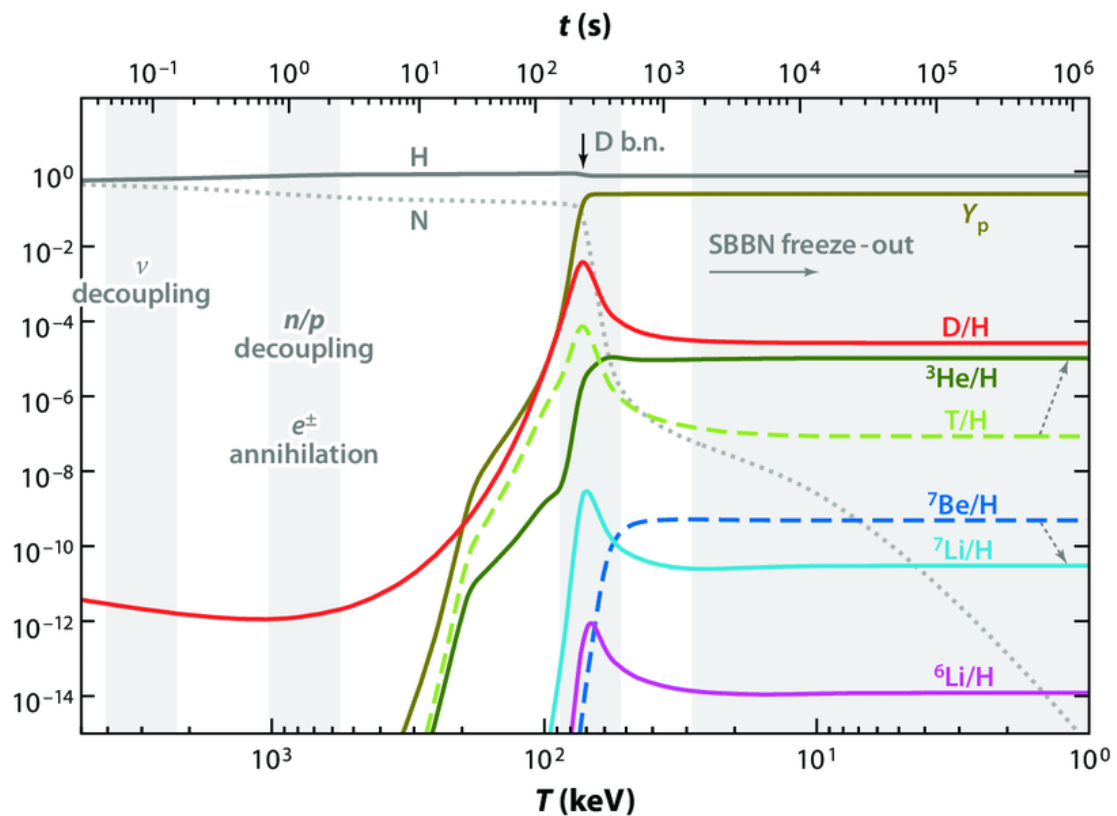


# Question 1

Find the graph about the mass fractions of isotopes in the Big Bang Nucleosynthesis (BBN). Try to explain what you found.

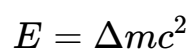


source: [https://www.researchgate.net/publication/262004321\\_S-factor\\_measurement\\_of\\_the\\_2Halpha6Li\\_reaction\\_at\\_energies\\_relevant\\_for\\_Big-Bang\\_nucleosynthesis](https://www.researchgate.net/publication/262004321_S-factor_measurement_of_the_2Halpha6Li_reaction_at_energies_relevant_for_Big-Bang_nucleosynthesis)

在宇宙形成初期，氫逐漸合成其他元素如  ${}^2\text{H}$ 、 ${}^3\text{H}$ 、 ${}^3\text{He}$  等等輕元素，在並在後續的反應中形成  ${}^7\text{Li}$ 、 ${}^7\text{Be}$ 、 ${}^8\text{Be}$  等等較重的元素



Find the rest mass of protons, electrons and hydrogens. Use what you found to calculate the binding energy of a hydrogen (13.6 eV).



element	mass(kg)	source
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element	mass(kg)	source
$m_H$	$1.007825031898(Da)$ $= 1.6735237 \cdot 10^{-27}(kg)$	<a href="https://en.wikipedia.org/wiki/Isotopes_of_hydrogen">https://en.wikipedia.org/wiki/Isotopes_of_hydrogen</a>
$m_p$	$1.67262 \cdot 10^{-27}(kg)$	<a href="https://www.britannica.com/science/proton-subatomic-particle">https://www.britannica.com/science/proton-subatomic-particle</a>
$m_e$	$9.109 \cdot 10^{-31}(kg)$	<a href="https://en.wikipedia.org/wiki/Electron_mass">https://en.wikipedia.org/wiki/Electron_mass</a>

$$\begin{aligned}
 \Delta m &= 1.6735 \cdot 10^{-27} - (1.6726 \cdot 10^{-27} + 9.109 \cdot 10^{-31})(kg) = -1.09 \cdot 10^{-32}(kg) \\
 &= -1.09 \cdot 10^{-32}(kg) \times (3 \cdot 10^8)^2(J/kg) = -9.81 \cdot 10^{-16}(J) \\
 &= \frac{-9.81 \cdot 10^{-16}(J)}{(1.602 \cdot 10^{-19})(J/eV)} = -6123.6(eV)
 \end{aligned}$$

Da to Kg: <https://www.unitconverters.net/weight-and-mass/dalton-to-kilogram.htm>