1. a) $m_{rel} = \dfrac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \dfrac{62.40\ \text{kg}}{\sqrt{1-\frac{\left(\frac{100.00\cdot 10^6}{3.6}\ \frac{\text{m}}{\text{s}}\right)^2}{\left(299'792'458\ \frac{\text{m}}{\text{s}}\right)^2}}} = \underline{\underline{62.67\ \text{kg}}}$

b) $m_{rel} = \dfrac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \qquad \sqrt{1-\frac{v^2}{c^2}} = \frac{m_0}{m_{rel}} \qquad 1-\frac{v^2}{c^2} = \left(\frac{m_0}{m_{rel}}\right)^2 \qquad \frac{v^2}{c^2} = 1-\left(\frac{m_0}{m_{rel}}\right)^2$

$\frac{v}{c} = \sqrt{1-\left(\frac{m_0}{m_{rel}}\right)^2} \qquad v = c\cdot\sqrt{1-\left(\frac{m_0}{m_{rel}}\right)^2} = 299'792'458\ \frac{\text{m}}{\text{s}}\cdot\sqrt{1-\left(\frac{62.40\ \text{kg}}{70.30\ \text{kg}}\right)^2} = 138'074'788\ \frac{\text{m}}{\text{s}}$

$= \underline{\underline{1.381\cdot 10^8\ \frac{\text{m}}{\text{s}}}} = 497'069'236\ \frac{\text{km}}{\text{h}} = \underline{\underline{4.971\cdot 10^8\ \frac{\text{km}}{\text{h}}}}$

2. a) $\Delta m = \dfrac{\Delta E}{c^2} = \dfrac{1.30\cdot 10^6\ \text{J}}{\left(299'792'458\ \frac{\text{m}}{\text{s}}\right)^2} = \underline{\underline{1.45\cdot 10^{-11}\ \text{kg}}}$

b) $\dfrac{\Delta m}{m} = \dfrac{1.45\cdot 10^{-11}\ \text{kg}}{5.24\ \text{kg}} = 2.76\cdot 10^{-12} = \underline{2.76\cdot 10^{-10}\ \%}$

3. $v = c\cdot\sqrt{1-\left(\dfrac{m_0}{m_{rel}}\right)^2} = c\cdot\sqrt{1-\left(\dfrac{m_0}{3\cdot m_0}\right)^2} = c\cdot\sqrt{1-\left(\dfrac{1}{3}\right)^2} = c\cdot\sqrt{\dfrac{8}{9}} = 0.94\cdot c$

<u>94 % der Lichtgeschwindigkeit</u>

4. a) $E_0 = m_0\cdot c^2 = 9.109\cdot 10^{-31}\ \text{kg}\cdot\left(299'792'458\ \frac{\text{m}}{\text{s}}\right)^2 = \underline{8.187\cdot 10^{-14}\ \text{J}} = \underline{512\ \text{keV}}$

b) $m_{rel} = \dfrac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \dfrac{m_0}{\sqrt{1-\frac{(0.8\cdot c)^2}{c^2}}} = \dfrac{9.109\cdot 10^{-31}\ \text{kg}}{\sqrt{1-(0.8)^2}} = \underline{\underline{1.52\cdot 10^{-30}\ \text{kg}}}$

c) $E = \dfrac{E_0}{\sqrt{1-\frac{v^2}{c^2}}} = \dfrac{E_0}{\sqrt{1-\frac{(0.8\cdot c)^2}{c^2}}} = \dfrac{8.187\cdot 10^{-14}\ \text{J}}{\sqrt{1-(0.8)^2}} = \underline{\underline{1.365\cdot 10^{-13}\ \text{J}}} = \underline{853\ \text{keV}}$

d) $E_{kin} = E - E_0 = 1.365\cdot 10^{-13}\ \text{J} - 8.187\cdot 10^{-14}\ \text{J} = \underline{\underline{5.458\cdot 10^{-14}\ \text{J}}} = \underline{341\ \text{keV}}$

5. a) $W_{\text{Beschleunigung}} = E_{\text{kin}} = q \cdot U = 1.602 \cdot 10^{-19}\ \text{C} \cdot 804.5 \cdot 10^{3}\ \text{V} = \underline{\underline{1.289 \cdot 10^{-13}\ \text{J}}} = \underline{\underline{804.5\ \text{keV}}}$

b) $E_0 = m_0 \cdot c^2 = 9.109 \cdot 10^{-31}\ \text{kg} \cdot \left(299'792'458\ \frac{\text{m}}{\text{s}}\right)^2 = \underline{\underline{8.187 \cdot 10^{-14}\ \text{J}}} = \underline{\underline{512\ \text{keV}}}$

c) $E = E_{\text{kin}} + E_0 = 1.289 \cdot 10^{-13}\ \text{J} + 8.187 \cdot 10^{-14}\ \text{J} = \underline{\underline{2.108 \cdot 10^{-13}\ \text{J}}} = \underline{\underline{1'317\ \text{keV}}}$

d) $m_{\text{rel}} = \frac{E}{c^2} = \frac{2.108 \cdot 10^{-13}\ \text{J}}{\left(299'792'458\ \frac{\text{m}}{\text{s}}\right)^2} = \underline{\underline{2.345 \cdot 10^{-30}\ \text{kg}}}$

e) $v = c \cdot \sqrt{1 - \left(\frac{m_0}{m_{\text{rel}}}\right)^2} = 299'792'458\ \frac{\text{m}}{\text{s}} \cdot \sqrt{1 - \left(\frac{9.109 \cdot 10^{-31}\ \text{kg}}{2.345 \cdot 10^{-30}\ \text{kg}}\right)^2} = 276'260'278\ \frac{\text{m}}{\text{s}} = \underline{\underline{2.76 \cdot 10^{8}\ \frac{\text{m}}{\text{s}}}}$

f) $W_{\text{Beschleunigung}} = E_{\text{kin}} = q \cdot U = \frac{1}{2} \cdot m \cdot v^2$

$v = \sqrt{\frac{2 \cdot q \cdot U}{m_0}} = \sqrt{\frac{2 \cdot 1.602 \cdot 10^{-19}\ \text{C} \cdot 804.5 \cdot 10^{3}\ \text{V}}{9.11 \cdot 10^{-31}\ \text{kg}}} = 531'924'617\ \frac{\text{m}}{\text{s}} = \underline{\underline{5.319 \cdot 10^{8}\ \frac{\text{m}}{\text{s}}}}$

<u>Überlichtgeschwindigkeit</u>