42.43. Solve:  (a) The binding energy of the electron in a hydrogen atom is \( B = 13.6 \text{ eV} \). That is, the mass decreases by the equivalent of 13.6 eV when an electron and proton form a hydrogen atom. Since \( B = \Delta mc^2 \),

\[
\Delta m = \frac{13.6 \text{ eV}}{c^2} = \frac{13.6 \text{ eV}}{931.49 \text{ MeV} / c^2} = \frac{1 \text{ u}}{1.007825 \text{ u}} = 1.46 \times 10^{-4} \text{ u}
\]

As a percentage of the hydrogen mass, the mass decrease is

\[
\frac{\Delta m}{1.007825 \text{ u}} = \frac{1.46 \times 10^{-4} \text{ u}}{1.007825 \text{ u}} = 1.45 \times 10^{-4}\%
\]

(b) The mass decrease is \( \Delta m = 2m_p + 2m_e - m_{\text{He nucleon}} \). These are nuclear masses, but Appendix C tabulates atomic masses. Add and subtract the mass of two electrons:

\[
\Delta m = 2(m_p + m_e) + 2m_n - (m_{\text{He nucleon}} - 2m_e) = 2m_p + 2m_n - m_{\text{He}}
\]

where \( m_p \) is the mass of a hydrogen atom and \( m_{\text{He}} \) is the mass of a helium atom. Using Appendix C,

\[
\Delta m = 2(1.007825 \text{ u}) + 2(1.008665) - 4.002602 = 0.0304 \text{ u}
\]

As a percentage of the helium mass, the mass decrease is

\[
\frac{0.0304 \text{ u}}{4.0026 \text{ u}} = 0.0076 = 0.76\%
\]

(c) Although mass does change in chemical reactions, the change is an incredibly small fraction of the mass of the atoms. No experiment will be sensitive to changes of \( \approx 1 \times 10^{-6}\% \), so this small change in mass is easily neglected. Not so in nuclear reactions, where the mass change can be \( \approx 1\% \) of the particle masses. Not only is this mass change easily detectable, it is essential for understanding nuclear reactions.