

HW # 12 Solutions

(1.) The odd nucleon gives the net contribution to the nuclear spin.

Protons and neutrons fill up shells independently.

$^{29}_{14}\text{Si}$   $Z=14$   $N=15$  odd nucleon in  $2s_{1/2}$ ,  $I = \frac{1}{2}$

↑  
nuclear spin equivalent to J

$^{37}_{17}\text{Cl}$   $Z=17$   $N=20$  "  $1d_{3/2}$ ,  $I = \frac{3}{2}$

$^{71}_{31}\text{Ga}$   $Z=31$   $N=40$  "  $2p_{3/2}$ ,  $I = \frac{3}{2}$

$^{59}_{27}\text{Co}$   $Z=27$   $N=32$   $1f_{7/2}$   $I = \frac{7}{2}$

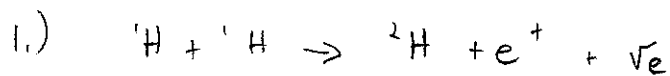
$^{73}_{32}\text{Ge}$   $Z=32$   $N=41$   $1g_{9/2}$   $I = \frac{9}{2}$

$^{33}_{16}\text{S}$   $Z=16$   $N=17$   $1d_{3/2}$   $I = \frac{3}{2}$

$^{87}_{38}\text{Sr}$   $Z=38$   $N=49$   $1g_{9/2}$   $I = \frac{9}{2}$

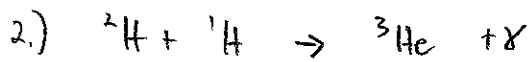
2.

calculate Q values

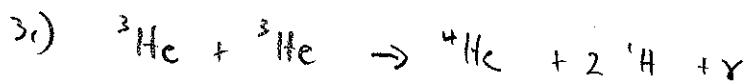


$$Q_1 = 2m_{{}^1\text{H}}c^2 - m_{{}^2\text{H}}c^2 - 2m_e c^2$$

↑ one electron lost  
since Z=1  
in  ${}^2\text{H}$



$$Q_2 = m_{{}^2\text{H}}c^2 + m_{{}^1\text{H}}c^2 - m_{{}^3\text{He}}c^2$$



$$Q_3 = 2m_{{}^3\text{He}}c^2 - m_{{}^4\text{He}}c^2 - 2m_{{}^1\text{H}}c^2$$

$$Q_1 + Q_2 + Q_3 =$$

$$\begin{aligned} & \cancel{2m_{{}^1\text{H}}c^2} - \cancel{m_{{}^2\text{H}}c^2} - 2m_e c^2 + \cancel{m_{{}^2\text{H}}c^2} + m_{{}^1\text{H}}c^2 - \cancel{m_{{}^3\text{He}}c^2} \\ & + \cancel{2m_{{}^3\text{He}}c^2} - m_{{}^4\text{He}}c^2 - \cancel{2m_{{}^1\text{H}}c^2} \end{aligned}$$

$$= m_{{}^1\text{H}}c^2 + m_{{}^3\text{He}}c^2 - m_{{}^4\text{He}}c^2 - 2m_e c^2$$

$$= (1.007825 + 3.016029 - 4.002602) 931.49401 \text{ MeV} - 2(0.51100 \text{ MeV})$$

$$= 18.8 \text{ MeV}$$

element	Mass
${}^1\text{H}$	1.007825 u
${}^2\text{H}$	2.014102 u
${}^3\text{He}$	3.016029 u
${}^4\text{He}$	4.002602 u
$e^+$	0.51100 MeV/c <sup>2</sup>
$\bar{\nu}_e$	~ 0 eV
$\gamma$	0 eV
u	931.49401 MeV/c <sup>2</sup>

3.

In a living organism

$$^{14}\text{C} / ^{12}\text{C} = 1.35 \times 10^{-12}$$

$T_{1/2}$  of  $^{14}\text{C}$  is 5730 years

The percentage of  $^{12}\text{C}$  is so low that

we can take the original mass of Carbon to be 15g.

Calculate initial amount of  $^{12}\text{C}$

$$N_0 = 15 \text{ g} \times \frac{1 \text{ mole}}{12.0107 \text{ g}} \times \frac{(0.022 \times 10^{23})}{\text{mole}} \times 1.35 \times 10^{-12}$$

$$N_0 = 1.02 \times 10^{12}$$

10,000 years is  $n = \left(\frac{10000}{5730}\right)$  half lives

Amount of  $^{12}\text{C}$  remaining is  $N_0 \left(\frac{1}{2}\right)^n$

$$R = \lambda N = \frac{0.693}{t_{1/2}} N_0 \left(\frac{1}{2}\right)^n$$

$$= \left(\frac{0.693}{5730 \text{ y}}\right) (1.02 \times 10^{12}) \left(\frac{1}{2}\right)^{\left(\frac{10000}{5730}\right)} = 3.68 \times 10^7 \text{ per year}$$

Note: we could also work from  $= 1.17 \text{ s}^{-1}$

$N = N_0 e^{-\lambda t}$  instead of using  $\frac{1}{2}$  lives

4.

a.)  $K^+ \rightarrow \pi^0 + \mu^+ + \bar{\nu}_\mu$

Lepton number, Baryon number, charge is conserved

Involves both leptons and hadrons, so

must involve weak interaction.

b.)  $p + e^- + \bar{\nu}_e \rightarrow e^- + \pi^+ + p$

Lepton number, charge not conserved. Not Allowed!

c.)  $\Lambda^0 \rightarrow \pi^+ + e^- + \bar{\nu}_e$

Baryon number not conserved. Not Allowed.

d.)  $p + \bar{\nu}_\mu \rightarrow \mu^+ + n$

Not Allowed. Lepton number not conserved

5.

	Q	B	$I_3$	S	Hadron
a.) $u\bar{d}$	+1	0	+1	0	$\pi^+$
b.) $d\bar{u}$	-1	0	-1	0	$\pi^-$
c.) $u\bar{s}$	+1	0	$+\frac{1}{2}$	+1	$K^+$
d.) $s\bar{s}$	0	0	0	0	$\phi$
e.) $d\bar{s}$	0	0	$-\frac{1}{2}$	+1	$K^0$

← this is a "strange" one.

Note: the convention is that  
(strange)ness  
(top)ness  
(up)ness  
⋮

has the same sign as the charge