# Physics 10164 - Exam 5C

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. (25 points) According to an observer on the Earth, a ship flying by has a length of 85 meters. The pilot of the ship measures the ship to be 144 meters long.

a) How fast (as a fraction of c) is the ship moving?

b) How long (in minutes) will it take for the ship to travel the 430 million mile distance to Jupiter from the Earth, as measured by the observer on the Earth?

c) How long will the trip take as measured by the pilot (in minutes)?

a) $\gamma = \frac{144}{85} = 1.694 \Rightarrow 2.87 = \frac{1}{1-\frac{v^2}{c^2}}$

$\Rightarrow 2.87 - 2.87\frac{v^2}{c^2} = 1 \Rightarrow \frac{v^2}{c^2} = \frac{1.87}{2.87} \Rightarrow v = 0.81c$

b) $t_E = \frac{d_E}{v} = \frac{(430\times10^6 \text{ mi})(1609 \text{ m/mile})}{(.81)(3\times10^8)} = 2857.8 \text{ s}$

$= 48 \text{ min}$

c) $t_{ship} = \frac{t_E}{\gamma} = 28 \text{ min}$

2. (25 pts) The cutoff wavelength for an illuminated metal to release electrons is observed to be 422 nm.

a) What is the work function of the metal (in eV)?

b) If the metal is illuminated by light of wavelength 315 nm, what will be the maximum velocity of the released electrons?

a) $\frac{hc}{\lambda_{co}} = \phi \qquad \frac{(6.62 \times 10^{-34})(3 \times 10^{8})}{422 \times 10^{-9}} = \phi$

$\phi = 4.71 \times 10^{-19} J = 2.9 \; eV$

b) $(KE)_{max} = \frac{hc}{\lambda} - \phi$

$= \frac{(6.626 \times 10^{-34})(3 \times 10^{8})}{315 \times 10^{-9}} - 4.71 \times 10^{-19}$

$= 1.6 \times 10^{-19} J = \frac{1}{2} m v^2$

$v^2 = 3.5 \times 10^{11}$

$v = 5.9 \times 10^{5} \; m/s$

3. (25 pts) Cobalt-56, a common by-product of a nuclear fission weapon, has a half-life of 77.3 days. A sample of Cobalt-56 is found to have an activity of 0.28 Curies (Ci).

a) What is the mass of Cobalt-56 in the sample, in kg?

b) How many years will it take for the activity to decrease to 7.5 micro-Curies (μCi)?

a)

$$T_{1/2} = 77.3 \text{ days} = 6.68 \times 10^{6} \text{ s}$$

$$\lambda = 1.0376 \times 10^{-7}$$

$$a = 0.28 \text{ Ci} = 1.036 \times 10^{10} \text{ Bq}$$

$$N = \frac{a}{\lambda} = 9.98 \times 10^{16} \text{ atoms}$$

$$m_{TOT} = N m_{Co} = (9.98 \times 10^{16})(56 \text{ u})(1.66 \times 10^{-27} \tfrac{\text{kg}}{\text{u}})$$

$$= 9.3 \times 10^{-9} \text{ kg}$$

b)

$$7.5 \times 10^{-6} = 0.28 e^{-\lambda t}$$

$$-10.53 = -(1.0376 \times 10^{-7}) t$$

$$t = 1.015 \times 10^{8} \text{ s}$$

$$= 3.2 \text{ yrs}$$

2. (25 pts) An electron is in energy level 7 of a Hydrogen atom. It jumps from level 7 -> 4 (transition A), then 4 -> 2 (transition B), then 2 -> 1 (transition C).

a) Determine the wavelengths of the photons emitted by the atom when the electron makes each of these transitions.

b) Transition B is also known as "Balmer-Beta." How many Hydrogen atoms would need to be emitted the photon from this particular transition in order for a cloud of Hydrogen to emit a total of 12 Joules of this energy?

a) $7 \to 4$ $\quad \frac{1}{\lambda} = (1.097 \times 10^{7})\left(\frac{1}{16} - \frac{1}{49}\right)$

$$\lambda = 2.166 \times 10^{-6}\,m = \underline{2166\,nm}$$

$4 \to 2$ $\quad \frac{1}{\lambda} = (1.097 \times 10^{7})\left(\frac{1}{4} - \frac{1}{16}\right)$

$$\lambda = 4.86 \times 10^{-7}\,m = \underline{486\,nm}$$

$2 \to 1$ $\quad \frac{1}{\lambda} = (1.097 \times 10^{7})\left(\frac{1}{1} - \frac{1}{4}\right)$

$$\lambda = 1.21 \times 10^{-7}\,m = \underline{121\,nm}$$

b) $E = \frac{hc}{486\,nm} = 4.09 \times 10^{-19}\,J$

$E_{TOT} = 12\,J = N E_{photon}$

$$N = \frac{12}{4.09 \times 10^{-19}} = 2.9 \times 10^{19} \text{ atoms}$$