

HW1

1) a) $E = mc^2$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$c = 2.998 \text{ m/s}$$

$$e = 1.602 \text{ C}$$

$$E_{m_e} = 8.20 \times 10^{-14} \text{ J} \times \frac{\text{MeV}}{1.6 \times 10^{-13} \text{ J}} = 0.511 \text{ MeV}$$

$$m_e = 0.511 \text{ MeV}/c^2$$

b) $m_p = 1.6726 \times 10^{-27} \text{ kg}$

$$E_{m_p} = 938 \text{ MeV}$$

$$m_p = 938 \text{ MeV}/c^2$$

c) $m_d = 2m_p + 2m_n = 6.695 \times 10^{-27} \text{ kg}$

$$E_{m_d} = 3760 \text{ MeV}$$

$$m_d = 3760 \text{ MeV}$$

(neglecting B.E.)

2 a)

$$F_e = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$$

$$8.998 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2} \times \frac{(1.602 \times 10^{-19})^2}{(10^{-10})^2} = \underline{2.3 \times 10^{-8} \text{ N}}$$

$$F_g = \frac{G m_1 m_2}{r^2}$$

$$6.67 \times 10^{-11} \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2} \times m_p \times m_e / 10^{-10} \text{ m}^2 = 1.0 \times 10^{-47} \text{ N}$$

$$\frac{F_e}{F_g} = 2.3 \times 10^{39}$$

HW 1 pro.

$$5. \lambda = \frac{h}{p} = \frac{h}{\gamma m v} \quad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

a) For $v = 1 \times 10^6 \text{ m/sec}$ $\frac{v}{c} = 1/300 \Rightarrow \gamma \approx 1$

$$\lambda = \frac{h}{m v} = \frac{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}{9.11 \times 10^{-31} \text{ kg} \times 1.6 \times 10^6 \text{ m/sec}}$$

$$\approx 0.73 \times 10^{-34+31-6} = 0.73 \times 10^{-9} \text{ m}$$

$$\approx 0.73 \text{ nm or } \boxed{730 \text{ pm}}$$

nano = 10^{-9} pico = 10^{-12}

b) For $v = 1 \times 10^8 \text{ m/sec}$ $\frac{v}{c} \approx \frac{1}{3}$ $\frac{v^2}{c^2} = \frac{1}{9}$ $\gamma \approx \frac{1}{\sqrt{1 - \frac{1}{9}}} = 1.06$

$$\lambda = \frac{h}{\gamma m v} = \left(\frac{h}{m v}\right)_a \times \frac{1}{1.06 \times 100} = \frac{730 \text{ pm}}{106} = \boxed{6.9 \text{ pm}}$$

What about alternate method (cross check part a)

$$\lambda = \frac{h}{p} \quad \lambda = \frac{h c}{p c} \quad \lambda = \frac{197 \text{ MeV}\cdot\text{F}}{m v c} \quad m = 0.511 \frac{\text{MeV}}{c^2}$$

$$\lambda = \frac{197 \text{ MeV}\cdot\text{Fm}}{\frac{0.511 \text{ MeV}}{c^2} \cdot \frac{c}{300} \cdot c}$$

$$\lambda = \frac{197 \times 300}{0.511} \text{ fm} = 1.16 \times 10^5 \text{ fm}$$

$$\lambda = 116 \text{ pm}$$

$$\lambda = 2\pi \times 116 \text{ pm} = 730 \text{ pm} \checkmark$$