Physics 10164 - Exam 4B

Each problem is worth 25 points. 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 of a box and remember to include correct units and significant figures.

1. Light of wavelength 232 nm shines upon potassium, which has a work function of 2.24 eV. What is the maximum speed electrons have upon escaping from the potassium, in m/s?

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

$$\frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34})(3 \times 10^{8})}{232 \times 10^{-9}} = 8.568 \times 10^{-19} J$$

$$\phi = 2.24 \, eV = 3.584 \times 10^{-19} J$$

$$(KE)_{max} = 4.98 \times 10^{-19} = \frac{1}{2} m v^2$$

$$v^2 = 1.09 \times 10^{12}$$

$$\boxed{v = 1.0 \times 10^{6} \, m/s}$$

2. Which has a higher energy, the photon ~~emitted~~ absorbed during a transition from n = 3 to n = 5? Or the photon ~~emitted~~ during a transition from n = 5 to n = 8? Calculate both energies (in eV) to come up with the answer.

For both photons, calculate the wavelength.

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$= 1.097 \times 10^7 \left(\frac{1}{9} - \frac{1}{25}\right)$$

$$= 7.80 \times 10^5$$

$$\lambda = \underline{1.28 \times 10^{-6}\ m} \qquad 3 \rightarrow 5$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{5^2} - \frac{1}{8^2}\right)$$

$$= 2.67 \times 10^5$$

$$\lambda = \underline{3.74 \times 10^{-6}\ m} \qquad 5 \rightarrow 8$$

$$E_{3\rightarrow 5} = \frac{(6.626 \times 10^{-34})(3 \times 10^8)}{1.28 \times 10^{-6}} = 1.55 \times 10^{-19}\ J$$

$$= \boxed{0.97\ eV} \leftarrow \text{higher is } 3 \rightarrow 5$$

$$E_{5\rightarrow 8} = 5.31 \times 10^{-20}\ J = \boxed{0.33\ eV}$$

3. Iodine-131 has a half-life of 8.04 days.

a) How many grams of Iodine-131 are necessary to produce a sample with an activity of 0.35 micro-Curies? Assume the mass of Iodine is approximately 131 amu.

b) After how many days will the sample's activity drop to 12% of its initial level?

$$R = 0.35 \times 10^{-6}\,Ci \cdot \frac{3.7 \times 10^{10}\,Bq}{1\,Ci}$$

$$= 1.295 \times 10^{4}\,Bq$$

$$T_{1/2} = 8.04\,d = 6.95 \times 10^{5}\,s$$

$$\lambda = \frac{0.693}{T_{1/2}} = 9.98 \times 10^{-7}\,s^{-1}$$

$$R = \lambda N \quad \text{so} \quad N = \frac{R}{\lambda} = 1.3 \times 10^{10}\,\text{atoms}$$

$$M = (1.3 \times 10^{10}\,\text{atoms})\left(131\,\frac{\text{amu}}{\text{atom}}\right)\left(1.67 \times 10^{-27}\,\frac{\text{kg}}{\text{amu}}\right)$$

$$= 2.84 \times 10^{-15}\,kg$$

$$\text{or} \quad \boxed{2.8 \times 10^{-12}\,g}$$

b) $$\frac{R}{R_0} = 0.12 = e^{-\lambda t}$$

$$-2.12 = -(9.98 \times 10^{-7})t$$

$$t = 2.12 \times 10^{6}\,s = \boxed{25\text{ days}}$$

4. Find the energy released in the fusion reaction, in MeV:

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

The n represents a neutron with mass 1.008665 u
The mass of ^{2}H is 2.014102 u
The mass of ^{3}H is 3.016049 u
The mass of ^{4}He is 4.002602 u

The TCU campus uses about 2.0 billion kW-hr of energy per year. How many kg of Hydrogen (assume 1 of each isotope per reaction) would be needed to satisfy this?

$$M_{in} = 2.014102 + 3.016049 = 5.030151$$

$$M_{out} = 4.002602 + 1.008665 = 5.011267$$

$$E = \Delta mc^2 = (.018884)(931.5 \frac{MeV}{c^2}) = \boxed{17.6 \text{ MeV}} = 2.8 \times 10^{-12} J$$

$$E_{TOT} = (2 \times 10^9 \text{ kW.hr})(3.60 \times 10^6 \frac{J}{kW hr}) = 7.2 \times 10^{15} J$$

$$\# \text{ of reactions} = \frac{7.2 \times 10^{15}}{2.8 \times 10^{-12}} = 2.57 \times 10^{27}$$

$$Mass = (2.57 \times 10^{27})(5.030151 \text{ amu})(1.67 \times 10^{-27} \text{ kg/amu}) = \boxed{22 \text{ kg}}$$