a deuteron), write down the various possible states specifying clearly its isospin, spin and orbital quantum numbers. 10

2019

Q10:

Draw a schematic diagram of the single particle energy levels in a shell model including the effect of spin-orbit coupling. Show how it explains magic numbers in nuclei. Give two examples to show how this scheme predicts the spins and particles of odd A nuclei. 20

2017

Q11:

Show that for a specific value (n, l), there exists a large degeneracy relative to the energy characterized by the quantum number (N). Find the shell closures and the magic numbers predicted by harmonic oscillator potential. 15

2022

Q12.

The total binding energies of $^{15}_{8}O$, $^{16}_{8}O$ and $^{17}_{8}O$ are 111·96 MeV, 127·62 MeV and 131·76 MeV respectively. Determine the energy gap between $1p_{1/2}$ and $1d_{5/2}$ neutron shells for the nuclide whose mass number is close to 16. 15

2025

Q13.

State the basic assumption of single-particle shell model. How do the centrifugal and spin-orbit terms remove the degeneracy of three-dimensional spherical harmonic oscillator? 10+10=20

2025