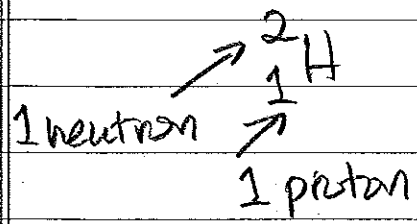


Energy of the Environment

Homework # 7 Ch 18: 31, 36, 41, 44 } 90 pts.
 19: 31, 34, 41 } total
 20: 34, 36 }

18.31 Find Binding energy of ${}^2_1\text{H}$



from Fig 18.4, Average

binding energy = 1.2 MeV/nucleon

Binding energy = $1.2 \frac{\text{MeV}}{\text{nucleon}} \times 2 \text{ nucleons}$

${}^2_1\text{H}$ Binding Energy = 2.4 MeV

from wikipedia, nuclear mass of ${}^2_1\text{H} =$

(3) 2.01355321270 u

(1) proton mass = 1.007276470 u

(2) neutron mass = 1.008664904 u

Mass defect = $(1) + (2) - (3) =$

$= .002388162 \text{ u}$

$E = mc^2 = \text{Binding energy} = .002388162 (1.66053873 \times 10^{-27} \text{ kg}) c^2$

$$\begin{aligned} * (3 \times 10^8)^2 &= 3.57 \times 10^{-13} \text{ J} = \text{Binding Energy} \\ &= \frac{3.57 \times 10^{-13} \text{ J}}{1.602176 \times 10^{-19} \text{ J/eV}} \end{aligned}$$

Binding Energy = 2.228 MeV

18.36 Find binding energy from ${}_{94}^{238}\text{Pu}$ $\approx 7.5 \text{ MeV/nucleon}$
 Fig. 18.4

Find conversion factor between $\text{u} \frac{1}{2} \text{ MeV}$

$$= \frac{(1.660539 \times 10^{-27}) (3 \times 10^8)^2 \text{ J/u}}{(1 \times 10^6 \frac{\text{eV}}{\text{MeV}}) (1.602176 \times 10^{-19} \frac{\text{J}}{\text{eV}})} = 932.8 \frac{\text{MeV}}{\text{u}}$$

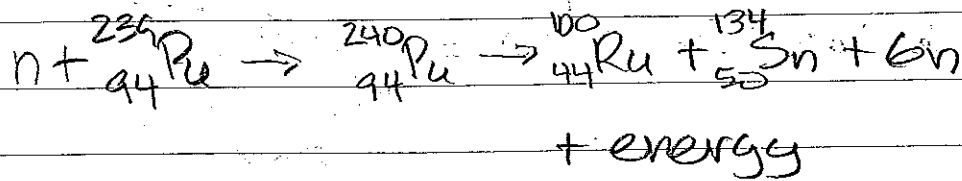
$$\left. \begin{array}{l} \text{meV} \\ \text{nucl.} \end{array} \right\} \text{Binding Energy} = \left(\frac{144(1.008665) + 94(1.007276) - 238.0496 \text{ u}}{238 \text{ nucleons}} \right) 932.8 \frac{\text{MeV}}{\text{u}}$$

${}_{94}^{238}\text{Pu}$ Binding Energy = $7.38 \frac{\text{MeV}}{\text{nucleon}}$

HWK #7

7/3

18.41



$${}_{94}^{240}\text{Pu} = 240(7.5) = 1800 \text{ MeV}$$

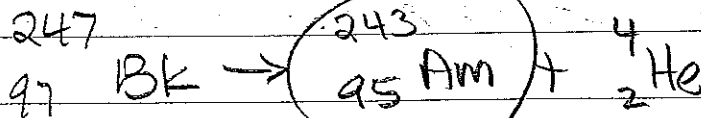
$${}_{44}^{100}\text{Ru} = 100(8.3) = 830 \text{ MeV}$$

$${}_{50}^{134}\text{Sn} = 134(8.3) = 1112 \text{ MeV}$$

$$\text{BE (MeV)} = 1112 + 830 - 1800$$

$$\text{Energy Released} = 142 \text{ MeV}$$

18.44



a) \swarrow daughter nucleus

b)

$$N(t) = N_0 e^{-t/\tau} \quad \tau = \text{mean life}$$

if $N_0 = 100,000$ $t = \tau$

$$N(\tau) = 100,000 e^{-1} = 36,790 \text{ nuclei remain}$$

c) $N(3\tau) = 100,000 e^{-3}$

$$N(3\tau) = 4,979 \text{ remain}$$

19.31

7/4

1000 MW plant @ 33% efficiency

$$\text{Consumes } 3 \times 10^9 \text{ W} = 3 \times 10^9 \frac{\text{J}}{\text{s}}$$

$$\frac{1.602 \times 10^{-19} \text{ J}}{\text{eV}}$$

$$= \frac{1.873 \times 10^{28} \text{ eV}}{\text{s}}$$

$$\frac{200 \times 10^6 \text{ eV}}{\text{fission}}$$

$$= 9.365 \times 10^{19} \text{ fissions/sec}$$

$$\text{Amt Uranium used} = \frac{(9.365 \times 10^{19} \text{ fissions/sec})(86400 \frac{\text{s}}{\text{d}})(235 \frac{\text{g}}{\text{mole}})}{6.023 \times 10^{23}}$$

$$\text{Amt Uranium used} = 3157 \text{ g/day} = 3.16 \text{ kg/d}$$

19.34

Assume 33% efficiency for coal plant.

$$\text{Amt Coal used} = \frac{(3 \times 10^9 \frac{\text{J}}{\text{s}})(86400 \frac{\text{s}}{\text{d}})}{(23.4 \times 10^6 \frac{\text{J}}{\text{kg}})}$$

$$= 1.1 \times 10^7 \frac{\text{kg}}{\text{day}}$$

from 19.31

$$\text{Amt Uranium used} = 3.16 \frac{\text{kg}}{\text{day}}$$

19.41

$$\text{response time} = \frac{\tau}{(k-1)}$$

 $k=1 \rightarrow \text{critical}$
 $k > 1 \text{ supercritical}$
 $k < 1+f, f = \text{fraction delayed}$

For $U_{235}, f = 0.007$

$$\tau = .993(10^{-14}) + .007(14) \text{ sec}$$

$$\tau = 9.8 \times 10^{-2} \text{ sec}$$

$$k = 1+f = 1.0 + 0.007 = 1.007$$

$$\text{response time (sec)} = \frac{9.8 \times 10^{-2} \text{ sec}}{1.007 - 1}$$

$$\text{response time} = 14 \text{ sec}$$

$$\text{if response time} = RT = \frac{\tau}{(k-1)}$$

$$k = 1.0008 \text{ for } RT = 120 \text{ sec's}$$

$$RT = \frac{9.8 \times 10^{-2}}{k-1}$$

$$|RT(k) - RT| = 9.8 \times 10^{-2}$$

$$k = 1.0010 \text{ for } RT = 100 \text{ sec}$$

$$k = \frac{RT + 9.8 \times 10^{-2}}{RT}$$

7/6

20.34

Given 25 SV/hr exposure
for 15 hours

$$\text{Dose} = (25 \text{ SV/hr})(15 \text{ hr}) = 3750 \text{ SV}$$

$$\text{Dose} = 37,500 \text{ mSV}$$

1/2 exposed people die @ 3,000-7,000 mSV
> 25,000 most tissue destroyed

20.36

Co-60 γ rays 1.16 MeV
1/2 life = 5.3 yr 1.30 MeV

Raccoon ingests 2g $\frac{1}{3}$ excretes it
after 32 h

(a) What is the dose?

$$\text{Amt decays after 32h} = 2g \left(1 - \exp\left(\frac{-0.693(32h)}{5.3(365)(24h)}\right) \right)$$

$$= 9.55 \times 10^{-4} \text{ g / (60g/mole)}$$

$$= 1.59 \times 10^{-5} \text{ mole} * 6.023 \times 10^{23} \frac{\text{quanta}}{\text{mole}}$$

$$= 9.59 \times 10^{18} \text{ quanta} / (6.24 \times 10^{18} \frac{\text{quanta}}{\text{Coulomb}})$$

$$= 1.536 \text{ C}$$

(J) Energy released = Volt * Coulomb

$$= \left(\frac{1.16 + 1.30}{2} \text{ MeV} \right) (1.536 \text{ C}) = 1.89 \times 10^6 \text{ J}$$

$$\text{Dose} = \frac{\text{Energy Absorbed (J)}}{\text{Body Mass (kg)}}$$

7/7

Assume 6 kg mass

$$\text{Dose} = \frac{1.89 \times 10^6 \text{ J}}{6 \text{ kg}} = 3.15 \times 10^5 \frac{\text{J}}{\text{kg}}$$

$$= 3.15 \times 10^5 \text{ Gy}$$

$$= 3.15 \times 10^5 \text{ Sv for}$$

γ rays

at this exposure the raccoon would surely die
