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CHEM 3420: Physical Chemistry II — Spring 2009

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Lecture 2: Failures of the classical world

References

1. Levine, *Physical Chemistry*, Sections 17.1–17.5

Key Concepts

- Blackbody radiation: when an object is heated it emits light
  - Classical picture: radiation is due to electron oscillations which can occur at any frequency.
  - Classical view (1) leads to the UV catastrophe and (2) does not agree with experiments.
  - Plank proposes that the energy of the electron oscillations (and the emitted light) is proportional to an integral multiple of the frequency:

    $$E = nh\nu$$

    where h is the constant of proportionality (we know it as Plank's constant today).
  - Was able to fit all the experimental data and come up with a single value for h.
- The photoelectric effect: when you shine light on a metal surface, electrons can be ejected
  - Two interesting observation of the photoelectric effect:
    1. There exists a threshold frequency (ν_o) which is independent of intensity.
    2. The kinetic energy of the ejected electrons depends only on frequency, not intensity.
  - **Einstein's explanation:** Light is *quantized* and exists in discrete packers called photons. The energy of light is related to the frequency through Plank's constant:

    $$E = h\nu$$

  - This explains the existence of a threshold frequency — there is a minimum energy needed to eject an electron and therefore a minimum frequency.

    $$E_{min} = h\nu_o \equiv \Phi$$

    where we call Φ the work function and it depends on the material being illuminated.
  - This allows us to calculate the value of Plank's constant by measuring the threshold frequency and the kinetic energy of ejected electrons:

    $$\underbrace{\frac{1}{2}mv^2}_{max\ KE\ of\ ejected\ electron} = \underbrace{h\nu}_{incident\ photon\ energy} - \underbrace{h\nu_o}_{Work\ function,\ \Phi}$$

    The value obtained by Einstein is the same as Plank's value.
- The Rutherford nuclear model of the atom makes a lot of sense, but can't be stable in terms of classical thinking. Where to go from here?

Related Exercises in Levine

Exercises 17.3, 17.4