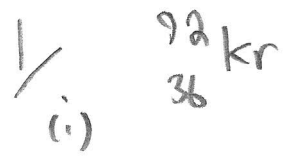


# NUCLEAR FISSION & FUSION



$$M_{\text{Kr}}c^2 = 36m_p c^2 + (92-36)m_n c^2 - B$$

$$M_{\text{Kr}} = 36m_p + 56m_n - \frac{B}{c^2}$$

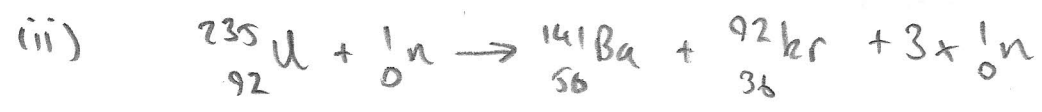
$$M_{\text{Kr}} = \frac{36 \times 1.6726 \times 10^{-27} + 56 \times 1.6749 \times 10^{-27} - 764.77 \times 10^6 \times 1.602 \times 10^{-19}}{(2.998 \times 10^8)^2} \quad (\text{kg})$$

$$= \boxed{1.526 \times 10^{-25} \text{ kg}}$$

$$= \boxed{91.927 \text{ u}}$$

(ie just a bit less than 92 as expected).

$$[1 \text{ u} = 1.6605 \times 10^{-27} \text{ kg}]$$



$$\Delta E = B_{\text{Ba}} + B_{\text{Kr}} - B_{\text{U}}$$

$$\therefore B_{\text{U}} = B_{\text{Ba}} + B_{\text{Kr}} - \Delta E$$

$$B_{\text{U}} = (1145.36 + 764.77 - 173.28) \text{ MeV}$$

$$\boxed{B_{\text{U}} = 1736.85 \text{ MeV}}$$

(iii) Assume mass of Uranium 235 is  $235 \text{ u}$  (any mass defect is negligible for this specific energy calculation).

$$\therefore \text{Energy released / kg of U-235 is } \frac{173.28 \times 10^6 + 1.602 \times 10^{-19} \text{ J}}{235 \times 1.6605 \times 10^{-27} \text{ kg}} = \boxed{7.11 \times 10^{13} \text{ J/kg}}$$

$$b) \frac{\text{Energy density of U-235}}{\text{Energy density of natural gas}} \approx \frac{7.11 \times 10^{13}}{4.9 \times 10^7} \approx \boxed{1.45 \times 10^6}$$

is about 1.5 million times more energy dense!

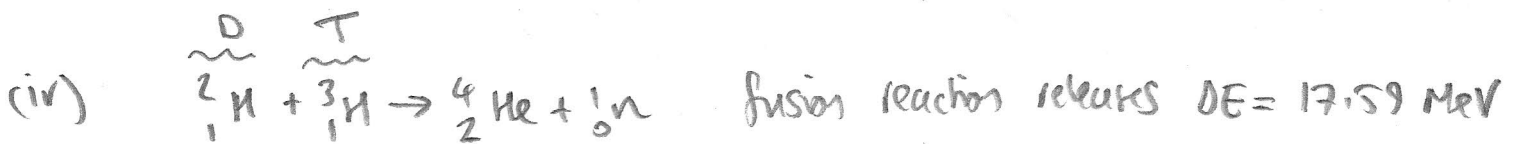
$$c) \frac{10^{19} \text{ J}}{7.11 \times 10^{13}} \div 1000 = \text{tonnes of U-235 to correspond to } 10^{19} \text{ J/year consumed by UK.}$$

$$= \boxed{140.6 \text{ tonnes}}$$

is a relatively small fleet of trucks, or a train, could easily transport this mass. Uranium has a density of  $19.1 \text{ g/cm}^3 = 19,100 \text{ kg/m}^3$ . So this is

$$\text{a volume of } \frac{140.6 \times 10^3}{19100} \text{ m}^3 = \boxed{7.36 \text{ m}^3}$$

is a cube  $(1.44 \text{ m})^3$  ! }



$$\Delta E = B_{\text{He}} - B_{\text{D}} - B_{\text{T}} \quad \therefore B_{\text{T}} = B_{\text{He}} - B_{\text{D}} - \Delta E$$

$$B_{\text{He}} = 27.27 \text{ MeV}$$

$$B_{\text{D}} = m_{\text{p}}c^2 + m_{\text{n}}c^2 - 2.0141 \frac{u}{c^2}$$

$$B_{\text{D}} = (938.3 + 939.6 - 2.0141 \times 931.5) \text{ MeV}$$

$$\Rightarrow B_{\text{T}} = 27.27 - 1.7659 - 17.59 \quad (\text{MeV})$$

$$\boxed{B_{\text{T}} = 7.91 \text{ MeV}}$$

{ NUBASE yields 7.9707 MeV }  
 Difference results from  
 higher precision of  $m_{\text{p}}, m_{\text{n}}$   
 etc. }

