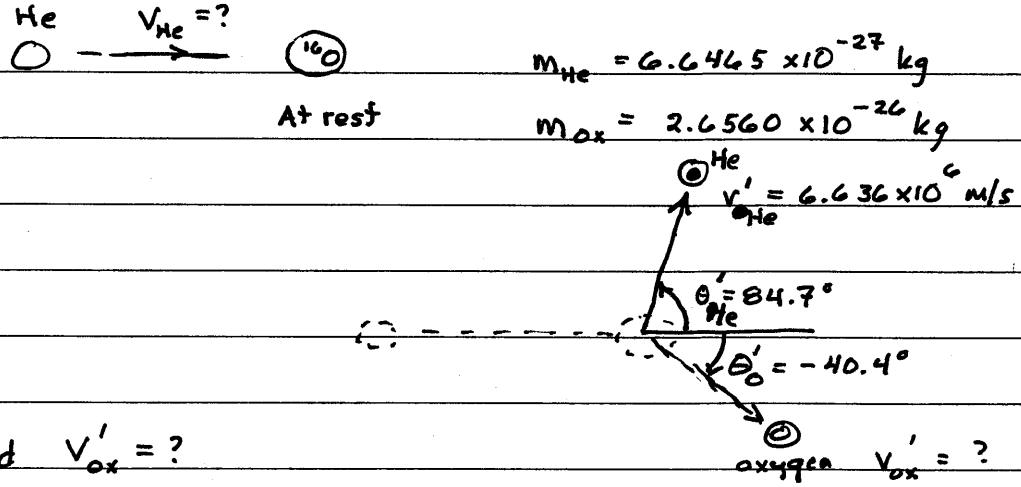
Modern Physics PS303 1/17/2016

DATE	
TOPIC	

Homework #1 1.2, 1.4, 1.6, 1.7, 1.8

Due Thurs. Jan. 21

1.2



a.) Find V'_{ox} = ?

$$P_{y,He} + P_{y,ox} = 0$$

$$m_{He} V'_{He} \sin\theta'_{He} + m_{ox} V'_{ox} \sin\theta'_{ox} = 0$$

$$V'_{ox} = -\frac{m_{He} V'_{He} \sin\theta'_{He}}{m_{ox} \sin\theta'_{ox}} = 2.55 \times 10^{6} \text{ m/s}$$

b.) Find V_{He} = ? $\quad P_{He,init} = P'_{x,He} + P'_{x,ox}$

$$m_{He} V_{He} = m_{He} V'_{He} \cos\theta_{He} + m_{ox} V'_{ox} \cos\theta'_{ox}$$

$$V_{He} = V'_{He} \cos\theta_{He} + \frac{m_{ox}}{m_{He}} V'_{ox} \cos\theta'_{ox} = 8.37 \times 10^{6} \text{ m/s}$$

1.4

$Be \rightarrow He + He$ $\quad Q = 92.2$ keV $\quad m_{Be} = 8.005305103$ u

8.00u 4.00u 4.00u $\quad Q = \frac{p^2}{2m_{He}} + \frac{p^2}{2m_{He}}$ $\quad m_{He} = 4.00260325415$ u

$mc^2 = (m_{Be} - 2m_{He})c^2 = 91.84$ keV

$1u = 931.494 \frac{MeV}{c^2}$

a.) KE_{He} = ?

$$KE_{He} = \frac{1}{2} Q = 46.1 \text{ keV}$$

b.) V_{He} = ? $\quad \frac{p^2}{m_{He}} = Q \quad m_{He} V_{He}^2 = Q \quad V_{He} = \sqrt{\frac{Q}{m_{He}}}\, c$

$$V_{He} = \sqrt{\frac{92.2 \times 10^{3} \text{ eV}}{4.00(931.494 \text{ MeV})}}\; 3 \times 10^{8} \text{ m/s} = 1.49 \times 10^{6} \text{ m/s}$$

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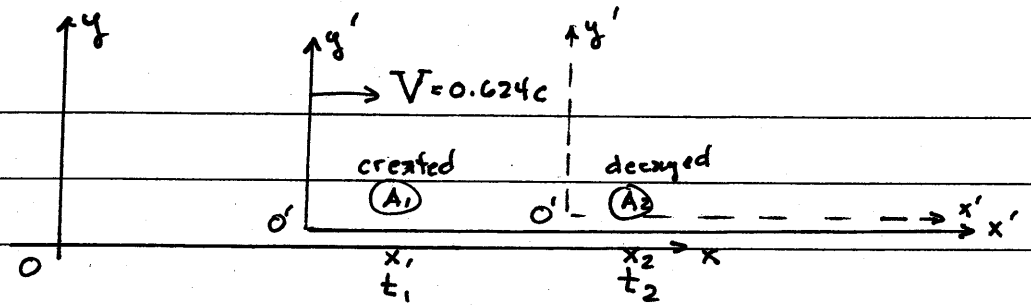
Homework #1

1.6



$t_2 - t_1 = 159$ ns

As seen by observer O (A)

$$x_2 - x_1 = V(t_2 - t_1) = 0.624\,c\,(159\text{ ns}) = 29.8 \text{ meters}$$

(159 ns: time dilation)

As seen by observer O' (B) $(x_2' - x_1') = ?$

$$x_2' - x_1' = (V)(124\text{ ns}) = 23.2 \text{ meters}$$

1.7

A sample of Ar gas $T = (273 + 35)C^\circ = 308$ K

$P = 1.22 \text{ atm}\left(1.013 \times 10^5 \text{ Pa}/\text{atm}\right) = 1.24 \times 10^5$ Pa

$R_{Argon} = 0.710 \times 10^{-10}$ m

$$PV = Nk_BT \qquad N = \frac{PV}{k_BT} = \frac{1.24\times10^5 \text{ Pa}\ V}{1.38\times10^{-23}\frac{J}{K}(308\text{ K})}$$

$$\frac{N}{V} = 2.91 \times 10^{25} \frac{\text{atoms}}{m^3} \qquad \frac{N(V_o)}{V} = \frac{N\left(\frac{4}{3}\pi R_o^3\right)}{V}$$

$$\frac{N(V_o)}{V} = 2.91\times10^{25}\frac{\text{atoms}}{m^3}\,\frac{4}{3}\pi\,(0.710\times10^{-10}\text{ m})^3 = 4.36\times10^{-5}$$

$$\boxed{\text{fraction} = 4.36 \times 10^{-5}}$$

1.8

Maxwell–Boltzmann Distribution of Energies

$f(E)$ = normalized pdf $\qquad f(E) = A\,E^{1/2}\,e^{-E/k_BT}$ (A: a constant)

$$\frac{d}{dE}f(E) = -\frac{1}{k_BT}E^{\frac{1}{2}}e^{-E/k_BT} + \frac{1}{2}E^{-1/2}e^{-E/k_BT} = 0$$

$$\frac{E}{k_BT} = \frac{1}{2} \qquad \boxed{E_{peak} = \frac{1}{2}k_BT}$$