**Chapter 8 Problem 24** [†]

**Given**

$r_p = 1.47 \times 10^{11}\ m$
$r_a = 1.52 \times 10^{11}\ m$
$m_e = 5.97 \times 10^{24}\ kg$
$m_s = 1.99 \times 10^{30}\ kg$

**Solution**

Find the change in potential energy from perihelion to aphelion.

$$\Delta U = U_a - U_p = \left(-\frac{Gm_s m_e}{r_a}\right) - \left(-\frac{Gm_s m_e}{r_p}\right)$$

$$\Delta U = Gm_s m_e \left(-\frac{1}{r_a} + \frac{1}{r_p}\right)$$

$$\Delta U = (6.67 \times 10^{-11}\ Nm^2/kg^2)(1.99 \times 10^{30}\ kg)(5.97 \times 10^{24}\ kg)\left(-\frac{1}{1.52 \times 10^{11}\ m} + \frac{1}{1.47 \times 10^{11}\ m}\right)$$

$$\Delta U = 1.77 \times 10^{32}\ J$$

[†]Problem from Essential University Physics, Wolfson