

1. $x'_1 = 0$ hingga $x'_2 = L_0$

$$L = x_2 - x_1$$

$$x' = \gamma(x - ut)$$

$$t' = \gamma(t - \frac{ux}{c^2})$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

• Waktu sama ($t_1 = t_2$)

$$x'_1 = \gamma(x_1 - ut)$$

$$x'_2 = \gamma(x_2 - ut)$$

$$L_0 = x'_2 - x'_1$$

$$L_0 = \gamma(x_2 - ut) - \gamma(x_1 - ut)$$

$$L_0 = \gamma(x_2 - x_1) \text{ atau}$$

$$L = \frac{L_0}{\gamma} \rightarrow \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

2. Diketahui

$$E = 25 \text{ GeV}$$

$$d = 3000 \text{ m}$$

$$m_0 = 0.511 \text{ MeV}/c^2$$

$$c = 3 \times 10^8 \text{ m/s}$$

Dit : a. kecepatan elektron yg energinya 25 GeV ?

b. waktu yg diperlukan untuk menempuh jarak 3000 m ?

c. panjang akselerator dalam kerangka acuan elektron ?

d. waktu tempuh elektron dalam kerangka acuan inersia Padi ?

Jawab :

$$a. E = \gamma m_0 c^2$$

$$\gamma = \frac{E}{m_0 c^2}$$

$$= \frac{25 \times 10^9 \text{ eV}}{0.511 \times 10^6 \text{ eV}}$$

$$= 4.89 \times 10^4$$

$$1 - \frac{v^2}{c^2} = \frac{1}{\gamma^2}$$

$$\frac{v^2}{c^2} = 1 - \frac{1}{(4.89 \times 10^4)^2}$$

$$v = c \sqrt{1 - \frac{1}{(4.89 \times 10^4)^2}}$$

$$v \approx c(1 - 1.05 \times 10^{-10})$$

$$\approx 2.99999 \times 10^8 \text{ m/s}$$

Selisih dgn kecepatan cahaya

$$c - v \approx 0.031 \text{ m/s}$$

Jadi elektron hampir bergerak dgn kecepatan cahaya

$$b) t = \frac{d}{v}$$

$$= \frac{3000 \text{ m}}{2,9999 \times 10^8 \text{ m/s}}$$

$$t \approx 1,0000000001 \times 10^{-8} \text{ s}$$

$$= 10 \text{ ns}$$

$$d) t' = \frac{t}{\gamma}$$

$$= \frac{10^{-8}}{4,89 \times 10^4}$$

$$t' \approx 2,04 \times 10^{-4} \text{ s} = 0,204 \text{ ns}$$

$$c) L' = L \sqrt{1 - \frac{v^2}{c^2}}$$

Karena $\gamma \approx 4,89 \times 10^4$ maka

$$L' = \frac{3000}{4,89 \times 10^4}$$

$$= 0,061 \text{ m} = 6,1 \text{ cm}$$

3. Dik: $\lambda_0 = 122 \text{ nm}$

$$\lambda' = 366 \text{ nm}$$

$$c = 3 \times 10^8 \text{ m/s}$$

Jawab:

$$a) \frac{\lambda'}{\lambda_0} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$$

$$\frac{366 \text{ nm}}{122 \text{ nm}} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$$

$$3 \text{ nm} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$$

$$9 = \frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}$$

$$9(1 - \frac{v}{c}) = 1 + \frac{v}{c}$$

$$9 - 9\frac{v}{c} = 1 + \frac{v}{c}$$

$$8 = 10\frac{v}{c}$$

$$v = \frac{8}{10} c = 0,8 c$$

$$v = 0,8 (3 \times 10^8 \text{ m/s})$$

$$= 2,4 \times 10^8 \text{ m/s}$$

$$b) \frac{\lambda''}{\lambda_0} = \sqrt{\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}}$$

$$\lambda'' = \lambda_0 \times \sqrt{\frac{1 - 0,8}{1 + 0,8}}$$

$$= \lambda_0 \times \sqrt{\frac{0,2}{1,8}}$$

$$= 122 \times \sqrt{0,111}$$

$$= 122 \times 0,332$$

$$\lambda'' \approx 40,67 \text{ nm}$$

4. Dik: $E_{\text{peratom}} = 200 \text{ MeV}$

M Uranium =

$$A = 235$$

$$1 \text{ MeV} = 1,602 \times 10^{-13} \text{ J}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$m_{\text{atom}} = \frac{235}{6,022 \times 10^{23}}$$

Jawab:

$$E = 200 \text{ MeV} \times 1,602 \times 10^{-13} \text{ J/MeV}$$

$$= 3,204 \times 10^{-11} \text{ J}$$

Jumlah atom dalam uranium 1 kg

$$N = \frac{1000}{M_{\text{atom}}} = \frac{1000}{\frac{235}{6,022 \times 10^{23}}} = 2,56 \times 10^{24} \text{ atom}$$

$$E_{\text{total}} = (3,204 \times 10^{-11} \text{ J/atom}) (2,56 \times 10^{24})$$
$$= 8,20 \times 10^{13}$$

$$E = mc^2 \rightarrow m = E/c^2$$

$$m = (8,20 \times 10^{13} \text{ J}) / (3 \times 10^8 \text{ m/s})^2$$
$$\approx 9,11 \times 10^{-4} \text{ kg}$$

5. Dik: $m_p = 1,007276 \text{ u}$

$$m_n = 1,66054 \times 10^{-27} \text{ kg}$$

$$m_n = 1,008665 \text{ u}$$

$$mc^2 = 931,5 \text{ MeV}$$

$$m_{\text{Helium}} = 4,001506 \text{ u}$$

Jawab:

$$a) \text{ Massa total} = 2 m_p + 2 m_n$$

$$= 2(1,007276 + 2(1,008665))$$

$$= 4,0318824$$

$$\Delta m = m_t - m_{\text{hel}}$$

$$= 4,0318824 - 4,001506$$

$$= 0,030376 \text{ u}$$

$$E = \Delta mc^2$$

$$= (3,044 \times 10^{-24} \text{ kg}) (2,9979 \times 10^8 \text{ m/s})^2$$

$$= 4,533 \times 10^{-12} \text{ J} = 28,3 \text{ MeV}$$

$$b) \Delta m \text{ kg} = (0,030376 \text{ u}) \times (1,66054 \times 10^{-27})$$
$$= 3,04 \times 10^{-29} \text{ kg}$$

6. Dik: $V_A = 0,8 c$

$$V_B = 0,6 c$$

$$\text{Jawab: } v' = \frac{V_A + V_B}{1 + \frac{V_A V_B}{c^2}} = \frac{0,8 + 0,6 c}{1 + \frac{(0,8)(0,6)}{c^2}} = \frac{1,4 c}{1 + 0,48} = \frac{1,4}{1,48} = 0,946 c$$

7. Dik: $P = 20 \text{ W}$

$$\lambda = 589 \text{ nm} = 589 \times 10^{-9} \text{ m}$$

$$h = 6,626 \times 10^{-34} \text{ J/s}$$

$$c = 3 \times 10^8 \text{ m/s}$$

Jawab:

$$E = \frac{hc}{\lambda} = \frac{(6,626 \times 10^{-34})(3 \times 10^8)}{589 \times 10^{-9}} = \frac{1,9878 \times 10^{-25}}{589 \times 10^{-9}} \approx 3,37 \times 10^{-19} \text{ J}$$

$$N = \frac{20}{3,37 \times 10^{-19}} = 5,94 \times 10^{19} \text{ foton/detik}$$

8. Dik: $W = 2,2 \text{ eV}$

$$\lambda = 3500 \text{ Å} = 3500 \times 10^{-10} \text{ m} = 3,5 \times 10^{-7} \text{ m}$$

$$h = 6,626 \times 10^{-34} \text{ J/s}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$1 \text{ eV} = 1,6 \times 10^{-19} \text{ J}$$

Jawab:

$$E = \frac{hc}{\lambda} = \frac{(6,626 \times 10^{-34})(3 \times 10^8)}{3,5 \times 10^{-7}} = \frac{1,9878 \times 10^{-25}}{3,5 \times 10^{-7}} \approx 5,68 \times 10^{-19} \text{ J}$$

$$E = \frac{5,68 \times 10^{-19}}{1,6 \times 10^{-19}} = 3,53 \text{ eV}$$

$$K = E - W$$

$$= 3,53 - 2,2 = 1,35 \text{ eV}$$