Practice Test 3 Solutions

1. \( v = 2.8 \times 10^8 \text{ m/s} \Rightarrow \gamma = \frac{1}{\sqrt{1 - (\frac{v}{c})^2}} = 2.8 \)
   (a) \( t' = \frac{5000 \text{ m}}{2.8 \times 10^8 \text{ m/s}} = 17.9 \mu s \)
   (b) \( t = t' / \gamma = 6.4 \mu s \)

2. \( P \cdot mc^2 = 938.272 \text{ MeV} \)
   \( h \cdot mc = 939.565 \text{ MeV} \cdot c \cdot mc^2 = \)
   total separate = \( 1877.837 \text{ MeV} - 1875.613 \text{ MeV} = 2.224 \text{ MeV} \)

3. distant galaxy
   gravitational lens
   massive object
   apparent ring
   earth

4. a) \( V = H_0 \cdot D = 74 \text{ km/s} \cdot \frac{13.1 \times 10^9 \text{ pc}}{3.26 \text{ Mpc}} = 2.97 \times 10^8 \text{ m/s} \)
   (b) age = 13.7 billion years - 13.1 billion years = 0.6 billion years

5. 73% of mass/energy is thought to be in dark energy
   23% is thought to be in dark matter

6. \( \lambda_{\text{max}} = \frac{hc}{E} = \frac{1240 \text{ eV nm}}{2.14 \text{ eV}} = 579 \text{ nm} \) visible light
7. (a) electron \( \lambda = \frac{h}{p} = 0.4193 \text{ nm} \)

\[ p \cdot c = \frac{\hbar c}{\lambda} = \frac{1240 \text{ eVnm}}{0.4193 \text{ nm}} = 2957 \text{ eV} \]

Energy \( R = \frac{1}{2} m v^2 = \frac{p^2}{2m} = \frac{(p c)^2}{2m c^2} = \frac{(2957 \text{ eV})^2}{2(511 \text{ keV})} = 8.56 \text{ eV} \)

(b) photon \( E = \frac{h c}{\lambda} = 2957 \text{ eV} \)

8. (a) \( \Delta x = 0.1 \text{ nm} \)

\[ \Delta x \Delta p \geq \frac{\hbar}{2} \]

\[ \Delta p = \frac{\hbar}{2 \Delta x} \]

\[ \Delta (p c) = \frac{\hbar c}{2 \Delta x} = \frac{197.3 \text{ eVnm}}{2(0.1 \text{ nm})} = 990 \text{ eV} \]

(b) \( p = m v = m c \left( \frac{v}{c} \right) \)

\[ \frac{v}{c} = \frac{1}{137} \approx \frac{1}{4} \text{ of the electron momentum} \]

\[ p c = m c^2 \frac{1}{137} = 3730 \text{ eV} \]

9. High \( T \) is required so that a large enough number of \( D \) and \( T \) nuclei will collide with enough energy to get past electrical repulsion and fuse.

10. atmospheric cosmic ray events
    - the sun
    - nuclear reactions in the Earth's core
    - gamma ray bursts
    - supernovas