Chapter 32

Problems & Exercises

1.

5.701 MeV

3.

$^{99}_{42}\text{Mo}_{57} \rightarrow ^{99}_{43}\text{Tc}_{56} + \beta^{-} + \bar{v}_e$

5.

1.43×10^{-9} g

7.

(a) 6.958 MeV

(b) 5.7×10^{-10} g

8.

(a) 100 mSv

(b) 80 mSv

(c) ~30 mSv

10.

~2 Gy

12.

1.69 mm

14.

1.24 MeV

16.

7.44×10^{8}

18.

4.92×10^{-4} Sv

20.

4.43 g

22.

0.010 g

24.

95%

26.

(a) A=1+1=2, Z=1+1=1+1, efn $= 0 = -1 + 1$

(b) A=1+2=3, Z=1+1=2, efn=0=0

(c) A=3+3=4+1+1, Z=2+2=2+1+1, efn=0=0

28.

$$\begin{aligned} E &= (m_{\mathrm{i}} - m_{\mathrm{f}})c^2 \\ &= \left[4m\left({}^1\mathrm{H}\right) - m\left({}^4\mathrm{He}\right)\right]c^2 \\ &= [4(1.007825) - 4.002603](931.5\ \mathrm{MeV}) \\ &= 26.73\ \mathrm{MeV} \end{aligned}$$

30.

3.12×10^5 kg (about 200 tons)

32.

$$\begin{aligned} E &= (m_{\mathrm{i}} - m_{\mathrm{f}})c^2 \\ E_1 &= (1.008665 + 3.016030 - 4.002603)(931.5\ \mathrm{MeV}) \\ &= 20.58\ \mathrm{MeV} \\ E_2 &= (1.008665 + 1.007825 - 2.014102)(931.5\ \mathrm{MeV}) \\ &= 2.224\ \mathrm{MeV} \end{aligned}$$

^{4}He is more tightly bound, since this reaction gives off more energy per nucleon.

34.

1.19×10^4 kg

36.

$2e^- + 4^1\mathrm{H} \rightarrow^4 \mathrm{He} + 7\gamma + 2v_e$

38.

(a) A=12+1=13, Z=6+1=7, efn $= 0 = 0$

(b) A=13=13, Z=7=6+1, efn $= 0 = -1 + 1$

(c) A=13 + 1=14, Z=6+1=7, efn $= 0 = 0$

(d) A=14 + 1=15, Z=7+1=8, efn $= 0 = 0$

(e) A=15=15, Z=8=7+1, efn $= 0 = -1 + 1$

(f) A=15 + 1=12 + 4, Z=7+1=6 + 2, efn $= 0 = 0$

40.

$E_\gamma = 20.6$ MeV

$E_{^4\mathrm{He}} = 5.68 \times 10^{-2} MeV$

42.

(a) 3×10^9 y

(b) This is approximately half the lifetime of the Earth.

43.

(a) 177.1 MeV

(b) Because the gain of an external neutron yields about 6 MeV, which is the average BE/A for heavy nuclei.

(c) $A = 1 + 238 = 96 + 140 + 1 + 1 + 1,\ Z = 92 = 38 + 53,\ \mathrm{efn} = 0 = 0$

45.

(a) 180.6 MeV

(b) $A = 1 + 239 = 96 + 140 + 1 + 1 + 1 + 1,\ Z = 94 = 38 + 56,\ \mathrm{efn} = 0 = 0$

47.

$^{238}\mathrm{U} + n\ \rightarrow^{239}\mathrm{U} + \gamma$ 4.81 MeV

$^{239}\mathrm{U} \rightarrow^{239}\mathrm{Np} + \beta^- + v_e$ 0.753 MeV

239Np→239Pu+ −+ve 0.211 MeV

49.

(a) 2.57×10^3 MW

(b) 8.03×10^{19} fission/s

(c) 991 kg

51.

0.56 g

53.

4.781 MeV

55.

(a) Blast yields 2.1×10^{12} J to 8.4×10^{11} J, or 2.5 to 1, conventional to radiation enhanced.

(b) Prompt radiation yields 6.3×10^{11} J to 2.1×10^{11} J, or 3 to 1, radiation enhanced to conventional.

57.

(a) 1.1×10^{25} fissions , 4.4 kg

(b) 3.2×10^{26} fusions , 2.7 kg

(c) The nuclear fuel totals only 6 kg, so it is quite reasonable that some missiles carry 10 overheads. The mass of the fuel would only be 60 kg and therefore the mass of the 10 warheads, weighing about 10 times the nuclear fuel, would be only 1500 lbs. If the fuel for the missiles weighs 5 times the total weight of the warheads, the missile would weigh about 9000 lbs or 4.5 tons. This is not an unreasonable weight for a missile.

59.

7×10^4 g

61.

(a) 4.86×10^9 W

(b) 11.0 y

62.

(a) $(-0.500, 2.00, 3.00)$ and $(0.500, 2.00, 3.00)$

(b) $(0.000, 1.50, 3.00)$ and $(0.000, 2.50, 3.00)$

(c) They travel in opposite directions along the same line.

(d) Yes.