Chapter 31

Problems & Exercises

1.

1.67×10^4

5.

$$\begin{aligned} m = \rho V = \rho d^3 \quad &\Rightarrow \quad a = \left(\frac{m}{\rho}\right)^{1/3} = \left(\frac{2.3 \times 10^{17}\ \text{kg}}{1000\ \text{kg/m}^3}\right)^{\frac{1}{3}} \\ &= \quad 61 \times 10^3\ \text{m} = 61\ \text{km} \end{aligned}$$

7.

1.9 fm

9.

(a) 4.6 fm

(b) 0.61 to 1

11.

85.4 to 1

13.

12.4 GeV

15.

19.3 to 1

17.

${}^3_1\text{H}_2 \rightarrow^3_2 \text{He}_1 + \beta^- + \bar{\nu}_e$

19.

${}^{50}_{25}M_{25} \rightarrow^{50}_{24} \text{Cr}_{26} + \beta^+ + \nu_e$

21.

${}^7_4\text{Be}_3 + e^- \rightarrow^7_3 \text{Li}_4 + \nu_e$

23.

${}^{210}_{84}\text{Po}_{126} \rightarrow^{206}_{82} \text{Pb}_{124} +^4_2 \text{He}_2$

25.

${}^{137}_{55}\text{Cs}_{82} \rightarrow^{137}_{56} \text{Ba}_{81} + \beta^- + \bar{\nu}_e$

27.

${}^{232}_{90}\text{Th}_{142} \rightarrow^{228}_{88} \text{Ra}_{140} +^4_2 \text{He}_2$

29.

(a) charge:$(+1)+(-1)=0$; electron family number: $(+1)+(-1)=0$; $A: 0+0=0$

(b) 0.511 MeV

(c) The two γ rays must travel in exactly opposite directions in order to conserve momentum, since initially there is zero momentum if the center of mass is initially at rest.

31.

$Z=(Z+1)-1; \quad A=A; \quad \text{efn}: 0=(+1)+(-1)$

33.

$Z-1=Z-1; \quad A=A; \quad \text{efn}:(+1)=(+1)$

35.

(a) ${}^{226}_{88}\mathrm{Ra}_{138} \rightarrow {}^{222}_{86}\mathrm{Rn}_{136} + {}^{4}_{2}\mathrm{He}_{2}$

(b) 4.87 MeV

37.

(a) $\mathrm{n} \rightarrow \mathrm{p} + \beta^{-} + \bar{\nu}_e$

(b)) 0.783 MeV

39.

1.82 MeV

41.

(a) 4.274 MeV

(b) 1.927×10^{-5}

(c) Since U-238 is a slowly decaying substance, only a very small number of nuclei decay on human timescales; therefore, although those nuclei that decay lose a noticeable fraction of their mass, the change in the total mass of the sample is not detectable for a macroscopic sample.

43.

(a) ${}^{15}_{8}O_7 + e^{-} \rightarrow {}^{15}_{7}N_8 + \nu_e$

(b) 2.754 MeV

44.

57,300 y

46.

(a) 0.988 Ci

(b) The half-life of ^{226}Ra is now better known.

48.

1.22×10^3 Bq

50.

(a) 16.0 mg

(b) 0.0114%

52.

1.48×10^{17} y

54.

$5.6 \times 10^4\ y$

56.

2.71 y

58.

(a) 1.56 mg

(b) 11.3 Ci

60.

(a) 1.23×10^{-3}

(b) Only part of the emitted radiation goes in the direction of the detector. Only a fraction of that causes a response in the detector. Some of the emitted radiation (mostly α particles) is observed within the source. Some is absorbed within the source, some is absorbed by the detector, and some does not penetrate the detector.

62.

(a) 1.68×10^{-5} Ci

(b) 8.65×10^{10} J

(c) \$$2.9 \times 10^3$

64.

(a) 6.97×10^{15} Bq

(b) 6.24 kW

(c) 5.67 kW

68.

(a) 84.5 Ci

(b) An extremely large activity, many orders of magnitude greater than permitted for home use.

(c) The assumption of 1.00 A is unreasonably large. Other methods can detect much smaller decay rates.

69.

1.112 MeV, consistent with graph

71.

7.848 MeV, consistent with graph

73.

(a) 7.680 MeV, consistent with graph

(b) 7.520 MeV, consistent with graph. Not significantly different from value for ^{12}C, but sufficiently lower to allow decay into another nuclide that is more tightly bound.

75.

(a) 1.46×10^{-8} u vs. 1.007825 u for ^{1}H

(b) 0.000549 u

(c) 2.66×10^{-5}

76.

(a) –9.315 MeV

(b) The negative binding energy implies an unbound system.

(c) This assumption that it is two bound neutrons is incorrect.

78.

22.8 cm

79.

(a) ${}^{235}_{92}\mathrm{U}_{143} \rightarrow {}^{231}_{90}\mathrm{Th}_{141} + {}^{4}_{2}\mathrm{He}_{2}$

(b) 4.679 MeV

(c) 4.599 MeV

81.

a) 2.4×10^{8} u

(b) The greatest known atomic masses are about 260. This result found in (a) is extremely large.

(c) The assumed radius is much too large to be reasonable.

82.

(a) –1.805 MeV

(b) Negative energy implies energy input is necessary and the reaction cannot be spontaneous.

(c) Although all conversation laws are obeyed, energy must be supplied, so the assumption of spontaneous decay is incorrect.

84.

$$r = r_0 A^{1/3} = 1.2(235)^{1/3} = 7.4 \text{ fm}$$

$$V = \frac{4\pi r^3}{3} = 1700 \text{ fm}^3$$

(a) $\rho = \frac{m}{v} = 0.14 \text{ u/fm}^3$

(b) For barium: $r = r_0 A^{1/3} = 1.2(142)^{1/3} = 6.3$ fm

$V = \frac{4\pi r^3}{3} = 1047 \text{ fm}^3$

$\rho = \frac{m}{v} = 0.14 \text{ u/fm}^3$

For krypton: $r = r_0 A^{1/3} = 1.2(92)^{1/3} = 5.4$ fm

$V = \frac{4\pi r^3}{3} = 660 \text{ fm}^3$

$\rho = \frac{m}{v} = 0.14 \text{ u/fm}^3$

To two significant figures, they are all alike.