Physics 10164 - Exam 5A

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (40 pts) The work function of Aluminum is 4.08 eV. If light of sufficient energy shines on the Aluminum, some electrons will be able to escape.

a) What is the cutoff wavelength for Aluminum?

b) For what wavelength of light will electrons escape with a maximum speed of 7.2 x 10^5 m/s?

a) $E = 4.08\,eV = 6.53 \times 10^{-19}\,J = \frac{hc}{\lambda_{cut}}$

$$\lambda_{cut} = \frac{(6.626\times10^{-34})(3\times10^{8})}{6.53\times10^{-19}} = \boxed{305\,nm}$$

b) $KE = \frac{1}{2}(9.11\times10^{-31})(7.2\times10^{5})^2$

$= 2.36\times10^{-19}\,J$

$= 1.48\,eV$

$1.48 = \frac{hc}{\lambda} - 4.08$ or $2.36\times10^{-19} = \frac{hc}{\lambda} - 6.53\times10^{-19}$

$8.89\times10^{-19} = \frac{hc}{\lambda}$

$$\lambda = \frac{(6.626\times10^{-34})(3\times10^{8})}{8.89\times10^{-19}} = 224\,nm$$

or $\boxed{220\,nm}$

2. (30 pts) When viewed through a filter, a small glowing cloud of Hydrogen gas in a laboratory experiment emits Balmer-gamma radiation (when the electron falls from level n=4 to n=2). The total energy emitted at this wavelength is 5.0 x 10^{-5} Watts.

a) What is the wavelength of the Balmer-gamma photon?

b) How many photons per second is the cloud emitting?

a) $\frac{1}{\lambda} = R_H\left(\frac{1}{4} - \frac{1}{16}\right)$

$= (1.097 \times 10^{7})(.1875)$

$\boxed{\lambda = 486\ nm}$

b) $E_\gamma = \frac{hc}{\lambda} = 4.09 \times 10^{-19}\ J$

$E_{TOT} = (5.0 \times 10^{-5}\ W) \cdot (1\ sec)$

$= 5.0 \times 10^{-5}\ J$

$N = \frac{E_{TOT}}{E_\gamma} = \frac{5.0 \times 10^{-5}}{4.09 \times 10^{-19}} = \boxed{1.2 \times 10^{14}\ photons}$

3. (30 pts) Strontium-90 has a mass of 90.0 amu and a half-life of 28.8 years.

a) What is the activity of 75 grams of Sr-90, in Curies?

b) How many years will it take for the activity of this initial sample to be reduced to 1.0% of its original value?

a) $m_{TOT} = N_0 m_{Sr}$

$m_{TOT} = .075 \, kg$

$m_{Sr} = 90 \, amu \cdot \frac{1.66 \times 10^{-27} kg}{amu} = 1.49 \times 10^{-25} kg$

$N_0 = \frac{.075}{1.49 \times 10^{-25}} = 5.02 \times 10^{23} \text{ atoms}$

$T_{1/2} = 28.8 \, yrs \cdot \frac{3.16 \times 10^7 s}{yr} = 9.1 \times 10^8 s$

$\lambda = \frac{0.693}{T_{1/2}} = 7.6 \times 10^{-10}$

$a_0 = \lambda N_0 = 3.8 \times 10^{14} \, Bq \cdot \frac{2.7 \times 10^{-11} Ci}{Bq}$

$= \boxed{10,300 \, Ci}$

b) $a = 0.01 a_0$

$.01 a_0 = a_0 e^{-\lambda t}$

$\ln(.01) = -\lambda t$

$t = \frac{-4.6}{-\lambda} = 6.1 \times 10^9 s \cdot \frac{1 \, yr}{3.16 \times 10^7 s} = \boxed{190 \, yrs}$