Investigations on the possible isotopes of superheavy elements in the atomic number range 110≤ Z≤126 and their synthesis

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Introduction

How many elements exist in the nature or what is the heaviest element has been an intriguing question since the periodic table was proposed for the chemical elements. Until now, the heaviest element that exist in nature is with atomic number Z=92 and heaviest synthesised element with Z=118. These elements must be synthesised using fusion reactions such as cold and hot fusion reactions [1]. Many experimental attempts were observed in order to synthesize the superheavy element Z=119 and Z=120 with the cross section in the order of fb. However all these fusion reactions are failed to confirm the production of the superheavy element. Hence it is important to identify the possible isotopes in the super-heavy region and possible projectile-target combination to synthesize the superheavy element in the range 110≤Z≤126. An effort was also made to construct a semi empirical formulae for barrier position and barrier height, one and two proton separation energy and fusion fission cross sections in the superheavy region.

Theoretical Frame work

The dominant decay of the superheavy element in the region range110≤Z≤126 is identified by studying different decay modes such as cluster radioactivity, alpha-decay and spontaneous fission (SF) [2-5] using different models available in literature. Again the possible projectile target combinations to synthesize superheavy element is identified by the study of compound nucleus probability, survival probability and evaporation residue cross sections [5]. The role of an entrance channel effects were also studied for different projectile-target combination [6].

Results and Discussions:

The semi-empirical formulae in the superheavy region for the fusion barrier height (V_B), fusion barrier position (R_B) and inverted parabola ($\hbar\omega$) within the atomic number range 104≤Z≤130 has been proposed [7]. The parameterization of nucleon separation energy with in the atomic and mass number range 104 ≤Z ≤ 118 and 253≤A≤295 has been studied. Finally, a semi-empirical formulae for fusion fission cross sections [8] estimates the cross sections with good accuracy.

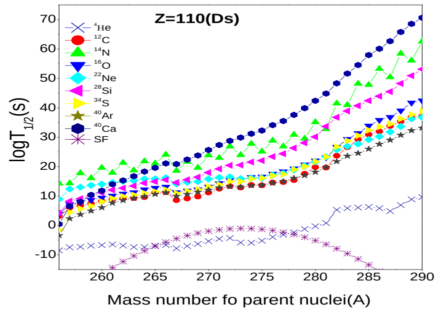

Fig 1: Variation of $\log T_{1/2}$ for different decay modes with mass number of SHE Z=110.

The dominant decay mode is studied using the theory as explained in the literature [9]. The figure 1 shows the variation of $\log T_{1/2}$ with that of mass number of parent nuclei. From this figure it is observed that half-lives for SF is smaller than the other decay modes for the nuclei ^{256}Ds to ^{265}Ds and ^{281}Ds to ^{300}Ds . It is also observed that the α-decay half-lives of $^{266-280}$Ds is shorter when compared to other decay modes. Hence, α-decay is dominating decay mode in the region ^{266}Ds to ^{280}Ds. Similarly, the identified possible isotopes to synthesize superheavy element in the region 118≤Z≤126 and it is shown in the figure 2. Furthermore, the possible projectile-target combinations in the superheavy region is identified by the study of compound nucleus probability, survival probability and evaporation residue cross sections [4]. The predicted projectile-target combinations to synthesize superheavy element in the region 118≤Z≤126 is in detail explained in literature [4] and it is shown in figure 3.

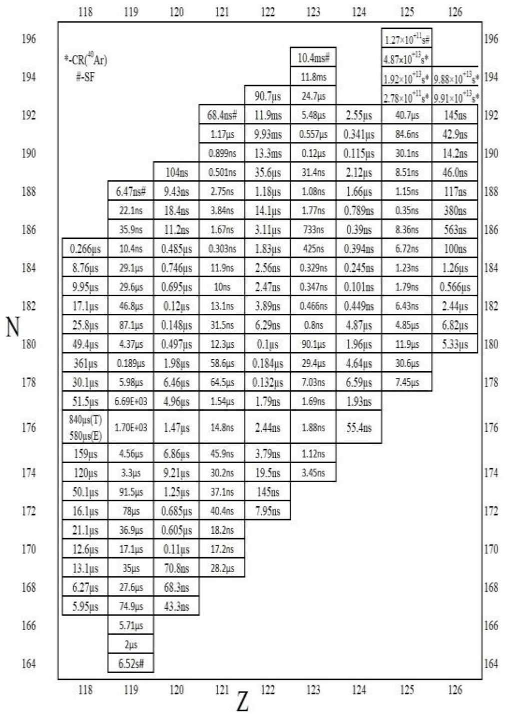

Figure 2: The predicted new isotopes in the superheavy region 118≤Z≤126. Isotopes with no symbol represents alpha decay half-lives.

The most predicted projectile-target combination for the synthesis of SHE Z=110 are Ni+Pb, Mg+Cf and Al+Bk. The possible P-T combination of the synthesis of Z=118 to 126 are shown in figure 3. The predicted σ_{ER} are in the order of pb to fb. In order to overcome the difficulties in-occurred during the synthesis of SHE, the predicted P-T combinations may be the solution to synthesize the SHE 118≤Z≤126. The predicted P-T combinations may extend the periodic table for Z ≥118.

Conclusions:

Constructed a semi em0pirical formulae for barrier position and barrier height, one and two proton separation energy and fusion fission cross sections. The possible decay modes have been studied in the superheavy region 118≤Z≤126. The values obtained from present work is compared with the ELDM and semi-empirical relation. The comparison of different decay modes enables to identify the possible isotopes during the synthesis of SHN. These identified isotopes are having half-lives of μs to ms and are in detectable range. The predicted P-T combinations in the synthesis of SHE 118≤Z≤126 produces the σ_{ER} in the order of pb to μb. In order to overcome the difficulties in-occurred during the synthesis of SHE, the predicted P-T combinations may be the solution to synthesize the SHE 118≤Z≤126.

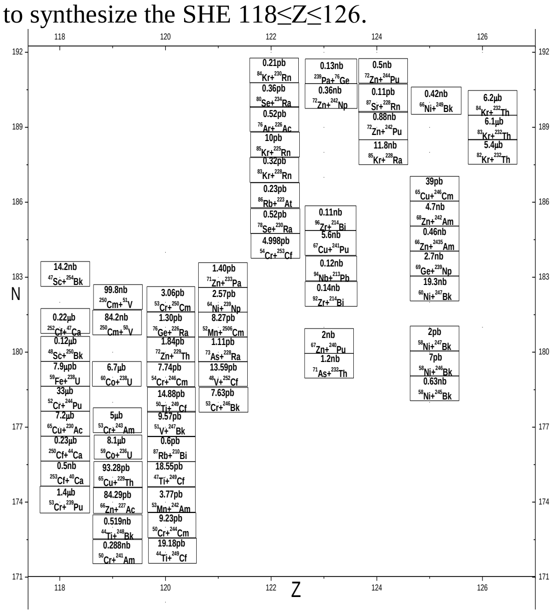

Figure 3: Chart of suitable P-T combination to synthesize the SHE 118 ≤Z ≤126.

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