Sunday, November 08, 2009
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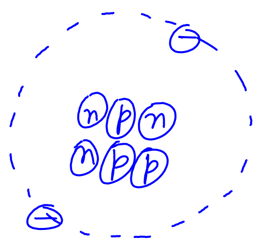
Solution to Selected Problems in HW 11.

Question 38.9

(a)



There are two "⊖"

So # of electrons = 2

lly, # of protons = 3

# of neutrons = 3

Now, we know that an atom with 3 protons is Lithium "Li" (with A = 3)

But to be neutral, it needs 3 electrons and has only 2.

Hence it has to be positively charged overall. we also have

$$Z = \underbrace{3}_{\text{protons}} + \underbrace{3}_{\text{neutrons}} = 6 \Rightarrow {}^{6}Li^{+}$$

(b) This has # of e^- = 7

# of p = 6

# of n = 7

Now, with 6 protons, it is Carbon C, with

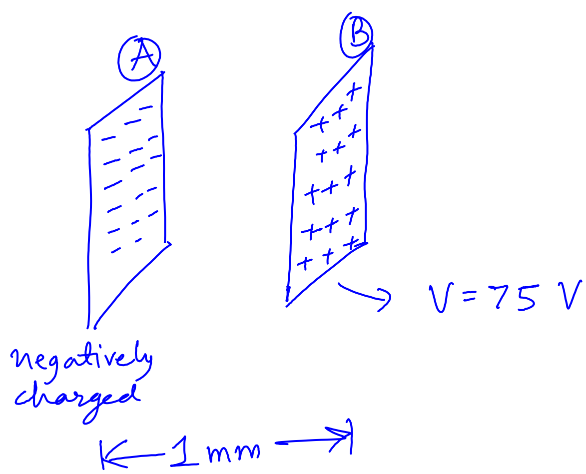
$Z = 6 + 7 = 13$ and it has one more

electron, than it needs to be neutral

$$\Rightarrow {}^{13}C^{-}$$

Problem 38.11.

Picture the problem as following:



The energy of proton at plate A is

$\frac{1}{2} m_p v_A^2 + eV_A$, and at plate B is

$\frac{1}{2} m_p v_B^2 + eV_B$

From energy conservation, they must be equal

$$\Rightarrow \frac{1}{2} m_p v_A^2 + eV_A = \frac{1}{2} m_p v_B^2 + eV_B$$

Now, we want the proton to barely reach the positive plate (plate B)

$$\Rightarrow v_B = 0$$

$$\Rightarrow \frac{1}{2} m_p v_A^2 + eV_A = 0 + eV_B$$

$$\Rightarrow \frac{1}{2} m_p v_A^2 = e(V_B - V_A)$$

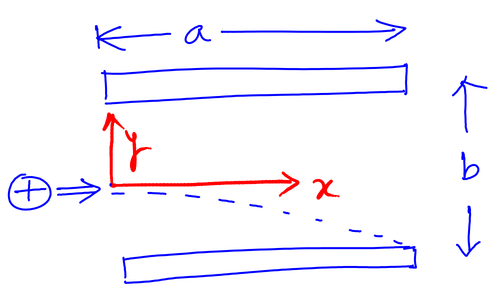
$= e \cdot 75$ Volts

$= 75$ eV

$=$ Kinetic energy of proton at plate A

Clearly, the plate separation doesn't matter.

Problem 38.32



The proton enters at the middle. Lets set-up a coordinate system first, with the origin at the point where the proton enters

Now, it is shown that proton deflects down, so the force on it must be in $-\hat{y}$ direction. Since the force on it must be in $-\hat{y}$ direction. Since it has a positive charge, the $\vec{E}$ is also in $-\hat{y}$, so the upper plate is positively charged.

The force acting on the proton is

$$\vec{F} = e\vec{E} = \frac{e\,\Delta V}{b}(-\hat{y})$$

$$= m a_x \hat{x} + m a_y \hat{y} \quad \left[\text{Newton's Law}\right]$$

$$\Rightarrow a_x = 0 \; ; \; a_y = -\frac{e\,\Delta V}{mb} \quad — ①$$

We also know that the proton hits the lower end of one plate. Hence it started at $x=0$ and reached $x=a$

$$\Rightarrow \quad a_x = 0 = \frac{d^2x}{dt^2}$$

$$\Rightarrow x_{final} = x_{initial} + v t$$

$$a = 0 + v_x t$$

$$\Rightarrow v_x t = a \Rightarrow t = \frac{a}{v_x} \quad — ②$$

We also know about the y-motion.

$$\frac{d^2y}{dt^2} = \frac{-e\,\Delta V}{mb} = a_y \;(\text{constant})$$

$$\Rightarrow y_{final} = y_{initial} + v_y t + \frac{1}{2} a_y t^2$$

$$\Rightarrow \frac{-b}{2} = 0 + 0 - \frac{e\,\Delta V}{2mb} t^2$$

where we assumed $v_y = 0$, as the proton enters horizontally

$$\Rightarrow \frac{\cancel{-}b}{2} = \frac{\cancel{-}e\,\Delta V}{2mb} \cdot \left(\frac{a}{v_x}\right)^2 \quad \text{Using ②}$$

$$\Rightarrow v_x = a\sqrt{\frac{e\,\Delta V}{mb^2}} \quad — ③$$

If we also apply a magnetic field, the magnetic force must cancel the Electric force for no deflection.

$$\Rightarrow \quad e \cdot \frac{\Delta V}{b} = e\, v_x\, B \qquad \text{— ④}$$

Hence B must be applied into the page

Using ③ & ④

$$B = \frac{\Delta V}{b v_x} = \frac{\Delta V}{ab}\sqrt{\frac{m b^2}{e\,\Delta V}} = \left[\frac{m\,\Delta V}{e\,a^2}\right]^{1/2}$$

Plugging numbers

$$B = \left[\frac{1.67\times10^{-27}\times 500 \times100\times100}{1.6\times10^{-19}\times 5\times5}\right]^{1/2}$$

$$\approx \frac{1}{\sqrt{500}} \simeq \frac{1}{22} \approx 0.045 \text{ Tesla.}$$

Problem 39.40

We have $(KE)_{max} = h\nu - \varphi$

where ν is the frequency or f.

φ is the work function, and is a constant we can always define it in terms of another constant

$$\varphi \equiv h f_0$$

$$\Rightarrow (KE)_{max} = hf - hf_0$$

$$= eV_{stopping}$$

$$\Rightarrow \quad V_s = \frac{h}{e}(f - f_0) \qquad \text{— ①}$$

Call $V_s \equiv y$ and $f \equiv x$; $\frac{h}{e} \equiv m$

and $f_0 \equiv x_0$

$\Rightarrow$ ① looks like

$$y = mx - mx_0 = m(x - x_0)$$

Hence a plot of y vs x has slope m

Hence a plot of y vs x has slope m and intercept x_0

We are given a y vs x plot here (ie. V_s vs f plot)

$\Rightarrow$ From plot $y = 0$ when $x = x_0$

$\Rightarrow x_0 = 1 \times 10^{15}$ Hz $= f_0$

and, slope

$$= \frac{h}{e} = \frac{\Delta y}{\Delta x} = \frac{2}{\frac{1}{2} \times 10^{15}} = 4 \times 10^{-15}$$

$$\Rightarrow h = 4 \times 10^{-15} \times 1.6 \times 10^{-19}$$

$$= 6.4 \times 10^{-34}$$

So, we do get a value of Planck's constant h, very close. Actually close upto 3.5 %