

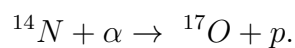
Homework 01

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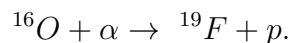
The nuclear reaction in the experiment where Rutherford observed protons is



According to the mass of proton and each atom, the energy of α should above

$$M(^{17}\text{O}) + M(p) - M(^{14}\text{N}) - M(\alpha) = 1.279 \times 10^{-3}\text{amu}.$$

Now, consider this nuclear reaction



The energy of α in this case should above

$$M(^{19}\text{F}) + M(p) - M(^{16}\text{O}) - M(\alpha) = 8.711 \times 10^{-3}\text{amu}$$

which is much higher than that in the case of N_2 gas. This is why Rutherford observed protons with N_2 gas instead of O_2 . To observe proton with O_2 gas, the energy needed of α is

$$8.711 \times 10^{-3}\text{amu} \approx 8.134\text{MeV}$$

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The rest mass of proton is $M_0(p)$

$$E_0(p) = M_0(p)c^2 = 9.4085 \times 10^2\text{MeV}$$

The Total energy of the proton is

$$E(p) = \nu M_0(p)c^2 = E_0(p) + 5.7\text{MeV} = 9.4655 \times 10^2\text{MeV}$$

where

$$\begin{aligned}\nu &= \frac{1}{\sqrt{1 - (v/c)^2}} = 1.00606 \\ \Rightarrow v &= 0.32878 \times 10^8\text{m/s}\end{aligned}$$

where v is the velocity of the outgoing proton. And the momentum of the proton is

$$P(p) = \nu M_0(p)v$$

We suppose that the deflection angle of the γ -ray is π . In this case, we obtain the minimum energy of the γ -ray:

$$E(\gamma) = \frac{P(p)}{2}c = 8.29885 \times 10^{-12}\text{J} \approx 51.868\text{MeV}$$

according to the conservation of momentum.