30.23

Use Eq. (30.1), $R = R_0 A^{1/3}$. For ^{238}U we have $R_U \approx (1.2\,\text{fm})(238)^{1/3} = 7.437\,\text{fm}$, and for ^{4}He $R_{He} \approx (1.2\,\text{fm})(4)^{1/3} = 1.905\,\text{fm}$. The difference between the two radii, to two significant figures, is then

$$\Delta R = R_U - R_{He} \approx 7.437\,\text{fm} - 1.905\,\text{fm} \approx 5.5\,\text{fm}\,.$$

In terms of the ratio R_U/R_{He}, since $R_U \propto A_U^{1/3}$ and $R_{He} \propto A_{He}^{1/3}$, we have

$$\frac{R_U}{R_{He}} = \left(\frac{A_U}{A_{He}}\right)^{1/3} = \left(\frac{238}{4}\right)^{1/3} = 3.9\,.$$

30.35

First, find the binding energy of the last neutron in the nuclide $^{40}_{20}$Ca. To do so, follow the same procedure in solving the previous two problems. The difference in mass between the $^{39}_{20}$Ca and $^{40}_{20}$Ca nuclides is $m_{40} - m_{39} = 39.962\,59\,\text{u} - 38.970\,69\,\text{u} = 0.991\,9\,\text{u}$, which is due to the addition of one neutron to the $^{39}_{20}$Ca nuclide. So the mass defect of the $^{40}_{20}$Ca nuclide associated with this last neutron is

$$\Delta m = m_n - (m_{40} - m_{39}) = 1.008\,665\,\text{u} - 0.991\,9\,\text{u} = 0.016\,765\,\text{u}\,,$$

and the corresponding binding energy of the last neutron in $^{40}_{20}$Ca is

$$\Delta m\,c^2 = (0.016\,765\,\text{u})(931.494\,\text{MeV/u}) = 15.616\,\text{MeV}\,,$$

which is equal to the amount of energy needed to strip the $^{40}_{20}$Ca of one neutron and turn it into $^{39}_{20}$Ca.

30.38

With the previous problem in mind, this time we are concerned with the Iron-55 atom, with $m_{Fe} = 54.938\,296\,\text{u}$, whose constituents, namely 26 protons, 26 electrons, and 29 neutrons, have a combined mass of $m = 26m_p + 26m_e + 29m_n = 26m_H + 29m_n$ before forming the atom. The mass defect of the nuclide is then

$$\begin{aligned}\Delta m &= m - m_{Fe} = (26m_H + 29m_n) - m_{Fe} \\ &= 26(1.007\,825\,\text{u}) + 29(1.008\,665\,\text{u}) - 54.938\,296\,\text{u} \\ &= 0.516\,439\,\text{u}\,.\end{aligned}$$