Lecture Problems (Ch. 1-3)

1. calculation of ppth mass conversion to energy
   
a) \( \text{H}^+ + \text{e}^- \rightarrow \text{H} \quad Q = 13.6 \text{ keV/atom} \)

\[
\frac{13.6 \text{ eV}}{\text{atom}} \times \frac{1 \text{ amu}}{931.5 \times 10^6 \text{ eV/amu}} \times \frac{1.66 \times 10^{-24} \text{ g}}{1 \text{ amu}} \times \frac{6.022 \times 10^{23} \text{ atom}}{1 \text{ mol H}} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 1.46 \times 10^{-8} \text{ g/g H} \rightarrow 0.0000146 \text{ ppth mass conversion (15 ppb)}
\]

b) \( \text{^1H} + \text{n} \rightarrow \text{^2H} \quad Q = 2.22 \text{ MeV/atom} \)

\[
\frac{2.22 \text{ MeV}}{\text{atom}} \times \frac{1 \text{ amu}}{931.5 \text{ MeV}} \times \frac{1.66 \times 10^{-24} \text{ g}}{1 \text{ amu}} \times \frac{6.022 \times 10^{23} \text{ atom}}{1 \text{ mol H}} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 2.38 \times 10^{-3} \text{ g/g H} \rightarrow 2.38 \text{ ppth mass conversion}
\]

2. calculation of energy equivalent of the rest mass of an electron

\( \text{e}^- \text{ rest mass} = 5.49 \times 10^{-4} \text{ amu} \)

\[
5.49 \times 10^{-4} \text{ amu} \times \frac{931.5 \text{ MeV}}{1 \text{ amu}} = 0.511 \text{ MeV}
\]

3. calculation of the binding energy for \(^{56}\text{Fe}\) using mass excess (\(\Delta\)) values

\[
E_B = Z\Delta(\text{^1H}) + N\Delta(\text{n}) - \Delta(\text{^{56}Fe}) = 26(7.289 \text{ MeV}) + 30(8.071 \text{ MeV}) - (-60.603 \text{ MeV}) = 492.23 \text{ MeV}
\]

4. calculation of the fission energy for \(^{236}\text{U}\) using mass excess (\(\Delta\)) values

\[
Q = \Delta(\text{^{238}U}) - \Delta(\text{^{140}Xe}) - \Delta(\text{^{83}Sr}) - 3\Delta(\text{n})
\]

\[
Q = (42.441 \text{ MeV}) - (-72.990 \text{ MeV}) - (-80.160 \text{ MeV}) - 3(8.071 \text{ MeV}) = 171.4 \text{ MeV}
\]
5. prediction of the stable isobar for A=31 based on shell model

As one goes from $^{31}$Al to $^{31}$Si to $^{31}$P, there is more stability (lower energy state) by converting a neutron into a proton ($\beta^-$ decay). However, this is not true as you go from $^{31}$P to $^{31}$S. In fact, $^{31}$S is made more stable by converting a proton into a neutron ($\beta^+$ decay). Thus, $^{31}$P is expected to be the stable nuclide for A=31.