

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

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

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

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

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

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

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

94 % der Lichtgeschwindigkeit

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

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

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

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

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

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

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

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

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

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

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

Überlichtgeschwindigkeit