Merits of the Shell Models:-

a) Periodicity of Nuclear Properties:-

The numerous discontinuities in nuclear properties as stability, binding energy, abundance in nature, neutrons absorption cross section etc. at magic number of neutrons or protons, an explanation on the basis of shell closures occuring at the magic number of nucleons.

b) Prediction of Total Angular momentum (spin), Parity and Magnetic momentum of a nucleus.

Odd-A nuclei: The spin and parity of odd-A nuclei are determined by j and l values of the odd nucleons respectively.
These values of nucleons are imparted to the nucleus as a whole.
In a large number of cases, the shell models correctly predicted the spin and parity of odd A nuclides.

(c) Correlation of nuclear isomerism with magic number:-

If the number of long-lived isomers ($T>1s$) in case of odd A nuclides is plotted versus the odd ~~electron~~ proton or neutrons numbers, islands of isomer occurs i.e. they tend to concentrate between two magic numbers and the number of such isomers sharply falls to zero at the magic number itself and the

isomers start reappearing as the next shell is about half full.
Nuclear isomerism appears when two neighbours energy levels in a nucleus have a large difference in spin so that the transition becomes highly forbidden. The γ- transitions in general are well explained as shell model.

d) Electric Quadrupole Moment:-

As we know there is a strong correlation between the electric quadrupole moment of a nucleus and the proton, or neutron magic numbers.

The electric quadrupole moment has highest positive value when the last shell is about two-thirds full, and the value drops as the shell fills up, become zero at the magic number when the shell closes, and goes to negative value in shells with a few nucleons in the next incomplete shell

As the new shells begins to fill in, the value rises again, crosses to reach a maximum positive value when the shell is two-thirds full to start the next cycle.

The Liquid Drop Model:-

→ Statistical model developed by Niels Bohr and Wheeler and independently by Frankel.

→ The model does not considers the motion of indivisual nucleons and treats the nucleus as a homogenous entity consisting of a certain numbers of protons and neutrons as in an ideal solution, each nucleon interacting strongly with all its neighbours.

→ The interaction force involved is assumed to be short range one tending to saturation as the number of nucleons increases.

It was further assumed that the interaction force is independent of charge and spin and hence, the energy of interaction amongst the nucleons is a continuous function of the mass of the nucleus and hence of the total number of nucleons present.

⇒ Analogy with a liquid drop:

The model is based on certain similarities between the nucleus and the drop of a liquid. Following are some of the similarities:-

① A liquid drop and an atomic nucleus both have large number of particles, molecules or atoms in the case of liquid drop and protons and neutrons in the case of a nucleus.

(2) Both the liquid drop and the nucleus are incompressible and homogenous.
Density, charge and all other properties are same throughout the drop and nucleus, except only at the surface boundary. This implies that nuclear volume $\propto$ mass $\propto A$.

The nuclear radius is given by

$$R = r_0 A^{1/3}$$

where r_0 is constant of the order 1.2 - 1.5 F.

(3) The liquid drop model considers ~~that~~ that as an ideal solution, the force between all the nucleons is same i.e.

$$f_{n-n} \approx f_{n-p} \approx f_{p-p}$$

i.e. nuclear force is charge and spin independent.

The binding energy of a pair of mirror nuclei is nearly the same i.e. the replacement of p-p-force by n-n force does not affect the total binding energy significantly.

(4) The nucleons interaction being only with the neighbours, the nuclear force is a short range one and hence it saturates, the interaction energy being proportional to A.
If nucleons interacted with neighbours as well as every other nucleon, the energy would be proportional to $A(A-1) \approx A^2$, as like Coulomb interactions between protons in a nucleus.

5) Analogous to the drop of liquid the atomic nucleus also displays surface tension force proportional to the surface area of nucleus, hence to $A^{2/3}$.

6) If the liquid drop or the nucleus is invaded by a high energy particle from the outside, the particle is captured with the formation of a compound nucleus.
The excess energy of the captured particle is rapidly shared by all the particles in the drops or the nucleons in the nucleus.
The time for this process of thermalization of energy in the case of compound nucleus is of the order of $10^{-21} - 10^{-17}$ sec. depending upon the velocity of incoming nucleon.

7) Deexcitation of the drop or the compound nucleus may occur by one of the following processes, depending upon the energy of excitation.

Drop	Compound nucleus
(a) by cooling i.e. by radiating the heat away.	(a) by emission of radiation.
(b) by evaporation of some particles	(b) by emission of nucleon(s)
(c) For high excitation, by the rupture of the drop into the droplets.	(c) by nuclear fission into the two nuclei.

Merits of a liquid drop model :-

→ It provides a satisfactory explaination for the behaviour of nuclei in excited states. (unlike the shell model which applies to the nuclei in the ground state). Besides providing plausible mechanisms of most lower energy nuclear radiation and explaining the phenomena of nuclear fission.

The liquid drop model provides the basis of equation of weizsacker for calculating the binding energy of nuclei and hence their atomic masses.

The equation for this semi empirical mass can be given as

$$m({}^{A}_{Z}X) = Zm_H + Nm_n - \Delta m$$

Here m_H is mass of a H-atom = 1.007825 u
≈ (mass of proton + mass of electron),

m_n → mass of neutron (= 1.008665 u)

Δm total loss in the mass in the ~~system~~ o synthesis of atom.

Since the total binding energy of atom
$B = 931 \Delta m$ MeV

The value of z and N can be calculated according.