Hydrogen → Helium Fusion

4 protons → 1 Helium Nucleus + energy.
(^4He = 2p & 2n)

a.) mass of $^4He = 6.64 \times 10^{-27}$ kg

mass of proton $= 1.67 \times 10^{-27}$ kg

Note: $4m_p > m_{He}$, the difference is converted to energy.

mass difference, $\Delta = 4m_p - m_{He}$

$= 4.0 \times 10^{-29}$ kg.

$\therefore$ Energy, $E = mc^2 = \Delta c^2$

$= \underline{3.6 \times 10^{-12}\ J}$.

So, the fusion of 4 protons → ^4He releases 3.6×10^{-12} J. Note, not all of the mass is converted to energy.

b.) $M_{H_2O} = 1$ kg, molecular mass, $m_{H_2O} \sim 18u$
mass of Hydrogen atom $m_H \sim 1u$

So, water is $\sim \frac{1}{9}$ hydrogen by mass

So, amount of hydrogen in jug, $M_H \sim \frac{1}{9}$ kg

Number of hydrogen atoms, $N = \frac{M_H}{m_p} = 6.6 \times 10^{25}$

For $4H \rightarrow {}^4He$, the number of fusion, $N_f = \frac{N}{4}$

and each fusion releases, $E = 3.6 \times 10^{-12}$ J

So, the total released energy is

$$E_{released} = \left(\frac{N}{4}\right)E = \underline{6 \times 10^{13} \text{ J}}$$

Energy used in US in 2010 ~ 1×10^{20} J.

So, we would need $\frac{E_{US}}{E_{rel,\,per\,jug}}$

~ 1.6 million jugs of water to power the US for one year!