Cluster radioactivity in superheavy nuclei Z=124

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Introduction

Cluster radioactivity of superheavy elements plays an important role in the identification and synthesis of superheavy elements. In 1984 Rose and Jones [1] for the first time observed emission of ^{14}C nucleus from ^{223}Ra.Warda, et al., [2] studied cluster radioactivity in heavy and superheavy nuclei. Zachary Matheson, et al., [3] studied alpha decay properties and cluster emission in Z=118. Zhang and Wang [4] studied cluster radioactivity in the superheavy region Z=118, 120 and 122. Previous workers [5-7] studied different decay modes in superheavy nuclei Z= 122, 124 and 126. Using unified fission model and preformed cluster model [8-10] studied cluster radioactivity in actinides. From the literature studies it is clearly observed that, the study on cluster radioactivity in the superheavy region is required for the synthesis of the superheavy element and also the possible decay mode for the same. Hence in the present work we have studied cluster radioactivity of ^{27}Al, ^{36}Ar, ^{9}Be, ^{40}Ca, ^{42}Ca, ^{43}Ca, ^{44}Ca, ^{46}Ca, ^{35}Cl, ^{4}He, ^{39}K, ^{41}K, ^{6}Li, ^{24}Mg, ^{25}Mg, ^{23}Na, ^{20}Ne, ^{22}Ne, ^{32}S, ^{33}S, ^{34}S, ^{28}Si, ^{29}Si and ^{30}Si in the superheavy nuclei Z=124 and also identified possible decay mode.

Theory:

The total interacting potential is the sum of coulomb potential, proximity potential and centrifugal force and it is given as follows;

$$V(R)=V_N(R)+V_C(R)+\frac{l(l+1)\hbar^2}{2\mu\times R^2} \qquad (1)$$

We have studied the total potential of the superheavy nuclei Z=124 as explained in previous work [9]. Using WKB approximation, we have studied penetration probability and half-lives of the superheavy element Z=124. The barrier penetration probability given by

$$P=\exp\left\{-\frac{2}{\hbar}\int_{R_a}^{R_b}\sqrt{2\mu(V_T(r)-Q)}\,dr\right\} \qquad (2)$$

where μ is the reduced mass fission fragments of cluster decay system, R_a and R_b are the initial and final turning points. The half-lives of cluster decay is studied using the relation,

$$T_{1/2}=\frac{\ln 2}{\lambda}=\frac{\ln 2}{\upsilon P} \qquad (3)$$

where $\upsilon=\frac{\omega}{2\pi}=\frac{2E_\upsilon}{h}$ represent assaults frequency and λ is the decay constant. E_v is the empirical vibration energy.

Results and discussions:

The amount of energy released during cluster decay is given by;

$$Q=\Delta M(A,Z)-\sum_{i}^{n}\Delta M(A_i,Z_i) \qquad (4)$$

where *ΔM(A,Z)* and *ΔM(A$_i$,Z$_i$)* are mass excess of the parent and for (i=1,2) for daughter nuclei and and cluster nuclei respectively. The amount of energy released (Q in MeV) of a parent nuclei against different decay modes are studied using mass excess values [12]. Where ever experimental values are not available we have used the theoretical values available in the literature [13-15]. We have studied cluster radioactivity by calculating driving potential, penetration probability and half-lives in the superheavy nuclei Z=124. The driving potential is the diffrence between total potential and the amount of energy released. The variation of energy released and logarithemic half-lives with the mass number of cluster nuclei are as shown in figure 1. From the figure it is observed that as mass number of cluster increases the amount of energy released and logarithemic half-lives also increases. The variation logarithemic half-lives of cluster decay such as (^{27}Al, ^{36}Ar, ^{9}Be, ^{40}Ca, ^{42}Ca, ^{43}Ca, ^{44}Ca, ^{46}Ca, ^{35}Cl, ^{4}He, ^{39}K, ^{41}K, ^{6}Li, ^{24}Mg, ^{25}Mg, ^{23}Na, ^{20}Ne, ^{22}Ne, ^{32}S, ^{33}S, ^{34}S, ^{28}Si, ^{29}Si and ^{30}Si) are shown in figure 2. The figure 2 depicts that the loagrithemic half-lives of 4He is less compared to all other cluster decay modes.

Fig. 1: The variation of energy released and logarithemic half-lives with the mass number of cluster nuclei.

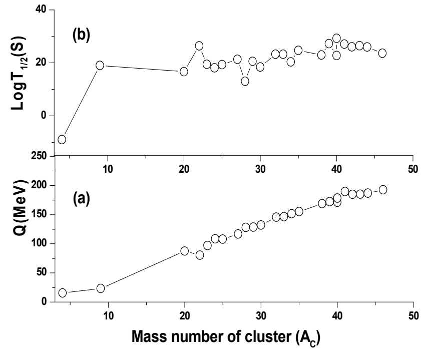
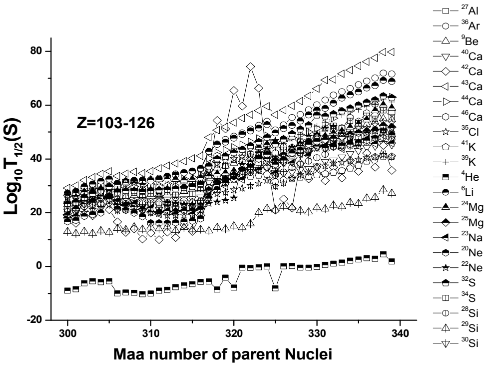


Fig. 2: The variation of logarithemic half-lives with mass number of parent nuclei.



Conclusions:

To summarize our work, we have studied the driving potential, penetration probability and cluster decay (^{27}Al, ^{36}Ar, ^{9}Be, ^{40}Ca, ^{42}Ca, ^{43}Ca, ^{44}Ca, ^{46}Ca, ^{35}Cl, ^{4}He, ^{39}K, ^{41}K, ^{6}Li, ^{24}Mg, ^{25}Mg, ^{23}Na, ^{20}Ne, ^{22}Ne, ^{32}S, ^{33}S, ^{34}S, ^{28}Si, ^{29}Si and ^{30}Si) half-lives of superheavy nuclei Z=124. From the study of cluster decay half-lives, we observed that alpha decay half-lives are smaller compared to other exotic decay modes. Hence the SHE Z=124 undergoes alpha decay only.

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