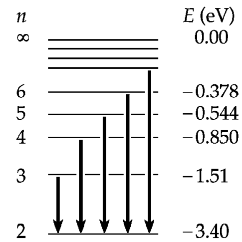
**P29.5** (a) Longest wavelength implies lowest frequency and smallest energy: the atom falls from $n = 3$

to $n = 2$

losing energy $-\dfrac{13.6 \text{ eV}}{3^2} + \dfrac{13.6 \text{ eV}}{2^2} = \boxed{1.89 \text{ eV}}$




**Balmer Series**

**FIG. P29.5**

The photon frequency is $f = \dfrac{\Delta E}{h}$

and its wavelength is

$$\lambda = \frac{c}{f} = \frac{hc}{\Delta E} = \frac{\left(6.626 \times 10^{-34} \text{ J} \cdot \text{s}\right)\left(3.00 \times 10^{8} \text{ m/s}\right)}{(1.89 \text{ eV})}\left(\frac{\text{eV}}{1.60 \times 10^{-19} \text{ J}}\right)$$

$$\lambda = \boxed{656 \text{ nm}}$$

(b) The biggest energy loss is for an atom to fall from an ionized configuration,

$n = \infty$

to the $n = 2$ state.

It loses energy $-\dfrac{13.6 \text{ eV}}{\infty} + \dfrac{13.6 \text{ eV}}{2^2} = \boxed{3.40 \text{ eV}}$

to emit light of wavelength $\lambda = \dfrac{hc}{\Delta E} = \dfrac{\left(6.626 \times 10^{-34} \text{ J} \cdot \text{s}\right)\left(3.00 \times 10^{8} \text{ m/s}\right)}{(3.40 \text{ eV})\left(1.60 \times 10^{-19} \text{ J/eV}\right)} = \boxed{365 \text{ nm}}$

**P29.34** Some electrons can give all their kinetic energy $K_e = e\Delta V$ to the creation of a single photon of x-radiation, with

$$hf = \frac{hc}{\lambda} = e\Delta V$$

$$\lambda = \frac{hc}{e\Delta V} = \frac{\left(6.626\,1 \times 10^{-34} \text{ J} \cdot \text{s}\right)\left(2.997\,9 \times 10^{8} \text{ m/s}\right)}{\left(1.602\,2 \times 10^{-19} \text{ C}\right)\Delta V} = \boxed{\frac{1\,240 \text{ nm} \cdot \text{V}}{\Delta V}}$$

**P30.8** Using atomic masses as given in Table A.3,

(a) For ${}^{2}_{1}\text{H}$: $\dfrac{-2.014\,102 + 1(1.008\,665) + 1(1.007\,825)}{2}$

$$\frac{E_b}{A} = (0.001\,194 \text{ u})\left(\frac{931.5 \text{ MeV}}{\text{u}}\right) = \boxed{1.11 \text{ MeV/nucleon}}.$$

(b) For ${}^{4}_{2}\text{He}$: $\dfrac{2(1.008\,665) + 2(1.007\,825) - 4.002\,603}{4}$

$$\frac{E_b}{A} = 0.007\,59 \text{ u}c^2 = \boxed{7.07 \text{ MeV/nucleon}}.$$

(c) For $^{56}_{26}\text{Fe}$: $30(1.008\,665)+26(1.007\,825)-55.934\,942=0.528\text{ u}$

$$\frac{E_b}{A}=\frac{0.528}{56}=0.009\,44\text{ u}c^2=\boxed{8.79\text{ MeV/nucleon}}.$$

(d) For $^{238}_{92}\text{U}$: $146(1.008\,665)+92(1.007\,825)-238.050\,783=1.934\,2\text{ u}$

$$\frac{E_b}{A}=\frac{1.934\,2}{238}=0.008\,13\text{ u}c^2=\boxed{7.57\text{ MeV/nucleon}}.$$

**P30.19** $Q=\left(M_{\text{U-238}}-M_{\text{Th-234}}-M_{\text{He-4}}\right)(931.5\text{ MeV/u})$

$$Q=(238.050\,783-234.043\,596-4.002\,603)\text{ u}(931.5\text{ MeV/u})=\boxed{4.27\text{ MeV}}$$

**P30.20** (a) A gamma ray has zero charge and it contains no protons or neutrons. So for a gamma ray $Z=0$ and $A=0$. Keeping the total values of $Z$ and $A$ for the system conserved then requires $Z=28$ and $A=65$ for $X$. With this atomic number it must be nickel, and the nucleus must be in an exited state, so it is $\boxed{^{65}_{28}\text{Ni}^*}$.

(b) $\alpha={}^4_2\text{He}$ has $Z=2$ and $A=4$

so for $X$ we require $Z=84-2=82$

for Pb and $A=215-4=211$, $X=\boxed{^{211}_{82}\text{Pb}}$.

(c) A positron $e^+={}^0_1e$ has charge the same as a nucleus with $Z=1$. A neutrino $^0_0\nu$ has no charge. Neither contains any protons or neutrons. So $X$ must have by conservation $Z=26+1=27$. It is Co. And $A=55+0=55$. It is $\boxed{^{55}_{27}\text{Co}}$.

Similar reasoning about balancing the sums of $Z$ and $A$ across the reaction reveals:

(d) $\boxed{^{0}_{-1}e}$

(e) $\boxed{^1_1\text{H (or p)}}$. Note that this process is a nuclear reaction, rather than radioactive decay. We can solve it from the same principles, which are fundamentally conservation of charge and conservation of baryon number.

**P30.24**

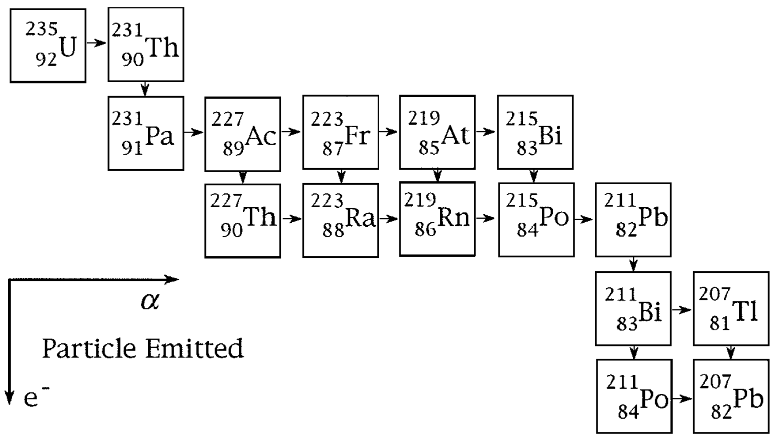



**FIG. P30.24**

**P30.26** (a) For $X$, $A = 24 + 1 - 4 = 21$

and $Z = 12 + 0 - 2 = 10$, so $X$ is $\boxed{{}^{21}_{10}\text{Ne}}$.

(b) $A = 235 + 1 - 90 - 2 = 144$

and $Z = 92 + 0 - 38 - 0 = 54$, so $X$ is $\boxed{{}^{144}_{54}\text{Xe}}$.

(c) $A = 2 - 2 = 0$

and $Z = 2 - 1 = +1$, so $X$ must be a positron.

As it is ejected, so is a neutrino: $\boxed{X = {}^{0}_{1}e^{+}}$ and $\boxed{X' = {}^{0}_{0}\nu}$.