Physics 104 Discussion Activity...

December 13, 2007

The Final Chapter(s)
Half-life: $T_{\frac{1}{2}} = \frac{0.693}{\lambda}$, $\lambda=$decay constant

Activity (i.e. - rate)=$\lambda N$, $N=$Number of atoms

Decay: $\lambda N = \lambda N_0 e^{-\lambda t} = \lambda N_0 \left( \frac{1}{2} \right)^n$, $n = \frac{t}{T_{\frac{1}{2}}}$

$1$Ci $= 3.7 \times 10^{10}$Bq, $1$Bq$=1$decay/sec

Notation: $\frac{A}{Z}X$, $A=#$ nucleons (protons+neutrons), $Z=#$ Atomic number (protons)

Neutron mass: $m_n = 1.008655$ u

Proton mass: $m_p = 1.007276$ u

Electron mass: $m_e = 5.49 \times 10^{-4}$ u

$\frac{4}{2}$He mass $= 4.002603$ u

$\frac{12}{6}$C mass $= 12.000000$ u

$\frac{235}{92}$U mass $= 235.043923$ u

$\frac{197}{79}$Au mass $= 196.96552$ u

amu: $1$ u $= 1.66 \times 10^{-27}$kg

amu mass-energy: $1$u $= 931.5$ MeV/$c^2 = 1.49 \times 10^{-10}$ J/$c^2$
1. (29.17) The half-life of $^{131}$I is 8.04 days.

   (a) Calculate the decay constant for this isotope in sec$^{-1}$.

   (b) Find the number of $^{131}$I nuclei necessary to produce a sample with an activity of 0.50 $\mu$Ci.

   (c) What is its Activity after 20.0 days.
2. (29.23) Complete the following radioactive decay formulas:

(a) $^{212}_{83}$Bi $\rightarrow ? + ^2_4$He

(b) $^{95}_{36}$Kr $\rightarrow ? + e^-$

(c) $? \rightarrow ^4_2$He + $^{140}_{58}$Ce

3. (29.25) The mass of $^{56}$Fe is 55.9349 u and the mass of $^{56}$Co is 55.9399 u.

(a) Which isotope decays into the other?

(b) by what process?

(c) How much mass is lost in each decay?

(d) What is the energy yield for each decay?
4. (29.27) Determine which of the following suggested decays can occur spontaneously:

(a) $^{40}_{20}\text{Ca} \rightarrow \text{e}^- + ^{40}_{19}\text{K}$

(b) $^{144}_{60}\text{Nd} \rightarrow \frac{4}{2}\text{He} + ^{140}_{58}\text{Ce}$

(c) Explain.

5. (29.37) Natural Gold has has only one isotope: $^{197}_{79}\text{Au}$. If gold is bombarded with slow neutrons, e$^-$ particles are emitted. (The mass of $^{198}_{80}\text{Hg}$ is 197.96675 u.)

(a) Write the appropriate reaction equation.

(b) Calculate the maximum energy of the emitted beta particles.
6. (29.46) A particular radioactive source produces 100 mrad of 2 MeV gamma rays per hour at a distance of 1.0 m.

(a) How long could a person stand at this distance before accumulating an intolerable dose of 1 rem?

(b) Assuming the gamma radiation is emitted uniformly in all directions, at what distance would a person receive a dose of 10 mrad/h from this source?

7. Regarding the four forces relevant to subatomic particles:

(a) What are the four forces?

(b) Which force keeps nucleons together?

(c) Which force is the strongest force at distances on the order of a nucleon?

(d) Which force is involved in the beta decay process?
8. (30.2) Find the energy released in the following fission reaction. The atomic masses of \( _{98}^{98} \text{Zr} \) and \( _{52}^{135} \text{Te} \) are 97.9120 u and 134.9087 u, respectively.

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\text{n} + \ _{92}^{235} \text{U} \rightarrow \ _{98}^{98} \text{Zr} + \ _{52}^{135} \text{Te} + 3\text{n}
\]

9. (30.6) A typical nuclear fission power plant produces about 1.00 GW of electrical power. Assume that the plant has an overall efficiency of 40.0% and that each fission produces 200 MeV of thermal energy. Calculate the mass of \( _{92}^{235} \text{U} \) consumed each day.
10. (30.11) When a star has exhausted its hydrogen fuel, it may fuse other nuclear fuels. At temperatures above $1.0 \times 10^8$ K, helium fusion can occur. Write the equations for the following processes. The mass of $^8\text{Be}$ is 8.0053059 u

(a) Two alpha particles fuse to produce a nucleus $A$ and gamma ray. What is nucleus $A$?

(b) Nucleus $A$ absorbs an alpha particle to produce a nucleus $B$ and a gamma ray. What is nucleus $B$?

(c) Find the total combined energy released in these reactions.

11. (30.16) A photon with an energy of 2.09 GeV creates a proton-anti proton pair in which the proton has a kinetic energy of 95.0 MeV. What is the kinetic energy of the anti-proton?