T.D.C. Part III^rd ; Chem (Hons)
Paper VI ! unit(IV) Nuclear Chemistry

(3) Theory of Packing fraction :-

It was given by Aston. It expressed the variation of isotopic mass from whole number in terms of packing fraction. It may be defined as —

$$\text{Packing fraction} = \frac{\text{isotopic mass} - \text{mass no.}}{\text{mass no.}} \times 10^4$$

pfs value may be -ve or +ve.

Consequences :-

(i) Zero value of packing fraction is found in monisotropic elements (having no isotope) and in those cases ~~isotopic mass~~ whose isotopic mass is equal to mass no. e.g. C^{12}.

(ii) -ve value of Packing fraction indicates that there is mass defect hence binding energy. such nuclei are assumed to be stable.

(iii) elements having +ve value of Packing fraction are unstable under going fission or fussion process.

e.g. $_1H^1$ → has (+ve) Packing fraction undergoes fusion.

$_{92}U^{235}$ → " " " " " " fission.

He, O, and C has low packing fraction and hence stable.

Note :- The above generalizations are not hard and fast.

8. Calculate Packing fraction, mass defect and energy released in the formation of Argon atom if its mass at isotope of Ar = 39.962384 amu.

Soln

No of p in Ar atom = 18

" " n " " " = 40-18 = 22

" " e_s " " " = 18.

$$\text{Packing fraction} = \frac{\text{Isotopic mass} - \text{Mass no.}}{\text{mass no.}} \times 10^4$$

$$= \frac{39.962384 - 40}{40} \times 10^4$$

$$= -9.4025.$$

Expected mass (M') = $18 \times 1.007825 \times 22 \times 1.008665$

$= 40.33148$

Actual mass (M) = 39.962384

$\therefore$ mass defect $\Delta m = M' - M$

$= 40.33148 - 39.962384$

$= 0.369096$ amu.

$\therefore$ B.E $= \Delta m \times 931.5$ MeV

$= 0.369096 \times 931.5 = 343.813$

(4) ~~Plesson~~ Pleson Theory of Nuclear forces :→ The force holding the nucleons in the nucleus is called nuclear force which operates only in the range of 0.1 fermi. These are short range forces. These forces do not follow the inverse sq. law. The exact nature of the nucleur forces is not well understood. These forces are believed to be associated with the interconversion of protons and neutons.

Hideki Yukawa (Japan) in 1935, suggested that another fundamental particle ~~to be called~~ which is called meson, oscillates between neighbouring nucleons with a velocity close to that of light. Mesons are three types - neutral, +ve and -ve. They interact with protons and neutons as a result of which a p may change into a neutron and a neutron may change into a p, for a part of the time. This may be represented as below →

$$ {}_1p^1 + {}_{-1}\pi^0 \rightleftharpoons {}_0n^1 $$

$$ {}_0n^1 + {}_1\pi^0 \rightleftharpoons {}_1p^1 $$

Plesons form glue for nucleons. This result in an attraction between neutron and protons.

Neutral π mesons also help to create the force between like particles.

$p_1 \rightleftharpoons p_2 + \pi^0$ or $p_1 + \pi^0 \rightleftharpoons p_2$

$n_1 \rightleftharpoons n_2 + \pi^0$ or $n_1 + \pi \rightleftharpoons n_2$

Note:- How the exchange of meson between two nucleons leads to attractive forces may be understood by a simple analogy in which the two nucleons are considered as two dogs and the meson as a piece of bone which each of them is trying to snatch from the other? In the scuffle, the bone is rapidly exchanged between the two dogs. Since neither of them is prepared to part with the bone, the latter keeps the two dogs ~~bond~~ bound together.

Hideki Yukawa (Japan) in 1935 ~~suggested that~~ explained real nature of nuclear force. He proposed that nucleons are surrounded by charged π meson i.e. $\pi^0 + \pi$ mesons interconverted the protons and neutrons.

$$_1p^1 + {}_{+1}\pi^0 \rightleftharpoons {}_0n^1$$

$$_0n^1 + {}_{+1}\pi^0 \rightleftharpoons {}_1p^1$$

(5) Shell model of nucleus :-

Nucleons try to be paired in the nucleus, in order to achieve stability. Pair. moment of two paired protons spining in opposite direction cancel each other and creates attractive force to bind them.

Odd no. of protons and neutrons is most unstable combination. on the other hand even no. of protons and neutrons is stable combination.

Magic Numbers :→

elements having 2, 8, 20, 28, 50, 82 and 126 protons or neutrons. stable abundand with greater no. of isotopes. These nos. are called magic number.

e.g., $_{82}Pb^{208}$ → 82 ps, 126 ns both are magic no., hence it is stable.

$_{92}U^{235}$ → 143 ns (unstable) undergo disintegration.

Unstable nuclei disintegrate to give α, β, γ rays in order to achieve magic no. and become radioactive.