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Problem 43.79P (HRW)

We have to calculate (a) *the energy needed to remove a proton from a* $^{121}\mathrm{Sb}$ *nucleus, and* (b) *the energy needed to remove a proton from the resulting* $^{120}\mathrm{Sn}$ *nucleus. The needed atomic masses are*

$^{121}\mathrm{Sb}$	120.9038 u
$^{120}\mathrm{Sn}$	119.9022 u
$^{119}\mathrm{In}$	118.9058 u.

Solution:

(a)

We have to calculate the energy needed to remove a proton from a $^{121}\mathrm{Sb}$ nucleus. We note that the atomic number of antimony $^{121}\mathrm{Sb}$ is 51 and therefore an antimony atom has 51 electrons.

The atomic number of $^{120}\mathrm{Sn}$ is 50 and so a $^{120}\mathrm{Sn}$ atom contains 50 electrons.

Therefore, the energy required for removing a proton from a $^{121}\mathrm{Sb}$ nucleus will be

$$-Q = \left(\left(m\left({}^{120}\text{Sn}\right) - 50m_e\right) + m(p) - \left(m\left({}^{121}\text{Sb}\right) - 51m_e\right)\right)c^2$$

$$= \left(m\left({}^{120}\text{Sn}\right) + m\left({}^{1}\text{H}\right) - m\left({}^{121}\text{Sb}\right)\right)c^2$$

$$= (119.9022 + 1.007825 - 120.9038)\,\text{u}c^2$$

$$= 0.006225\ \text{u}c^2 = 0.006225\ \text{u}c^2 \times 931.5\ \text{MeV}$$

$$= 5.798\ \text{MeV}.$$

(b)

We have to calculate the energy needed to remove a proton from a ${}^{120}\text{Sn}$ nucleus. We note that the atomic number of indium ${}^{119}\text{In}$ is 49 and so an ${}^{119}\text{In}$ atom contains 49 electrons.

Therefore, the energy required for removing a proton from a ${}^{120}\text{Sn}$ nucleus will be

$$-Q = \left(\left(m\left({}^{119}\text{In}\right) - 49m_e\right) + m(p) - \left(m\left({}^{120}\text{Sn}\right) - 50m_e\right)\right)c^2$$

$$= \left(m\left({}^{119}\text{In}\right) + m\left({}^{1}\text{H}\right) - m\left({}^{120}\text{Sn}\right)\right)c^2$$

$$= (118.9058 + 1.007825 - 119.9022)\,\text{u}c^2$$

$$= 0.011425\ \text{u}c^2 = 0.011425\ \text{u}c^2 \times 931.5\ \text{MeV}$$

$$= 10.639\ \text{MeV}.$$

We note that ${}^{120}\text{Sn}$ nucleus contains 50 protons, which is a magic nucleon number. Therefore, ${}^{120}\text{Sn}$ nucleus, which requires 10.6 MeV for removing a proton form it, is more stable than ^{121}Sb nucleus, which requires 5.8 MeV for removing a proton from it.