Phys 301 Class 19
Finishing the Bohr Model

Derivation Results

$$r_n = a_0 \frac{n^2}{Z}$$

$$E_n = Z^2 \frac{E_0}{n^2}$$

$n =$ Quantum Number

$Z =$ atomic number (charge of nucleus)

$a_0 = 5.29 \times 10^{-11}\text{m} = 0.529$ Å

Bohr Radius of Hydrogen (radius of first orbital)

$E_0 = -13.6$ eV , ground state energy of hydrogen atom

Use this to complete Part III of handout: draw energy level diagram for Hydrogen.

Continue with Parts IV and V: State Transitions

Caveats? Hydrogen-like atoms only. (Also low enough Z.)
Otherwise, electrons interact with one another.

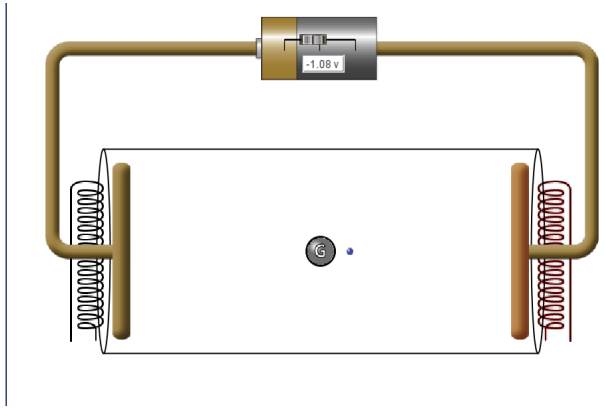
The Result

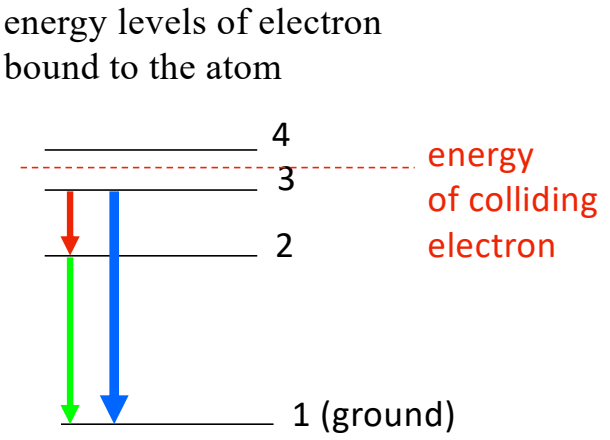
- Bohr's Model reproduces the Rydberg Formula

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \quad for\ n_i = n_f + 1, n_f + 2, n_f + 3 \cdots$$

$$R_H = 1.09737 \times 10^7 \mathrm{m}^{-1} (\text{Rydberg Constant for Hydrogen})$$

- Many of you asked in your Reading Memos: What is n_f? What is n_i? Rydberg probably felt the same way.
- Now we know: they are the final and initial quantum numbers (energy levels) of the electron.





If the colliding electrons have an energy between that of level 3 and level 4 when they hit the atoms

a. no levels will be excited, and so no light will come out.

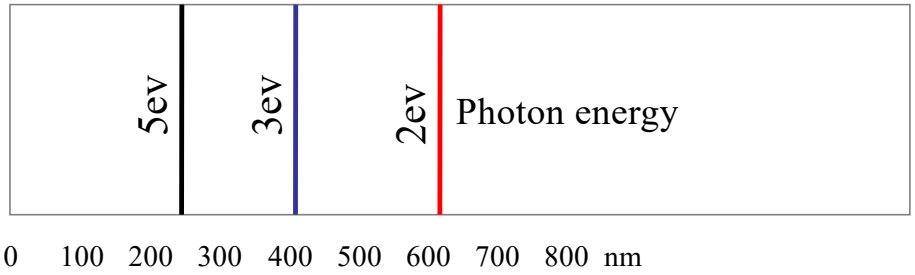
b. 1 color of light will come out

c. 2 colors of light will come out

d. 3 colors of light will come out

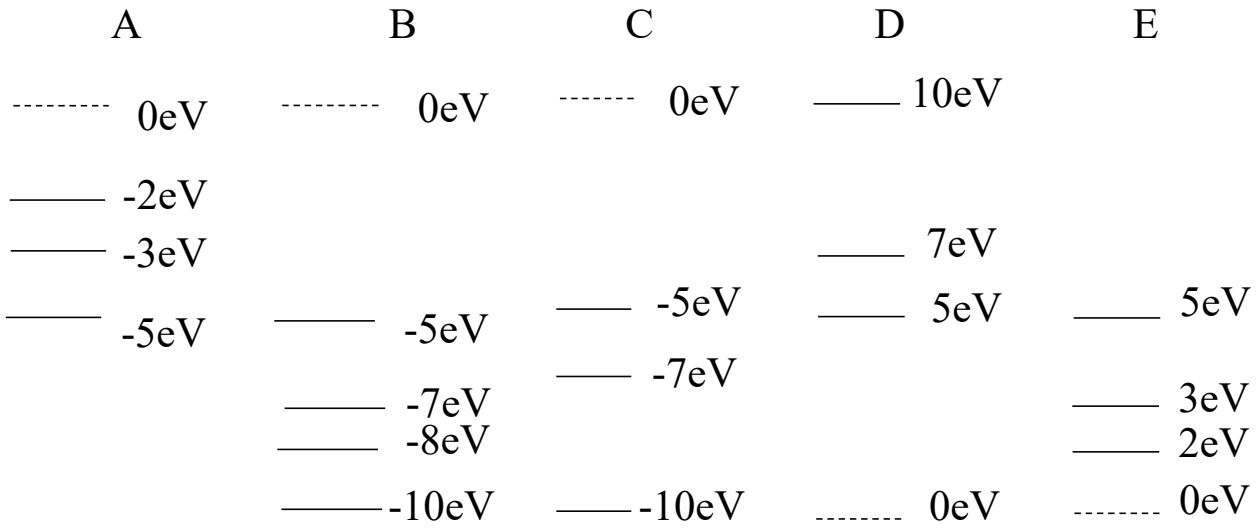
e. 4 colors come out.

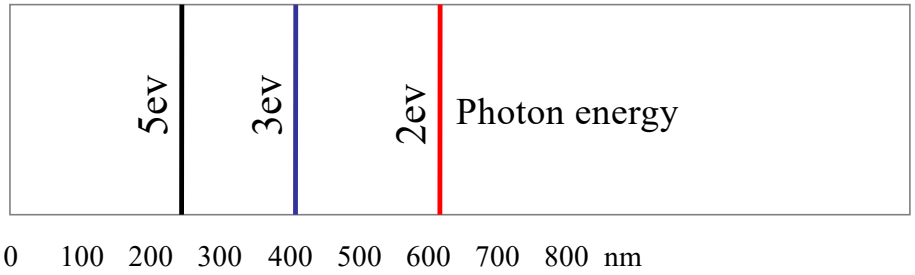
ans. d. enough energy to excite level 3, then get **3→2** followed by **2→1**, but also can go **3→1**.



What energy levels for electrons are consistent with this spectrum for "*Griffin*onium"?

Electron Energy levels:





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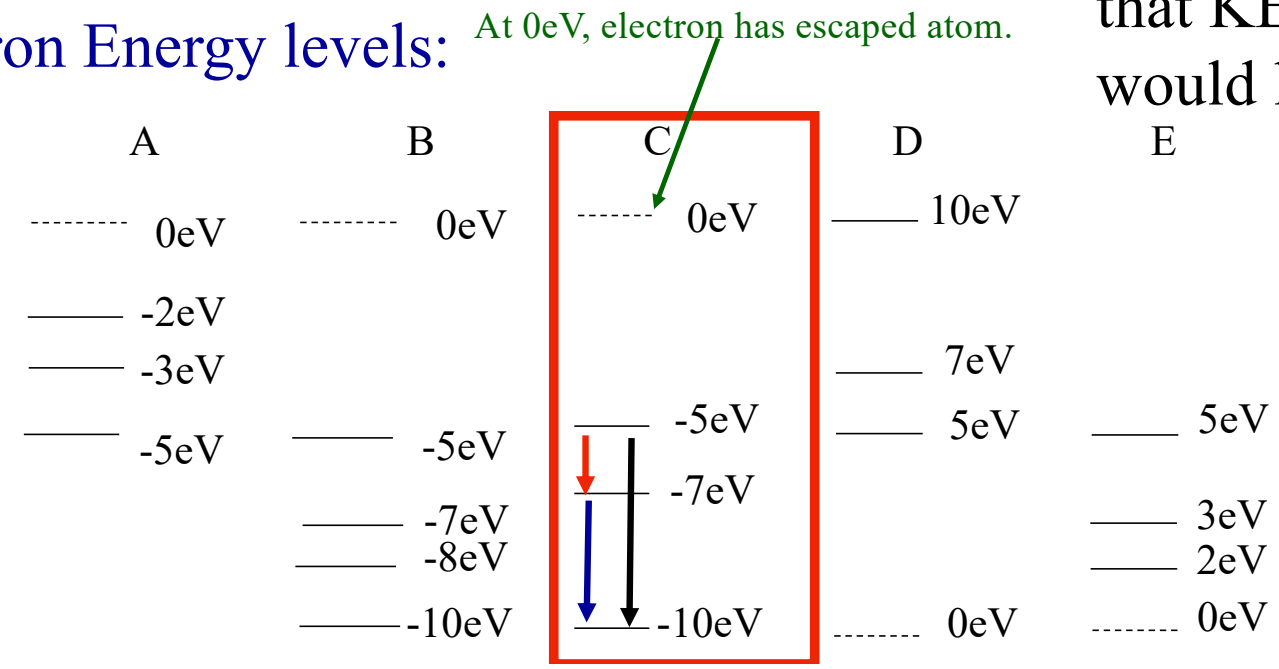

Electron energy levels = PE + KE

Since PE = 0 at infinity (*e.g.*, electron escaping from atom), a positive total energy would mean that KE > PE and electron would leave atom!

What Have We Learned?

- Young's Double Slit Experiment
  - Light acts like a wave.
- Blackbody Radiation, Planck Function
  - Energy of oscillators is quantized.
- Photoelectric Effect and Compton Scattering
  - Light acts like a particle of energy $E = hf$.
- Spectroscopy and Bohr's Model
  - Energy levels of electrons around atoms are quantized.