Phys 201 F'09 PS 6 Solutions

3.22 $-N_A|e| = -(6.022\times10^{23})(1.602\times10^{-19}\,C)$

$= \boxed{-96{,}470\,C}$

3.24 a) Mass of CO_2 molecule $= (12+2\cdot16)u = 44u$

$1g = N_A u = (\#CO_2 \text{ molecules})\cdot 44u$

$\rightarrow \#CO_2 \text{ molecules} = \frac{N_A u}{44u} = \frac{6.02\times10^{23}}{44} = 1.37\times10^{22}$

$\#C \text{ atoms} = \#CO_2 \text{ molecules} = \boxed{1.37\times10^{22}}$

$\boxed{\frac{1}{3}}$ atoms are C, $\frac{m_C}{m_{CO_2}} = \frac{12u}{44u} = \boxed{\frac{3}{11}}$ mass in C.

b) 1 mole $CH_4 = 6.02\times10^{23}$ CH_4 molecules

$\#C \text{ atoms} = \#CH_4 \text{ molecules} = \boxed{6.02\times10^{23}}$

$\boxed{\frac{1}{5}}$ atoms are C, $\frac{m_C}{m_{CH_4}} = \frac{12u}{(12+4\cdot1)u} = \boxed{\frac{3}{4}}$ mass in C

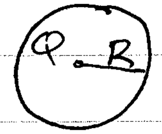
c) 1 Kmole $C_2H_6 = 6.02\times10^{26}$ C_2H_6 molecules

$\#C \text{ atoms} = 2\cdot\#C_2H_6 \text{ molecules} = \boxed{1.20\times10^{27}}$

$\frac{3}{8} = \boxed{\frac{1}{4}}$ atoms are C

$\frac{m_{C_2}}{m_{C_2H_6}} = \frac{2\cdot12u}{(2\cdot12+6\cdot1)u} = \boxed{\frac{4}{5}}$ mass in C

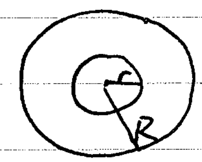
3.47



Field outside sphere of charge $Q = |Ze|$:

$$|\vec{E}_{out}| = \frac{ZK|e|}{r^2} \quad , r = \text{distance from center}$$

Field inside sphere: Use Gauss' law.



Charge enclosed in sphere of radius $r<R$:

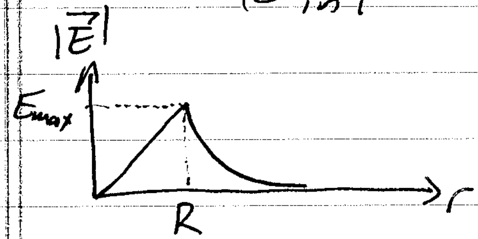
$$Q_r = \rho \cdot \tfrac{4}{3}\pi r^3$$

$$\rho = \text{charge density} = \frac{Q}{\tfrac{4}{3}\pi R^3} \quad , \text{so}$$

$$Q_r = Q\frac{r^3}{R^3} = \frac{|Ze|r^3}{R^3}$$

$$|\vec{E}_{in}| \cdot 4\pi r^2 = 4\pi K Q_r = 4\pi K \cdot \frac{|Ze|r^3}{R^3} \quad \text{Gauss' Law}$$

$$|\vec{E}_{in}| = \frac{K|Ze|}{R^3} r$$



Max field @ $r = R$.

Thomson Model: $R = 0.18$ nm

$$E_{max} = \frac{K|Ze|}{R^2} = \frac{79 \cdot (1.44 \text{ V}\cdot\text{nm})}{(0.18 \text{ nm})^2} = 3500 \text{ V/nm}$$

$$= \boxed{3.5\times10^{12} \text{ V/m}}$$

Rutherford Model: $R = 8$ fm $= 8\times10^{-15}$ m

$$E_{max} = \frac{79\,(1.44\times10^{-9} \text{ V}\cdot\text{m})}{(8\times10^{-15} \text{ m})^2} = \boxed{1.8\times10^{21} \text{ V/m}}$$

3.50 N_θ = # α particles observed

$$= \underbrace{\frac{Nnt}{4s^2}\left(\frac{zke^2}{E}\right)^2 \cdot \frac{1}{\sin^4(\theta/2)}}_{\#/\text{unit area}} \cdot A_{screen}$$

(Rutherford formula)

$$N_\theta = \frac{(10^6)\cdot\left(\frac{19.3\ g/cm^3}{197\ g/(6.02\times10^{23}\ nuclei)}\right)\cdot(2\times10^{-4}\ cm)}{4\ (12\,cm)^2}$$

$$\times \left(\frac{79\,(1.44\ MeV\cdot 10^{-13}\ cm)}{5.2\ MeV}\right)^2 \cdot \frac{1}{\sin^4(\theta/2)} \cdot (1\,cm^2)$$

$$\approx \frac{0.10}{\sin^4(\theta/2)}$$

$$\boxed{\begin{aligned} N_{15^\circ} &\approx 345 \\ N_{30^\circ} &\approx 22 \\ N_{45^\circ} &\approx 4.7 \end{aligned}}$$

(on average)