

## C N O - Cycle

$$\Leftrightarrow \begin{array}{l} p^6.n^6.e^{-6} = p^6.n^6.e^{-6} \quad v^6.v^{-6} \quad / 60 / \\ (p.e^{-}).(p^6.n^6.e^{-6} = p^6.n^6.e^{-7}).(p.e^{-}). \quad v^8.v^{-8} \quad / 67 / \\ p \quad . \quad p^6.n^6.e^{-6} = p^7.n^6.e^{-7} \quad . \quad \underline{e^+.v.v^-} \quad v^7.v^{-7} \quad / 67 / \end{array}$$

The opening state :  $p + {}^{12}\text{C}_6 \rightarrow {}^{13}\text{N}_7 + \underline{\gamma} \Downarrow$  / 67 / +1,95MeV

$$\begin{array}{l} \underline{e^- . v . v^-} . p \quad . \quad p^6.n^6.e^{-6} = p^7.n^6.e^{-7} \quad . \quad v^7.v^{-7} \\ v . v . v^- . e^- \quad . \quad \underline{v^- . p} \quad . \quad p^6.n^6.e^{-6} = p^7.n^6.e^{-7} \quad . \quad v^6.v^{-6} \quad / 67 / \\ v . v^- . e^- \quad . \quad \underline{e^+ . n} \Downarrow \quad . \quad p^6.n^6.e^{-6} = p^7.n^6.e^{-7} \quad . \quad v^6.v^{-6} \quad \Downarrow / 69 / \\ \underline{v . v^- . e^-} \quad . \quad e^+ . v \quad . \quad p^6.n^7.e^{-6} = p^7.n^6.e^{-7} \quad . \quad v^6.v^{-6} \end{array}$$

$\Downarrow \gamma^* + e^+ + v + {}^{13}\text{C}_6 \leftarrow {}^{13}\text{N}_7$  / 69 /

$$\begin{array}{l} (p).(v.v^- . e^- \quad e^+ . v \quad . \quad p^6.n^7.e^{-6} = p^7.n^6.e^{-7}) . (n . e^+ . v) \quad v^6.v^{-6} \quad \Downarrow / 74 / \Leftrightarrow \\ p \quad . \quad p^6.n^7.e^{-6} = p^7.n^6.e^{-7} \quad . \quad n . e^+ . v \quad . \quad v^7.v^{-7} . e^- . e^+ . v^- / 74 / \\ p \quad . \quad p^6.n^7.e^{-6} = p^7.n^7.e^{-7} \quad . \quad . e^+ . [v^8 . v^{-8} . e^- . e^+] \quad / 74 / \\ \text{after annihilation} \\ p \quad . \quad p^6.n^7.e^{-6} = p^7.n^7.e^{-7} \quad . \quad . e^+ . [v . v^- \quad v^6.v^{-6} \quad ] \quad / 72 / \Uparrow \\ p \quad . \quad p^6.n^7.e^{-6} = p^7.n^7.e^{-7} \quad . \quad . \underline{e^+ . v . v^-} \quad v^6.v^{-6} \end{array}$$

$p + {}^{13}\text{C}_6 \rightarrow {}^{14}\text{N}_7 + \underline{\gamma} \Downarrow$  + 7,5 MeV

$$\Leftrightarrow (p.e^{-}).(e^- . v . v^- \quad p \quad . \quad p^6.n^7.e^{-6} = p^7.n^7.e^{-7}) . (p . e^+ . v^2 . v^{-2}) . v^6.v^{-6} \quad / 79 / \Downarrow \\ \begin{array}{l} e^+ . v . v^- \quad . \quad p^8.n^7.e^{-8} = p^7.n^7.e^{-7} \quad . \quad p \quad . \quad \underline{v^8.v^{-8}} \quad / 79 / \\ \underline{e^+ . v . v^-} \quad . \quad p^8.n^7.e^{-8} = p^7.n^7.e^{-7} \quad . \quad p \quad . \quad v^8.v^{-8} \quad / 79 / \end{array}$$

$\Downarrow \gamma + {}^{15}\text{O}_8 \leftarrow {}^{14}\text{N}_7 + p$  / 79 / + 7,35 MeV

$$\begin{array}{l} p^8.n^7.e^{-8} = p^7.n^7.e^{-7} \quad . \quad \underline{p . v^- . v} \quad . \quad e^- . v^8.v^{-8} \quad / 79 / \\ p^8.n^7.e^{-8} = p^7.n^7.e^{-7} \quad . \quad \underline{\Downarrow n . e^+} \quad . \quad / 81 / \Downarrow \\ p^8.n^7.e^{-8} = p^7.n^8.e^{-7} \quad . \quad e^+ . v . e^- . v . v^- \quad . \quad v^7.v^{-7} / 81 / \end{array}$$

${}^{15}\text{O}_8 \rightarrow {}^{15}\text{N}_7 + e^+ + v + \underline{\gamma^*} \Downarrow$

$$\begin{array}{l} (n . e^+ . v) . ( \Leftrightarrow \quad p^8.n^7.e^{-8} = p^7.n^8.e^{-7}) . (p) . e^+ . v \quad . \quad e^- . v . v^- \quad . \quad v^7.v^{-7} / 86 / \Downarrow \\ (n . e^+ . v) . (e^- . v^- \quad . e^+ . v . v^- \quad . \quad p^8.n^7.e^{-8} = p^7.n^8.e^{-7}) . (p) . \quad v^7.v^{-7} / 86 / \\ n \square . e^+ \quad . e^- \quad . \quad e^+ \quad . \quad \underline{v^2 . v^{-2}} \quad . \quad p^8.n^7.e^{-8} = p^7.n^8.e^{-7} \quad . \quad p \quad . \quad v^7.v^{-7} / 86 / \\ e^+ \quad . e^- \quad . \quad e^+ \quad . \quad v^2 . v^{-2} \quad . \quad p^8.n^8.e^{-8} = p^7.n^8.e^{-7} \quad . \quad p \quad . \quad v^7.v^{-7} / 86 / \\ [e^+ \quad . e^- . v . v^-] . e^+ . v . v^- \quad . \quad p^8.n^8.e^{-8} = p^7.n^8.e^{-7} \quad . \quad p \quad . \quad v^7.v^{-7} / 84 / \Uparrow \\ \text{annihilation} \end{array}$$

$$\begin{array}{l} \underline{v . v^-} \quad . \quad e^+ \quad . \quad p^8.n^8.e^{-8} = p^7.n^8.e^{-7} \quad . \quad p \quad . \quad v^7.v^{-7} / 84 / \\ \Downarrow \underline{\gamma} \quad . \quad p^2.n^2.e^{-2} \quad . \quad p^6.n^6.e^{-6} = p^7.n^8.e^{-7} \quad . \quad p \quad . \quad v^7.v^{-7} / 84 / \end{array}$$

$\gamma + {}^4\text{He}_2 + {}^{12}\text{C}_6 \leftarrow {}^{15}\text{N}_7 + p$  + 4,96 MeV