Physics 10164 - Exam 4B

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 pts) A metal surface is illuminated with light of wavelength 310 nm. The ejected photoelectrons have a maximum velocity of 7.5 x 10^5 m/s.

a) What is the work function of the metal (in eV)?
b) What is the minimum wavelength photon necessary in order for electrons to escape the metal?

a) $KE_{max} = \frac{1}{2}mv^2 = 2.56 \times 10^{-19} J$

$= 1.60 \ eV$

$E_\gamma = \frac{hc}{\lambda} = 6.41 \times 10^{-19} J = 4.01 eV$

$1.60 = 4.01 - \phi$ $\boxed{\phi = 2.41 \ eV}$

b) $\phi = 3.85 \times 10^{-19} = \frac{hc}{\lambda_{cut}}$

$\lambda_{cut} = 5.16 \times 10^{-7} m$ or $\boxed{516 \ nm}$

2. (25 pts) The first three photons in the Balmer series for neutral Hydrogen emission involve the the transitions:

$n_3 = 3 \rightarrow 2$ // $n_4 = 4 \rightarrow 2$ // $n_5 = 5 \rightarrow 2$

a) What is the energy (in eV) of each of these three photons?

b) Which emitted photon has the longest wavelength? What is that wavelength?

c) What is the maximum wavelength photon that can ionize an atom if the electron is in energy level n = 2?

a) $E_3 = 13.6\left(\frac{1}{4} - \frac{1}{9}\right) = 1.89\,eV$

$E_4 = 13.6\left(\frac{1}{4} - \frac{1}{16}\right) = 2.55\,eV$

$E_5 = 13.6\left(\frac{1}{4} - \frac{1}{25}\right) = 2.86\,eV$

b) Lowest $E = 1.89\,eV = 3.02 \times 10^{-19}\,J$

$= \frac{hc}{\lambda}$

Transition E_3, $\lambda = 656\,nm$

c) E_{min} would be $n = 2 \rightarrow \infty$, no E leftover

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

$\lambda = 365\,nm$

3. (25 pts) The lowest temperature fusion reaction that does not release any excess neutrons is:

$$^{1}H + ^{11}B \rightarrow ^{12}C$$

The mass of ^{1}H is 1.007276 u.
The mass of ^{11}B is 11.009306 u.
The mass of ^{12}C is 12.000000 u.

a) How much energy is liberated in this reaction, in MeV?
b) How many kg of Boron-11 would be needed in order to satisfy the needs of the United States, which requires about 2.6 x 10^{13} kw-hr? (for one year)

a) $\Delta m = .016582\ u = \boxed{15.4\ MeV}$

b) $E_{TOT} = 2.6 \times 10^{13}\ kw\text{-}hr = 9.36 \times 10^{19}\ J$

$E_{reac} = 15.4\ MeV = 2.46 \times 10^{-12}\ J$

$N_{reac} = \frac{E_{TOT}}{E_{reac}} = 3.8 \times 10^{31}$ reactions

$M_{TOT} = (3.8 \times 10^{31}\ atoms)(11\ u)(1.66 \times 10^{-27}\ \frac{kg}{u})$

$= \boxed{6.9 \times 10^{5}\ kg}$

4. (25 pts) Carbon-14 has a half-life of approximately 5700 years and a mass of approximately 14 u. A bone sample contains 1.7 milligrams of C-14.

a) What is the activity of this sample, in Curies?
b) If the initial amount of C-14 in the bone was 35 milligrams, how old is the bone (in years)?

a) $m = 1.7 \times 10^{-6}\ kg = N m_c$

$N_0 = 7.3 \times 10^{19}$ atoms

$\lambda = \frac{0.693}{1.8 \times 10^{11}\ s} = 3.85 \times 10^{-12}$

$a_0 = \lambda N_0 = 2.8 \times 10^{8}\ Bq$

$= .0076\ Ci$

b) $1.7 = 35 e^{-\lambda t}$

$-3.02 = -\lambda t$

$t = 7.86 \times 10^{11}\ s = 25{,}000\ yrs$