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. (25 points) A spaceship travels from Earth to Jupiter at a constant veleocity. According to clocks on board the spaceship, the trip takes 32 minutes. According to observers on the Earth, however, the trip takes 56 minutes.

a) How fast is the ship traveling, as measured in Earth's reference frame? Answer as a fraction of c.

b) What is the distance between Earth and Jupiter, as measured in Earth's reference frame?

c) According to passengers on the ship, what is the distance that they have travelled?

a) $\gamma = \frac{t_E}{t_{ship}} = \frac{56}{32} = 1.75 \Rightarrow 3.06 = \frac{1}{1-\frac{v^2}{c^2}}$

$\Rightarrow 3.06 - 3.06\frac{v^2}{c^2} = 1 \Rightarrow 3.06\frac{v^2}{c^2} = 2.06$

$\Rightarrow \frac{v^2}{c^2} = 0.67347 \Rightarrow v = 0.82c$

b) $d_E = vt_E = (.82)(3\times10^8)(56\,m)(60\,s/m) = 8.3\times10^{11}\,m$

$= 5.5\,AU$

c) $d_s = vt_s = (8.3\times10^{11})\left(\frac{32}{56}\right) = 4.7\times10^{11}\,m$

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) Carbon-14 has a half-life of 5700 years and mass of approximately 14 amu. A sample of wood contains 13 milligrams of Carbon-14.

a) What is the activity of this sample, in Curies?

b) How many years will it take for the activity to fall to 1.3% of its initial level?

$m_{TOT} = 13 \times 10^{-6}\ kg = N m_C$

$$N = \frac{13 \times 10^{-6}}{(14\ u)\left(\frac{1.66 \times 10^{-27}\ kg}{u}\right)} = 5.6 \times 10^{20}\ atoms$$

$T_{1/2} = 5700\ yr = 1.8 \times 10^{11}\ s$

$$\lambda = \frac{0.693}{T_{1/2}} = 3.85 \times 10^{-12}$$

a) $a = \lambda N = 2.15 \times 10^{9}\ Bq$

$= .058\ Ci$

b) $a = a_0 e^{-\lambda t}$

$.013 = e^{-\lambda t}$

$-4.34 = -(3.85 \times 10^{-12}) t$

$t = 1.13 \times 10^{12}\ s = 35{,}700\ yrs$

or 36,000 yrs

4. (25 pts) Find the energy released in the fusion reaction, in MeV:

$^2H + {}^3H \longrightarrow {}^4He + n$

The n represents a neutron with mass 1.008665 amu.
The mass of ^2H is 2.014102 amu.
The mass of ^3H is 3.016049 amu.
The mass of ^4He is 4.002602 amu.

The TCU campus uses about 2.5 billion kW-hr of energy in a given year. How many kg of Hydrogen (5 amu of Hydrogen per reaction) would be needed to satisfy this?

$m_{in} = 5.030151$

$m_{out} = 5.011267$

$\Delta m = .018884$

$E = 17.6\ MeV$

$= 2.8 \times 10^{-12}\ J$

$E_{TOT} = N E_{reac}$ $E_{TOT} = 2.5 \times 10^9\ kWhr$

$= 9.0 \times 10^{15}\ J$

$$N = \frac{9.0 \times 10^{15}}{2.8 \times 10^{-12}} = 3.2 \times 10^{27}\ atoms$$

$M_{TOT} = N M_{atom} = (3.2 \times 10^{27})(5u)(1.66 \times 10^{-27} kg/u)$

$= 26.6$ or (27 kg)