1) $^{230}_{90}Th \rightarrow X + \alpha \Rightarrow X = {}^{230-4}_{90-2}? = {}^{226}_{88}Ra$

$\alpha \rightarrow {}^{4}_{2}He$

$^{35}S \rightarrow X + e^- + \bar{\nu} \Rightarrow X = {}^{35-0}_{16-(-1)}? = {}^{35}_{17}Cl$

$X \rightarrow {}^{40}_{19}K + e^+ + \nu \Rightarrow X = {}^{40+0}_{19+1}? = {}^{40}_{20}Ca$

$^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + e^- + \bar{\nu} \rightarrow X + \gamma$

$\Rightarrow X = {}^{24+0}_{12-0}? = {}^{24}_{12}Mg$

$X \rightarrow {}^{224}_{88}Ra + \alpha \rightarrow X = {}^{224+4}_{88+2}? = {}^{228}_{90}Th$

$\alpha \downarrow {}^{4}_{2}He$

2) $E_{release} = (m_{start} - m_{end})c^2$ $\qquad {}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He + E_{release}$

$= (238.05079\,u - 234.04363\,u - 4.00260\,u)\left(931.494\,\frac{MeV}{\cancel{c^2}\text{-}u}\right)\cancel{c^2}$

$= (0.00456\,u)\left(931.494\,\frac{MeV}{u}\right)$

$$\boxed{E_{release} = 4.25\ MeV}$$

Consider ${}^{238}_{92}U \rightarrow {}^{237}_{91}Pa\ {}^{1}_{1}H$

$E_{release} = (238.05079 - 237.05121\,u - 1.00783\,u)\left(931.494\,\frac{MeV}{u}\right)$

$\boxed{E_{release} = -7.684\ MeV < 0}$ ∴ Can't happen

3) $^{4}_{2}He \rightarrow ^{3}_{1}H + ^{1}_{1}H$ $\quad E_{release} = \left(m_{^4_2He} - m_{^3_1H} - m_{^1_1H}\right)c^2$

$$= (4.00260u - 3.01605u - 1.00783u) \times \left(931.494 \frac{MeV}{u \cdot c^2}\right)c^2$$

$$= \underline{-19.82 \text{ MeV}}$$

$^{3}_{1}H \rightarrow ^{2}_{1}H + n$ $\quad E_{release} = (3.01605u - 2.01410u - 1.00867) \times \left(931.494 \frac{MeV}{c^2 \cdot u}\right)c^2$

$$= \underline{-6.26 \text{ MeV}}$$

$^{2}_{1}H \rightarrow ^{1}_{1}H + n$ $\quad E_{release} = (2.01410u - 1.00783u - 1.00867u) \times \left(931.494 \frac{MeV}{c^2 \cdot u}\right)c^2$

$$= \underline{-2.24 \text{ MeV}}$$

$E_{bind} = -(\text{sum of each step})$

$= -(-19.82 \text{ MeV} - 6.26 \text{ MeV} - 2.24 \text{ MeV})$

$$\boxed{E_{bind} = +28.32 \text{ MeV}}$$

$$\boxed{E_{\text{Total per nuclear}} = \frac{28.32 \text{ MeV}}{A} = 7.08 \text{ MeV}/A}$$

4) $\rho_{nuke} = 2.0 \times 10^{17}\ \text{kg/m}^3$

$m_{sun} = 1.99 \times 10^{30}\ \text{kg}$ $\qquad R_{sun} = 6.96 \times 10^{8}\ \text{m}$

$V_{sun} = \frac{4}{3}\pi R_{sun}^3$

$$\rho = \frac{m}{V} = \frac{m}{\frac{4}{3}\pi R^3}$$

$$R^3 = \frac{3m}{4\pi\rho}$$

$$R_{ns} = \left(\frac{3 m_{sun}}{4\pi\,\rho_{nuke}}\right)^{1/3}$$

$$= \left(\frac{3(1.99 \times 10^{30}\ \text{kg})}{4\pi(2.0 \times 10^{17}\ \text{kg/m}^3)}\right)^{1/3}$$

$$= 1.3 \times 10^{4}\ \text{m}$$

$$\boxed{R_{ns} = 13\ \text{km}}$$

$T_s = 27\ \text{days}$

$$L_i = L_f$$

$$I_i \omega_i = I_f \omega_f$$

$$\cancel{\tfrac{2}{5}}\,\cancel{m}_{sun} R_{sun}^2 \frac{2\pi}{T_s} = \cancel{\tfrac{2}{5}}\,\cancel{m}_{sun} R_{ns}^2 \frac{2\pi}{T_{ns}}$$

$$\frac{R_{sun}^2}{T_s} = \frac{R_{ns}^2}{T_{ns}}$$

$$T_{ns} = \frac{R_{ns}^2}{R_{sun}^2} T_s$$

$$= \left(\frac{1.3 \times 10^{4}\ \text{m}}{6.96 \times 10^{8}\ \text{m}}\right)^2 27\ \text{days}$$

$$\boxed{T_{ns} = 9.4 \times 10^{-9}\ \text{days} = 0.00081\ \text{s}}$$