Physics 30 – Lesson 31
Bohr Model of the Atom

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1. Rutherford stated that electrons go in circular orbits. If they do, they are experiencing a centripetal acceleration. An accelerating charge, according to Maxwell, will radiate
/2 electromagnetic waves. No such waves are detected.

2.
A) The electric energy causes electrons around atoms to jump to excited states of energy.
/4 B) An electron in an excited state is one which has more energy than normal
C) As an electron jumps down it must lose its excess energy. A photon is emitted.
D) Each photon's energy has a wavelength given by $\lambda = \frac{hc}{E}$. Different energy jumps produce different wavelengths of light being emitted across the spectrum.

3. *Emission spectra* – as excited electrons fall down in energy level a photon with a specific wavelength is emitted. Different electrons falling from / to different energy levels produce different wavelengths of light
/2 *Absorption spectra* – as white light (all frequencies) passes through a gas, only those frequencies which give energy to the atoms in the gas will be absorbed. The remainder of light just passes through the gas.

4. Strengths:
- Provided a model whose internal energy levels matched the emission patterns for hydrogen atoms.
- Accounted for stability of the atom
- Applied equally well to other one-electron atoms

/5 Weaknesses
- did not work for atoms that have more than one electron
- did not account for the fine structure of emission lines

5) $$E_2 - E_1 = \left|-3.40\text{eV} - (-13.6\text{eV})\right| = \boxed{10.2\text{eV}}$$

/4 $$E_3 - E_1 = \left|-1.51\text{eV} - (-13.6\text{eV})\right| = \boxed{12.1\text{eV}}$$

6) Total energy in = Total energy out
/1

7) blue $\rightarrow$ higher energy $\rightarrow$ bigger quantum jump $\rightarrow$ n=5 to n=2
red $\rightarrow$ lower energy $\rightarrow$ smaller quantum jump $\rightarrow$ n=3 to n=2
/4

8) Ionization energy = 13.6eV
/1

9) A)

$$E_4 - E_2 = |-0.85\,\text{eV} - (-3.40\,\text{eV})| = 2.55\,\text{eV}$$

$$\lambda = \frac{hc}{E}$$

$$\lambda = \frac{(4.14\times10^{-15}\,\text{eV}\cdot\text{s})(3.00\times10^{8}\,\text{m/s})}{2.55\,\text{eV}}$$

$$\boxed{\lambda = 487\,\text{nm}}$$

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B)

$$E_5 - E_1 = |-0.54\,\text{eV} - (-13.6\,\text{eV})| = 13.06\,\text{eV}$$

$$\lambda = \frac{hc}{E}$$

$$\lambda = \frac{(4.14\times10^{-15}\,\text{eV}\cdot\text{s})(3.00\times10^{8}\,\text{m/s})}{13.06\,\text{eV}}$$

$$\boxed{\lambda = 95.1\,\text{nm}}$$

10) The energies shown in the diagram are relative to 0 eV being the energy of the electron when it is not part of the atom. We need to know the energies required to excite the electron around the hydrogen atom from its ground state.

$$E_2 - E_1 = |-3.40\,\text{eV} - (-13.6\,\text{eV})| = \boxed{10.2\,\text{eV}}$$

$$E_2 - E_1 = |-1.51\,\text{eV} - (-13.6\,\text{eV})| = \boxed{12.09\,\text{eV}}$$

A 12.3 eV electron collides with the electron in the hydrogen atom and excites the atom to n = 2 (10.2 eV) or n = 3 (12.09 eV). When the atom falls back toward the ground state a direct jump and an intermediate jump are possible resulting in three possible wavelengths:

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$$\lambda_1 = \frac{hc}{E_1}$$

$$\lambda_1 = \frac{4.14\times10^{-15}\,\text{eV}\cdot\text{s}(3.0\times10^{8}\,\text{m/s})}{10.2\text{eV}}$$

$$\boxed{\lambda_1 = 122\text{nm}}$$

$$\lambda_2 = \frac{hc}{E_2}$$

$$\lambda_2 = \frac{4.14\times10^{-15}\,\text{eV}\cdot\text{s}(3.0\times10^{8}\,\text{m/s})}{12.09\,\text{eV}}$$

$$\boxed{\lambda_2 = 103\,\text{nm}}$$

$$\lambda_3 = \frac{hc}{E_3}$$

$$\lambda_3 = \frac{hc}{|E_2 - E_1|}$$

$$\lambda = \frac{4.14\times10^{-15}\,\text{eV}\cdot\text{s}(3.0\times10^{8}\,\text{m/s})}{|12.09\,\text{eV} - 10.2\,\text{eV}|}$$

$$\boxed{\lambda = 657\,\text{nm}}$$

11)
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The energy required to ionize the atom from its first excitation state is **3.40 eV**. This is not a very likely event since the electron is not at this level for very long and the odds of the correct energy photon hitting it at that time is remote.

12)

A)
$$\lambda = \frac{hc}{E}$$
$$\lambda = \frac{4.14\times10^{-15}\,\mathrm{eV\cdot s}(3.00\times10^{8}\,\mathrm{m/s})}{|-9.113\mathrm{eV}-(-1.013\mathrm{eV})|}$$
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$$\boxed{\lambda = 153\mathrm{nm}}$$

B)
$$f = \frac{E}{h}$$
$$f = \frac{|-4.050\mathrm{eV}-(-0.744\mathrm{eV})|}{4.14\times10^{-15}\,\mathrm{eV\cdot s}}$$
$$\boxed{f = 7.978\times10^{14}\,\mathrm{Hz}}$$

C)
$$\Delta E = |-36.450\mathrm{eV}-(-0.570\mathrm{eV})|$$
$$\Delta E = 35.880\mathrm{eV}$$

D) $\boxed{E_{ionization} = 36.450\mathrm{eV}}$