Decay channels of Superheavy nuclei ^{298}119

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Introduction:

Superheavy elements, those with atomic numbers significantly higher than those occurring naturally, exhibit various decay modes due to their extreme instability [1]. These elements, synthesized in laboratories, undergo processes like alpha decay, where they emit helium nuclei (alpha particles), and beta decay, which involves the emission of electrons (beta particles) or positrons [2].

Spontaneous fission is another common decay mode, causing the nucleus to split into two smaller fragments. Cluster decay is relatively rare [3], where the nucleus emits small clusters of nucleons. Electron capture can occur, converting a proton into a neutron by capturing an inner-shell electron. Additionally, spontaneous alpha-emission and neutron emission can occasionally take place [4]. The specific decay modes and rates vary based on the element's atomic number and nuclear properties. Understanding these decay modes [5] is vital for unraveling the behavior of superheavy elements, shedding light on nuclear physics, and extending our knowledge of matter's fundamental forces. In addition many experiments were failed to synthesize the superheavy element Z=119. Hence, this motivated us to investigate decay modes of superheavy nuclei ^{298}119.

In the presented work, we focused on decay modes like heavy particle radioactivity, cluster emission and evaluated the Q value [6] of the reaction and their half-lives of ^{298}119.

Theoretical Frame work

The logarithmic half-lives are calculated using the following equation [7];

$$T_{1/2} = \frac{\ln 2}{\lambda} \tag{1}$$

Where, $\lambda = \nu_o P$, $\nu_o = 10^{-20} s^{-1}$ called assault frequency and P is penetration probability, it is evaluated by

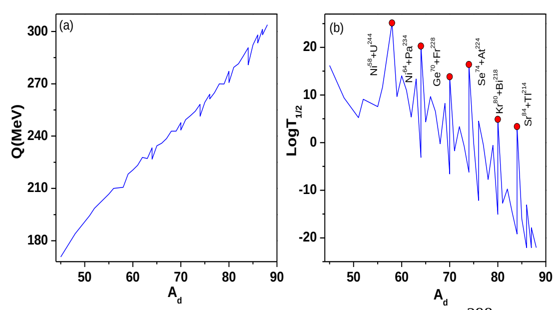
$$P = \exp\left[-\frac{2}{h}\int_{R_{in}}^{R_{out}} \sqrt{2B(r)E(r) - E(sphere)}\,dr\right] \tag{2}$$

and Q value of the reaction is given by

$$Q = m_p - (m_1 + m_2) \tag{3}$$

Where m_p is the mass of the parent nuclei and m_1, m_2 are the masses of the fission fragments.

Results and Discussions:



Decay modes of superheavy element ^{298}119 evaluated by Modified Generalized Liquid Drop

Fig-1: (a) A plot of decay energy of heavy particle radioactivity and (b) logarithmic half-lives as a function of mass number of daughter nuclei.

Model (MGLDM) [8]. The variation of Q value and logarithmic half-lives of heavy particle radioactivity with mass number of the daughter nuclei as shown in the figure 1. Q value shows linear increase with A_d as shown in layer (a) of figure 1. Logarithmic half-lives with A_d show peaks because of the daughter nuclei consists of magic numbers or semi magic numbers or double magic numbers.

Further, we investigated decay chain for ^{298}199, firstly it undergo α-decay, β+, α-decay and finally end up with spontaneous fission. The corresponding decay chain with half-lives is represented in the figure 2.

We also studied the cluster emission of ^{298}119. Decay mode, Q value and corresponding logarithmic half-lives of the emitted clusters are tabulated in the Table 1. From this table it is concluded that ^{298}119 firstly undergo α-decay and its half-life is found to be 2μs.

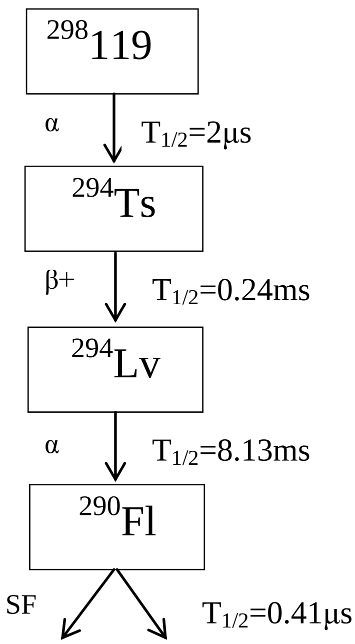


Fig 2: Decay chain for ^{298}119 [9].

Table 1: Calculated decay modes with Q value and corresponding half-lives for ^{298}119.

Decay mode	Q(MeV)	$LogT_{1/2}$
α	12.50	-6.83
Li^{6}	9.46	33.37
Be^{9}	19.60	21.80
Ne^{20}	71.63	23.72
Ne^{21}	72.46	22.64
Ne^{22}	77.07	15.28
Na^{23}	82.62	21.08
Mg^{24}	89.79	23.68
Mg^{25}	91.38	21.57
Mg^{26}	97.12	13.44
Al^{27}	101.52	19.97
Si^{28}	107.94	23.10
Si^{29}	110.5	19.86
Si^{30}	114.52	14.45
P^{31}	117.39	22.05
S^{32}	120.86	28.21
S^{33}	124.49	23.81
S^{34}	129.97	17.04
Ca^{46}	174.63	0.70
SF	-	9.37

Conclusions

The decay modes of ^{298}119 have been studied using Modified generalized liquid drop model. Q value of the reaction increases with mass number of the daughter nuclei. The peaks in the half-lives verses mass number of daughter nuclei indicates more stable than their neighbors. The decay chain for ^{298}119 was studied and that concludes ^{298}119 undergo firstly α-decay with a half-life of 2μs.

Finally cluster emitters with Q value and Logarithmic half-lives are tabulated in Table 1. These results help to know the reasons for failure to synthesis the compound nucleus 119.

References:

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