HW 13
Chapter 13

13.1

a) $^{4}_{2}He$ — $^{16}O(d,\alpha)^{14}N$ — $A = 16 + 2 \Rightarrow 18 - 14 = 4$, $Z = 8 + 1 \Rightarrow 9 - 7 = 2 \Rightarrow He$

b) $^{1}_{1}H$

c) $^{18}_{9}F$

d) $^{76}_{34}Se$

e) $^{108}_{48}Cd$

f) $^{3}_{2}He$

13.8

$^{16}O(d,\alpha)^{14}N$ — $Q = [M(^{16}O) + M(^{2}H) - M(^{4}He) - M(^{14}N)]u.c^2 = 3.11\ MeV$ exo

$^{12}C(^{12}C,d)^{22}Na$ — $Q = -7.95\ MeV$ endo

$^{23}Na(p,^{12}C)^{12}C$ — $Q = -2.24\ MeV$ endo

13.14 $^{10}B(n,\gamma)^{11}B$

$$E_\gamma = [M(^{10}B) + M(n) - M(^{11}B)]\,u \cdot c^2 = 11.5 \text{ MeV}$$

13.19 @ threshold $^{14}N(\alpha, p)^{17}O$ $E(\alpha) = 6.7$ MeV

$$\alpha + {}^{14}N \longrightarrow {}^{18}F \longrightarrow {}^{17}O + p$$

$$K_{cm}(\alpha) = \frac{M(^{14}N)}{M(^{14}N) + M(\alpha)} K_{lab}(\alpha) = \frac{14}{18}(6.7) = 5.21 \text{ MeV}$$

in cm compound nucleus is at rest

$$E^* = [M(^{14}N) + M(^4He) - M(^{18}F)]\,u \cdot c^2 = 4.41 \text{ MeV}$$

so back in lab

$$E = E^* + K_{cm} = 9.62 \text{ MeV}$$

13.22 a) $T_{1/2} = 109\,ms$

need τ in order to get Γ:

$$\tau = \frac{T_{1/2}}{\ln 2} = \frac{109\,ms}{0.67} = 157\,ms$$

$$\tau\Gamma = \frac{\hbar}{2} \Rightarrow \Gamma = \frac{\hbar}{2\tau} = \frac{6.65\times10^{-16}\,eV\cdot s}{2(0.157\,s)} = 2.1\times10^{-15}\,eV$$

b) stable Ne is $^{20}_{10}Ne_{10}$. This is $^{17}_{10}Ne_{7}$ $\Rightarrow$ excess of protons, so good candidate for e^+ decay

$$^{17}_{10}Ne \longrightarrow {}^{17}_{9}F + e^+ + \nu$$

$$p \to n + e^+$$

$$e^- + p \to n + \nu$$

$$^{17}_{10}Ne + e \to {}^{17}_{9}F + \nu$$

13.26

$$n + {}^{230}Pu \longrightarrow {}^{240}Pu^* \longrightarrow {}^{95}Zr + {}^{142}Xe + 3n$$

$$\Delta E = [M({}^{239}Pu) + M(n) - M({}^{95}Zr) - M({}^{142}Xe) - 3M(n)]\,u \cdot c^2$$

$$\Delta E = 183.6 \text{ MeV}$$

13.30

reactor power 1250 MWe → megawatts "electric"

each fission is 200 MeV from ^{235}U

so energy / day ⇒ $1250\text{ MW} = \dfrac{(1.25 \times 10^9 \text{ J/s})(86{,}400 \text{ s/d})}{1.6 \times 10^{-13} \text{ J/MeV}}$

$= 6.74 \times 10^{26}$ MeV/d

↑ from fission, 200 MeV at a time

$$(6.74 \times 10^{26} \text{ MeV/d}) \left(\frac{1 \text{ fission}}{200 \text{ MeV}} \right) \left(\frac{0.235 \text{ kg}}{\text{mol}} \right) \left(\frac{\text{mol}}{6.02 \times 10^{23}} \right) = 1.32 \text{ kg/d}$$

13.31 for 1kg:

$$(1\,\text{kg})\left(\frac{6.02\times10^{23}\ \text{atoms}}{0.235\ \text{kg}}\right)\left(\frac{200\ \text{MeV}}{\text{atom}}\right) = 5.13\times10^{26}\ \text{MeV}$$

$\longrightarrow$ kWh ... 2.3×10^{7} kWh

from table 13.1, 1kg coal worth 3×10^{7} J $\longrightarrow$ 8.33 kWh

fission $\sim 10^{6}\times$ coal