In [3]:
```python
# Question 3

import numpy as np

M_Po = 218.00897
M_Bi = 216.0063
M_D = 2.0141

Q = (M_Po - M_Bi - M_D) * 931.494 # MeV

print('Q =', np.round(Q, decimals=2), 'MeV')
print('Since Q < 0, polonium will not spontaneously decay by deuteron emission.')
```

```
Q = -10.65 MeV
Since Q < 0, polonium will not spontaneously decay by deuteron emission.
```

In [4]:
```python
import numpy as np

"alpha decay half lives of the following process:"
" 222 86 Rn -> 218 84 Po + 4 2 He "

"fission half life of the following process:"
" 241 95 Am -> 233 91 Pa + 8 4 Be"

def half(M_p, M_d, M_a, Z_a, Z_d):

    c_sq = 931.494 # MeV / u
    r_0 = 1.5 # fm
    hbar = 197.33 # MeV / fm
    e_sq = 1.44 # elementary charge - MeV fm

    Q = (M_p - M_d - M_a) * c_sq # MeV

    R = r_0 * (M_p)**(1/3)
    b = (Z_a * Z_d * e_sq) / Q
    M_0 = (M_a * M_d * c_sq) / (M_a + M_d) # reduced mass


    cos_inv = (np.arccos(np.sqrt(R / b)) - np.sqrt((R / b) * (1 - (R / b))))
    gamma = 4 * np.sqrt(2 * M_0) * (1 / (137)) * (Z_d / np.sqrt(Q)) * cos_inv


    V_in = np.sqrt((2 * Q) / M_0) * (2.99e8) * 1e15 # m /s * fm/m
    decay = (V_in / (2 * R)) * np.exp(- gamma) # (fm / s) / fm

    t_half = np.log(2) / decay

    half_life = np.round(t_half/ (60 * 60 * 24), decimals=2)

    return half_life


Radon_decay = half(222.01758, 218.00897, 4.00260, 2, 84)
Americium_decay = half(241.0568, 233.0402, 8.0053, 4, 91)

print("Half life of Radon Alpha Decay:", Radon_decay, "days")
print("Half life of Americium Fission:", np.round(Americium_decay / 365, decimals=2), "years")
```

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Half life of Radon Alpha Decay: 2.59 days
Half life of Americium Fission: 497.52 years
```

In [ ]: