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 Mata Kuliah : Fisika Modern

1. $x'_1 = 0$ hingga $x'_2 = l_0$
 $l = x_2 - x_1$

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

$$t' = \gamma \left(1 - \frac{ux}{c^2}\right)$$

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

* waktu sama ($t_1 = t_2$)

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

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

$$l_0 = x'_2 - x'_1$$

$$l_0 = \gamma (x_2 - ut) - \gamma (x_1 - ut)$$

$$\begin{aligned} l_0 &= \gamma (x_2 - x_1) \text{ atau} \\ l &= \frac{l_0}{\gamma} \rightarrow \gamma = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}} \\ l &= l_0 \sqrt{1 - \frac{u^2}{c^2}} \end{aligned}$$

2) Diketahui :

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

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

$$m_0 = 0,511 \text{ MeV}/c^2$$

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

Jawab :

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

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

$$= \frac{25 \times 10^9 \text{ eV}}{0,511 \times 10^6 \text{ eV}}$$

$$= 4,89 \times 10^4$$

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

$$\frac{v^2}{c^2} = 1 - \frac{1}{(4,89 \times 10^4)^2}$$

$$v = c \sqrt{1 - \frac{1}{(4,89 \times 10^4)^2}}$$

$$v \approx c (1 - 1,05 \times 10^{-10})$$

$$v \approx 2,9999 \times 10^8 \text{ m/s}$$

selisih dengan kecepatan cahaya

$$c - v \approx 0,031 \text{ m/s}$$

Jadi elektron hampir bergerak dengan kecepatan cahaya.

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

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

$$t \approx 1,000000001 \times 10^{-3} \text{ s}$$

$$= 10 \text{ ns}$$

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

$$\text{diketahui } l = 4,89 \times 10^4, \text{ maka}$$

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

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

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

$$t' = \frac{10^{-9}}{4,89 \times 10^4}$$

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

$$= 0,204 \text{ ms}$$

$$(3) \text{ Diketahui } = \lambda_0 = 122 \text{ nm}$$

$$\lambda_1 = 366 \text{ nm}$$

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

Jawab:

$$a) \frac{\lambda_1}{\lambda_0} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$$

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

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

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

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

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

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

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

$$v = 0,8 (3 \times 10^8 \text{ m/s}) = 2,4 \times 10^8 \text{ m/s}$$

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

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

$$= 122 \times \sqrt{\frac{0,2}{1,8}}$$

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

$$= 122 \times 0,3323$$

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

4). Diketahui :

$$E \text{ peratom} = 200 \text{ MeV}$$

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 :

$$N = \frac{1000 \text{ g}}{m \text{ atom}}$$

$$= \frac{1000 \text{ g}}{235}$$

$$= 2,56 \times 10^{24} \text{ atom}$$

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

$$= 8,20 \times 10^{13} \text{ J}$$

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

$$m = (8,20 \times 10^{13} \text{ J}) / (3 \times 10^8 \text{ m/s})^2$$

$$\approx 9,11 \times 10^{-14} \text{ kg}$$

5). Diketahui :

$$m_p = 1,007276 \text{ u}$$

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

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

$$1 \text{ u}^2 = 931,5 \text{ MeV}$$

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

Jawab:

a) massa total = 2 m_p + 2 m_n

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

$$= 4,031882 \text{ u}$$

$$4m = m_{\text{total}} - m_{\text{helium}}$$

$$= 4,031882 - 4,001506$$

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

$$E = 4mc^2$$

$$= (3,044 \times 10^{-29} \text{ kg}) (2,9979 \times 10^8 \text{ m/s})^2$$

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

$$= 26,3 \text{ MeV}$$

b) $4m_{\text{kg}} = (0,030376 \text{ u}) \times (1,66054 \times 10^{-27} \text{ kg})$

$$= 3,04 \times 10^{-29} \text{ kg}$$

6) Diketahui :

$$v_A = 0,8c$$

$$v_B = 0,6c$$

Jawab

$$v' = \frac{v_A + v_B}{1 + \frac{v_A v_B}{c^2}} = \frac{0,8c + 0,6c}{1 + \frac{(0,8)(0,6)}{1}} = \frac{1,4c}{1,48} = \frac{1,4}{1,48} = 0,946c$$

(1) Diketahui:

$$P = 20 \text{ W}$$

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

$$h = 6,626 \times 10^{-34} \text{ Js}$$

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

Jawab:

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

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

(2) Diketahui: $W = 2,2 \text{ eV}$

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

$$h = 6,626 \times 10^{-34} \text{ Js}$$

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

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

Jawab:

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

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

$$K = E - W \\ = 3,53 - 2,2 \\ = 1,33 \text{ eV}$$