Physics 262 Practice Exam 3 Solutions

(1.) $$E = \gamma m_e c^2 = m_p c^2$$

$$E^2 = m^2c^4 + p^2c^2$$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{E^2/c^2 - m_e^2c^2}} = \frac{h}{\sqrt{m_p^2c^2 - m_e c^2}}$$

$$= \frac{hc}{\sqrt{(m_p c^2)^2 + (m_e c^2)^2}}$$

No calculator allowed, so estimate using

$$m_p \gg m_e$$

$$m_p c^2 \sim 1\ \text{GeV}$$

$$\lambda = \frac{(1240\ \text{eV}\cdot\text{nm})}{1\times 10^9\ \text{eV}} \sim 10^{-6}\ \text{nm}$$

2.

$\phi = 2eV$

$$E_n = -\frac{hcR}{n^2} = (-13.6\ eV)\frac{1}{n^2}$$

transitions must give at least 2eV

$n_i \to n_f$

$2 \to 1$: $(-13.6\ eV)\left(\frac{1}{4} - 1\right) = (13.6\ eV)\frac{3}{4} \sim 10\ eV$ ← ✓

all other transitions will give higher energy photons,

so $n_i \to 1$ for all n_i.

Check $n_f = 2$

$n_i \to n_f$

$3 \to 2$: $(-13.6\ eV)\left(\frac{1}{9} - \frac{1}{4}\right) = (13.6\ eV)\left(\frac{5}{36}\right) \sim \frac{70}{36} < 2eV$

doesn't work

$4 \to 2$: $(-13.6\ eV)\left(\frac{1}{16} - \frac{1}{4}\right) = (13.6\ eV)\left(\frac{3}{16}\right) \sim \frac{42}{16} > 2eV$ ✓

all $n_i \geq 4$ work

check $n_f = 3$:

highest possible energy with $n_f = 3$

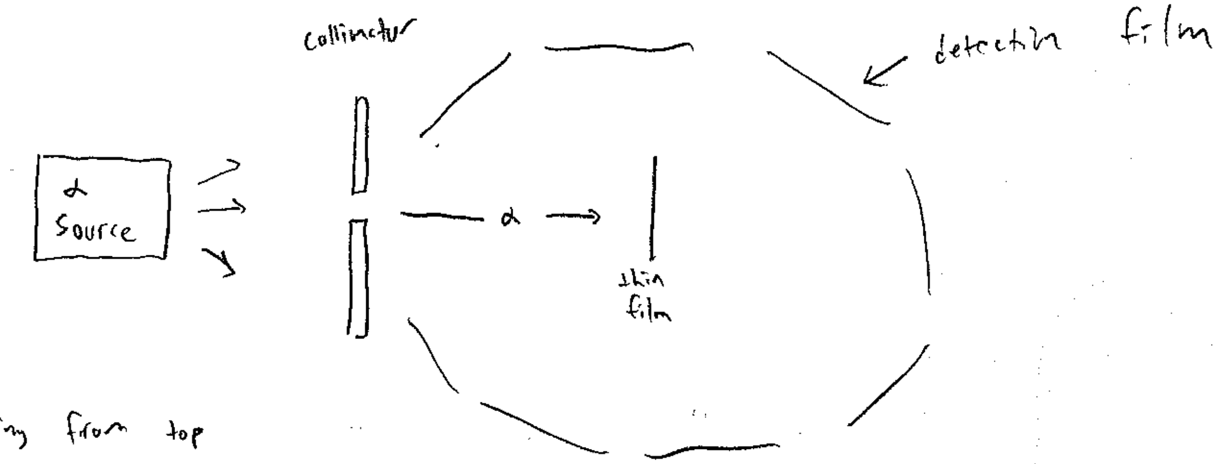
is $n_i \to \infty$

$\infty \to 3$: $(-13.6\ eV)\left(0 - \frac{1}{9}\right) = \frac{13.6\ eV}{9} < 2eV$

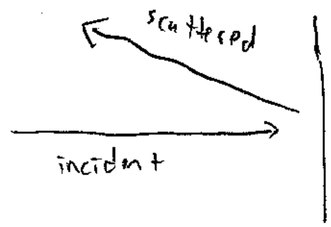
doesn't work

no other transitions work.

(3.)



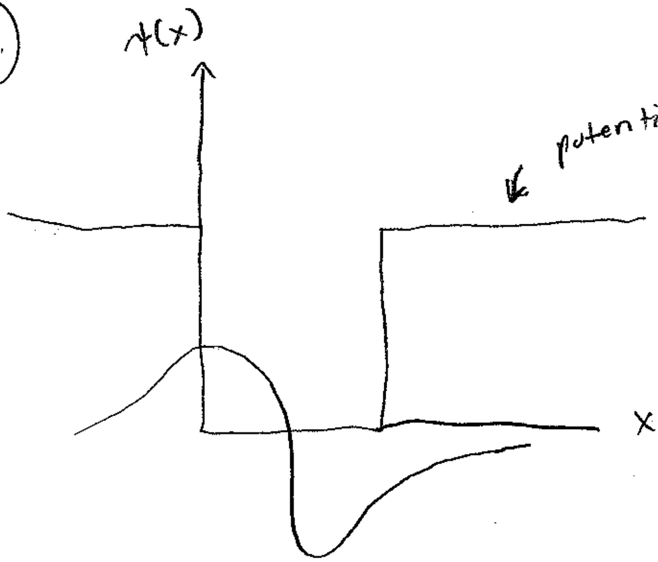
looking from top



High angle scattering events were observed, consistent with positive charge of the atom being concentrated at the center of the atom.

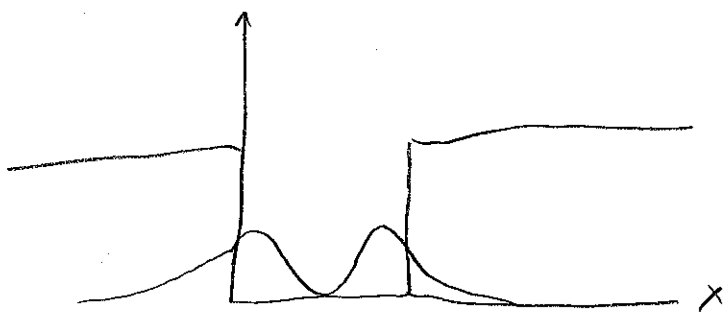
This disproved the "plum pudding" model and led to the nuclear model of the atom.

4.



← potential drawn for reference.

$\rho(x) = |\psi(x)|^2$



5.

$$P = \sigma T^4 * \text{Area}$$

$$P = \sigma T^4 \, 4\pi r^2$$

$$\frac{P_1}{P_2} = \frac{(5000\,K)^4 \; r^2}{(3000\,K)^4 \; (100\,r)^2} = \frac{5^4}{3^4} \times \frac{1}{10^4} = \frac{625}{81} \times 10^{-4}$$

$$\frac{P_1}{P_2} < 1$$

so P_2 radiates more power.

6.

$$\lambda_f - \lambda_i = \frac{h}{m_e c}(1 - \cos\theta)$$

at $\theta = 0$

$$(1 - \cos\theta) = 0$$

in this case

$$\lambda_f - \lambda_i = 0$$

and there is no change in λ.