1.a Nuclear binding energy per nucleon

^{56}Fe : $B/A = \frac{1}{A}(\Delta_H \cdot 26 + \Delta_n \cdot 30) = 8.79$ MeV

^{238}U : 7.57 MeV

1.b Total binding energy per nucleon of $^{56}Fe + 182n$

$\cancel{\frac{B_{total}}{A} = \frac{B}{A}_{^{56}Fe} \cdot 56 \cdot \frac{1}{56+182}} =$

(only 56Fe has binding energy) (but all nucleons count)

$$\frac{B_{total}}{A_{total}} = \frac{B_{^{56}Fe}}{56+182} = 2.07 \text{ MeV}$$

so the process increases B/A from 2.07 MeV to 7.57 MeV

1.c $Q = \Delta_{^{56}Fe} + 182\,\Delta_n - \Delta_{^{238}U} = 1361$ MeV or $2.180 \cdot 10^{-3}$ erg

\# of 238U nuclei in $10^{-5} \cdot M_\odot$:

$$N_{^{238}U} = \frac{10^{-5} \cdot M_\odot}{\Delta_{^{238}U} + 238 \cdot m_u} = 5.04 \cdot 10^{49}$$

total energy released : $Q \cdot N_{^{238}U} = 1.10 \cdot 10^{47}$ erg

which is much less than the 10^{53} erg of the SN

-> this does not contribute to the energetics

2. a/b

β^+ : $^{56}Ni \to {}^{56}Co + e^+ + \nu_e$ $\quad Q = \Delta_{56Ni} - \Delta_{56Co} - 2m_e = 1.11$ MeV

β^- : $^{56}Ni \to {}^{56}Cu + e^- + \bar{\nu}_e$ $\quad Q = \Delta_{56Ni} - \Delta_{56Cu} = -15.3$ MeV

EC : $^{56}Ni + e^- \to {}^{56}Co + \nu_e$ $\quad Q = \Delta_{56Ni} - \Delta_{56Co} = 2.14$ MeV

p : $^{56}Ni \to {}^{55}Co + p$ $\quad Q = \Delta_{56Ni} - \Delta_{55Co} - \Delta_H = -7.17$ MeV

n : $^{56}Ni \to {}^{55}Ni + n$ $\quad Q = \Delta_{56Ni} - \Delta_{55Ni} - \Delta_n = -16.6$ MeV

α : $^{56}Ni \to {}^{52}Fe + \alpha$ $\quad Q = \Delta_{56Ni} - \Delta_{52Fe} - \Delta_\alpha = -8.00$ MeV

→ β^+ and EC are possible

EC dominates on earth

c. BE from Weizsäcker: 475 MeV

So nuclear mass $M_{nuc} = m_p \cdot 28 + m_n \cdot 28$

m_p: Proton mass 938.3 MeV

m_n: Neutron mass 939.565 MeV

$M_{atomic} \approx M_{nuc} + 28 \cdot m_e$ (neglecting electron binding energy!)

$\Delta_{atomic} = M_{atomic} - 56 \cdot m_u = -44.32$ MeV

d. this is almost 10 MeV off (only 0.02% of M_{nuc})

Weizsäcker is pretty precise for absolute masses but not good enough to calculate Q-values