Name____

Physics 111 Quiz #5, November 13, 2015

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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Strontium-90 is chemically similar to calcium and if ingested can replace calcium in bones leading to health problems. ${}^{90}_{38}Sr$ is produced as a nuclear fission product of uranium and ${}^{90}_{38}Sr$ has too many neutrons to be stable and thus decays with a half-life of about $29\,yr$.

1. How long would you have to wait for the amount of ${}^{90}_{38}Sr$ on the Earth's surface to reach 1% of its current level, assuming no new material is scattered about?

From the half-life we calculate the decay constant:

$$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{29\,yr} = 0.024\,yr^{-1}$$

Then the time to reach this amount is:

$$m = 0.01 m_o = m_o e^{-\lambda t} \rightarrow t = -\frac{\ln(0.01)}{\lambda} = -\frac{\ln(0.01)}{0.024\,yr^{-1}} = 192.7\,yr$$

2. What is the decay reaction and what is the maximum kinetic energy available to the decay particle? (See table 1 on the back of the page for pertinent data.)

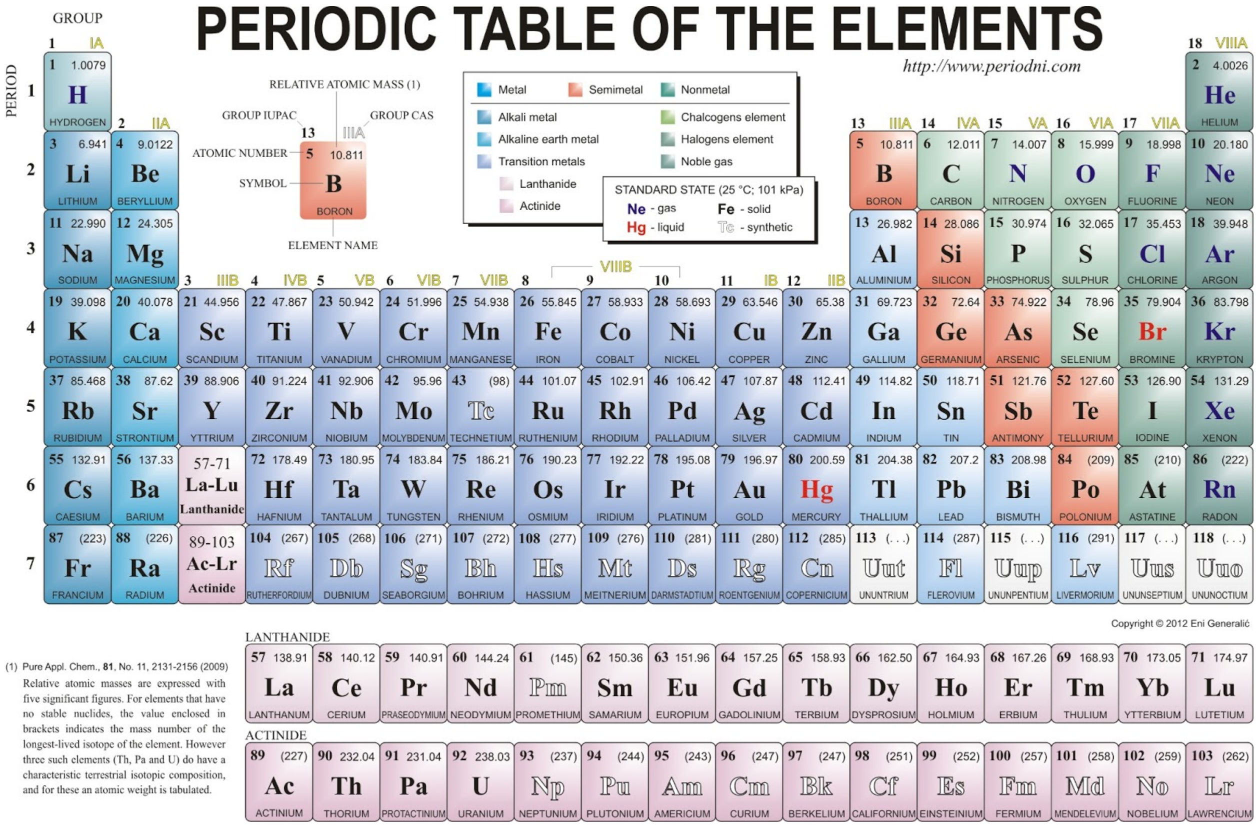
Too many neutrons mean that this is a beta-minus decay. We have: ${}^{90}_{38}Sr \rightarrow {}^{0}_{-1}e + {}^{90}_{39}Y + \bar{\nu}_e$

The maximum kinetic energy available to the beta particle is (assuming that the ${}^{90}_{39}Y$ is at rest after the decay) and the electron's mass is included in the rest mass of Yittrium:

$$KE_{\max} = (m_{Sr} - m_Y)c^2$$

$$KE_{\max} = \left[(89.90773u - 89.90585u) \times \left(\frac{931.5\,\frac{MeV}{c^2}}{1u}\right)\right]c^2 = 1.75\,MeV$$

3. ${}^{90}_{38}Sr$ has 38 protons in its nucleus. Why doesn't the strontium nucleus break apart?
   a. The repulsive Coulomb force doesn't act inside of the nucleus.
   b. The force of gravity overpowers the repulsive Coulomb force inside of the nucleus.
   c. The negatively charged neutrons balance the positively charged protons.
   d. Protons lose some of their positive charge inside the nucleus.
   e. The strong nuclear force holds the nucleus together.



http://www.chemizzle.com/p/chemistry.html

Element	$^{90}_{38}Sr$	$^{90}_{39}Y$	$^{87}_{37}Rb$	$^{94}_{40}Zr$	$^{86}_{36}Kr$	$^{4}_{2}He$	$^{0}_{-1}e$ or $^{0}_{+1}e$
Mass (unified mass units)	89.90773	89.90585	86.90918	93.90632	86.91062	4.00260	0.00055

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1 Q_2}{r^2}\hat{r}$$

$$\vec{E} = \frac{\vec{F}}{q}$$

$$\vec{E}_Q = k\frac{Q}{r^2}\hat{r}$$

$$PE = k\frac{Q_1 Q_2}{r}$$

$$V(r) = k\frac{Q}{r}$$

$$E_x = -\frac{\Delta V}{\Delta x}$$

$$W = -q\Delta V_{f,i}$$

Magnetic Forces and Fields

$$F = qvB\sin\theta$$

$$F = IlB\sin\theta$$

$$\tau = NIAB\sin\theta = \mu B\sin\theta$$

$$PE = -\mu B\cos\theta$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\varepsilon_{induced} = -N\frac{\Delta\phi_B}{\Delta t} = -N\frac{\Delta(BA\cos\theta)}{\Delta t}$$

Constants

$$g = 9.8\,\tfrac{m}{s^2}$$

$$1e = 1.6\times10^{-19}\,C$$

$$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^{9}\,\tfrac{C^2}{Nm^2}$$

$$\varepsilon_o = 8.85\times10^{-12}\,\tfrac{Nm^2}{C^2}$$

$$1eV = 1.6\times10^{-19}\,J$$

$$\mu_o = 4\pi\times10^{-7}\,\tfrac{Tm}{A}$$

$$c = 3\times10^{8}\,\tfrac{m}{s}$$

$$h = 6.63\times10^{-34}\,Js$$

$$m_e = 9.11\times10^{-31}\,kg = \frac{0.511MeV}{c^2}$$

$$m_p = 1.67\times10^{-27}\,kg = \frac{937.1MeV}{c^2}$$

$$m_n = 1.69\times10^{-27}\,kg = \frac{948.3MeV}{c^2}$$

$$1amu = 1.66\times10^{-27}\,kg = \frac{931.5MeV}{c^2}$$

$$N_A = 6.02\times10^{23}$$

$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$$

Electric Circuits

$$I = \frac{\Delta Q}{\Delta t}$$

$$V = IR = I\left(\frac{\rho L}{A}\right)$$

$$R_{series} = \sum_{i=1}^{N} R_i$$

$$\frac{1}{R_{parallel}} = \sum_{i=1}^{N}\frac{1}{R_i}$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$Q = CV = \left(\frac{\kappa\varepsilon_0 A}{d}\right)V = (\kappa C_0)V$$

$$PE = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \frac{Q^2}{2C}$$

$$Q_{\text{charge}}(t) = Q_{\max}\left(1-e^{-\frac{t}{RC}}\right)$$

$$Q_{\text{discharge}}(t) = Q_{\max}e^{-\frac{t}{RC}}$$

$$C_{parallel} = \sum_{i=1}^{N} C_i$$

$$\frac{1}{C_{series}} = \sum_{i=1}^{N}\frac{1}{C_i}$$

Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\varepsilon_o\mu_o}}$$

$$S(t) = \frac{energy}{time\times area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_0}$$

$$I = S_{avg} = \tfrac{1}{2}c\varepsilon_o E_{\max}^2 = c\frac{B_{\max}^2}{2\mu_0}$$

$$P = \frac{S}{c} = \frac{Force}{Area}$$

$$S = S_o\cos^2\theta$$

$$v = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{c}{n}$$

$$\theta_{inc} = \theta_{refl}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$M_{total} = \prod_{i=1}^{N} M_i$$

$$S_{out} = S_{in}e^{-\sum_i \mu_i x_i}$$

$$HU = \frac{\mu_w - \mu_m}{\mu_w}$$

Light as a Particle & Relativity

$$E = hf = \frac{hc}{\lambda} = pc$$

$$KE_{\max} = hf - \phi = eV_{stop}$$

$$\Delta\lambda = \frac{h}{m_e c}(1-\cos\phi)$$

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$p = \gamma mv$$

$$E_{total} = KE + E_{rest} = \gamma mc^2$$

$$E_{total}^2 = p^2c^2 + m^2c^4$$

$$E_{rest} = mc^2$$

$$KE = (\gamma-1)mc^2$$

Nuclear Physics

$$E_{binding} = (Zm_p + Nm_n - m_{rest})c^2$$

$$\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$$

$$A(t) = A_o e^{-\lambda t}$$

$$m(t) = m_o e^{-\lambda t}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Geometry

$$Circles: \quad C = 2\pi r = \pi D \qquad A = \pi r^2$$

$$Triangles: \quad A = \tfrac{1}{2}bh$$

$$Spheres: \quad A = 4\pi r^2 \qquad V = \tfrac{4}{3}\pi r^3$$

Misc. Physics 110 Formulae

$$\vec{F} = \frac{\Delta\vec{p}}{\Delta t} = \frac{\Delta(m\vec{v})}{\Delta t} = m\vec{a}$$

$$\vec{F} = -k\vec{y}$$

$$\vec{F}_C = m\frac{v^2}{R}\hat{r}$$

$$W = \Delta KE = \tfrac{1}{2}m\left(v_f^2 - v_i^2\right) = -\Delta PE$$

$$PE_{gravity} = mgy$$

$$PE_{spring} = \tfrac{1}{2}ky^2$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$

$$\phi = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

$$\vec{v}_f = \vec{v}_i + \vec{a}t$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\vec{x}_f = \vec{x}_i + \vec{v}_i t + \tfrac{1}{2}\vec{a}t^2$$