ECE 30
Day 21 Notes

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Agenda

- The Bohr Postulate
- Atomic Energy Levels
- Intro to Solid State Physics

The Bohr Postulate

An electron can circle a nucleus if its orbit contains an integral number of waves.

$$nx = 2\pi r_n$$

Where $n \triangleq$ quantum number and r_n is the radius of the orbit from the nucleaus.

Substituting for λ we get:

$$\frac{nh}{e}\sqrt{\frac{4\pi\epsilon_0 r_n}{m}} = 2\pi r_n$$

Therefore:

$$r_n = \frac{n^2 h^2 \epsilon_0}{\pi m_e e^2}$$

Also the energy levels in terms of orbit radius.

$$E_n = \frac{-e^2}{8\pi\epsilon_0 r_n}$$

Substituting:

$$E_n = \frac{-me^4}{8\epsilon_0^2 h^2}\frac{1}{n^2}$$

$$E_n \triangleq \text{ Energy Level of the Hydrogen Atom}$$

Electrons away from an atom can be any energy level.

As it approaches an atom it is constrained to specific discrete energy levels. Calculating E_1 we get -13.6eV.

Note: 1eV $= 1.588 \times 10^{-19}$J

Above $n = 2$ The energy becomes less negative, which means the electron is less attracted. In addition the higher the energy levels the closer the energy levels are to each other.

Because of the large gaps between energy levels for low values of n electrons are very stable and require tens of electron volts per electron to ionize.

Bohr: Discrete proton emitted when an electron moves from one energy level to another, releasing the difference in energy as electromagnetic radiation.

From Planck: Photon energy $E = hf$

$$f = \frac{me^4}{8\epsilon_0^2 h^3}(\frac{1}{n_f^2} - \frac{1}{n_s^2})$$

And for Photons, $\lambda = \frac{C}{f}$. Therefore:

$$\frac{1}{\lambda} = \frac{f}{C} = \frac{me^4}{8\epsilon_0^2 C h^3}(\frac{1}{n_f^2} - \frac{1}{n_s^2})$$

So the spectrum of light emissions from H gas fits perfectly with the empirical measurements.

Solid State Physics

$$E_p = -\frac{1}{4\pi\epsilon_0}\frac{q|e|}{x}$$

This is the potential energy of an electron.

$q \triangleq$ Positively charged ion (nucleus)

$e \triangleq$ Charge of he electron

$x \triangleq$ Distance between q and e.

As an electron is brought near to the nucleus the energy will go deeper negative. However because of the discretization of energy levels it will drop to the lowest energy level it can.

In a lattice the potential energy of the electrons follows a periodic, wave like distribution, with many holes with slight bumps between ions.

What happens to Bohr Energy Levels under these conditions?

Schroedinger's equation describes the probability distribution for an electron under some arbitrary situation. Analytically unsolvable.

We know:

$$p = mv$$

And:

$$K_e = \frac{1}{2}mv^2$$

We know from De Brogli and Planck:

$$p = \frac{h}{\lambda}$$

Combining:

$$E = \frac{p^2}{2m}$$

Which implies:

$$E = (\frac{hk}{2\pi})^2 \frac{1}{2m}$$

Where $k = \frac{2\pi}{\lambda}$