① (a) $m_H V_{H,initial} + m_{He} V_{He,initial} = m_H V_{H,final} + m_{He} V_{He,final}$

With $V_{He,initial} = 0$,

$$V_{He,final} = \frac{m_H (V_{H,initial} - V_{H,final})}{m_{He}} = \frac{(1.674\times10^{-27}\,kg)\left[1.1250\times10^{7}\,\frac{m}{s} - (-6.724\times10^{6}\,\frac{m}{s})\right]}{6.646\times10^{-27}\,kg}$$

$$= 4.527\times10^{6}\ m/s$$

(b) $\frac{1}{2} m_H V_{H,initial}^2 + \frac{1}{2} m_{He} V_{He,initial}^2 = \frac{1}{2} m_H V_{H,final}^2 + \frac{1}{2} m_{He} V_{He,final}^2$

$$V_{He,final} = \sqrt{\frac{m_H (V_{H,initial}^2 - V_{H,final}^2)}{m_{He}}}$$

$$= \sqrt{\frac{(1.674\times10^{-27}\,kg)\left[(1.1250\times10^{7}\,m/s)^2 - (-6.724\times10^{6}\,m/s)^2\right]}{6.646\times10^{-27}\,kg}}$$

$$= 4.527\times10^{6}\ m/s$$

② $p_i = p_f \Rightarrow (8.0kg)(2.0\,m/s) = (4.0kg)v_1 + (4.0kg)v_2 \Rightarrow 4 = v_1 + v_2$

$K_i + \Delta K = K_f \Rightarrow \frac{1}{2}(8.0kg)(2.0\,m/s)^2 + 16\,J = \frac{1}{2}(4.0kg)(v_1^2) + \frac{1}{2}(4.0kg)(v_2^2)$

$\Rightarrow 16 = v_1^2 + v_2^2$

$16 = v_1^2 + (4 - v_1)^2 = v_1^2 + 16 - 8v_1 + v_1^2$

$0 = 2v_1^2 - 8v_1 \Rightarrow v_1 = 0,\ 4.0\,m/s$

$p_i = (8.0kg)(2.0\,m/s) = 16\ kg\cdot m/s$

$p_f = (4.0kg)(0) + (4.0kg)(4.0\,m/s) = 16\ kg\cdot m/s$

$K_i = \frac{1}{2}(8.0kg)(2.0\,m/s)^2 = 16\,J$

$K_f = \frac{1}{2}(4.0kg)(0) + \frac{1}{2}(4.0kg)(4.0\,m/s)^2 = 32\,J = K_i + 16\,J.$

③ $p_i = p_f \Rightarrow \quad m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f$

With $v_2 = 0$, $\quad m_1 v_1 = (m_1 + m_2) v_f \quad$ or $\quad v_f = \frac{m_1}{m_1 + m_2} v_1$

$K_i = \frac{1}{2} m_1 v_1^2 \qquad K_f = \frac{1}{2}(m_1 + m_2) v_f^2 = 0.73 K_i = 0.73\left(\frac{1}{2} m_1 v_1^2\right)$

$$\frac{1}{2}(m_1 + m_2)\left[\frac{m_1}{m_1 + m_2} v_1\right]^2 = 0.73\left(\frac{1}{2} m_1 v_1^2\right)$$

$$\frac{m_1^2}{m_1 + m_2} = 0.73 m_1 \qquad m_1 = 0.73(m_1 + m_2)$$

$$m_2 = \frac{m_1}{0.73} - m_1 = 0.370 m_1 = \underline{\underline{12.9 \text{ tons}}}$$