# Physics 10164 - Exam 5B

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. (30 pts) A Hydrogen atom has an atom in the level n=4.

a) What is the shortest wavelength of light that can be emitted by an electron transitioning out of this level?

b) What is the longest wavelength of light that can be absorbed by an electron transitioning out of this level?

c) Which has a greater energy difference, a transition from level 4 to level 1 or a transition from level 4 to level 7? Calculate both and compare.

a) Shortest emission = Biggest drop $n=4 \rightarrow 1$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{1} - \frac{1}{16}\right) = 1.03 \times 10^7 \ m^{-1}$$

$$\boxed{\lambda = 97 \ nm}$$

b) Longest absorption = smallest energy increase

$= n = 4 \rightarrow 5$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{16} - \frac{1}{25}\right) = 2.47 \times 10^5$$

$$\lambda = 4.05 \times 10^{-6} = \boxed{4050 \ nm}$$

c) $4 \rightarrow 1 = \left|13.6\left(\frac{1}{1} - \frac{1}{16}\right)\right| = 12.8 \ eV$

$4 \rightarrow 7 = \left|13.6\left(\frac{1}{16} - \frac{1}{49}\right)\right| = 0.57 \ eV$

2. (30 pts) Light of wavelength 220 nm illuminates a metal with a work function of 4.1 eV.

a) What is the maximum speed with which electrons escape the metal?

b) What is the cutoff frequency below which no electrons escape the metal?

$$\frac{hc}{\lambda} = \frac{(6.626\times10^{-34})(3\times10^{8})}{220\times10^{-9}\,m} = 9.04\times10^{-19}\,J$$

$$= 5.65\,eV$$

a) $(KE)_{max} = 5.65 - 4.1 = 1.55\,eV$

$$= 2.48\times10^{-19}\,J$$

$$\frac{1}{2}(9.11\times10^{-31})v^2 = 2.48\times10^{-19}\,J$$

$$v^2 = 5.44\times10^{11}$$

$$\boxed{v = 7.4\times10^{5}\,m/s}$$

b) $hf = \phi$

$$(6.626\times10^{-34})f = (4.1\,eV)(1.6\times10^{-19}\,J/eV)$$

$$\boxed{f = 9.9\times10^{14}\,Hz}$$

3. (40 pts) The transition $p + {}^{11}B \rightarrow {}^{12}C$ is a form of fusion that doesn't release a neutron and could potentially generate a lot of energy for us. Assuming we can capture 100% of the energy released by this reaction, how many kg of Boron-11 would be necessary to power the world for one day, assuming the world uses energy at a rate of $15 \times 10^{12}$ Watts, or 15 terawatts?

Mass of p = 1.007276
Mass of Boron-11 = 11.009306
Mass of Carbon-12 = 12.000000

$$\Delta m = 1.007276 - 11.009306 - 12.000000$$

$$= .016582 \text{ u}$$

$$= 15.45 \text{ MeV or } 2.47 \times 10^{-12} \text{ J}$$

$$E_{reac} = 2.47 \times 10^{-12} \text{ J}$$

1 day

$$E_{TOT} = P \cdot t = (15 \times 10^{12})(86400 \text{ s})$$

$$= 1.30 \times 10^{18} \text{ J}$$

$$N_{reac} = \frac{E_{TOT}}{E_{reac}} = \frac{1.30 \times 10^{18}}{2.47 \times 10^{-12}} = 5.2 \times 10^{29}$$

$$M_{TOT} = N m_B = (5.2 \times 10^{29})(11.009306 \text{ u})(1.66 \times 10^{-27})$$

$$= \boxed{9600 \text{ kg}}$$