Ch 37: Early Quantum Theory and Models of the Atom

Electron Microscope and Atomic Spectra

Objective:

I. Solve problems involving an **Electron Microscope**

$\rightarrow$ By finding the **de Broglie wavelength** of the electron.

II. Solve problems involving **Atomic Spectra**

$\rightarrow$ By identifying whether light (photons) are being absorbed or emitted.

$\rightarrow$ By using **Conservation of Energy**

Content Review:

I. Wave Nature of Matter

The **de Broglie wavelength** is given by

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

II. Atomic Spectra

From the Bohr Model of the Atom, we find that atoms must have discretely defined energy levels. Atoms may transition between energy levels in the following 2 ways:

1. Absorbing an incident photon, transitioning UP energy level(s)
2. Emitting a photon as it transitions DOWN energy level(s)

We can use Conservation of Energy to relate the photon's energy to the change in energy of the atom.

$$E_{\text{photon}} = |E_2 - E_1|$$

where E_2 may represent the final energy state while E_1 is the initial.

NOTE: The above equation is often written with "initial" minus "final" energies, but we can play it safe by just taking the absolute value of the difference.

When we're dealing with the absorption or emission spectra of a **hydrogen atom**, the energy of the atom at level n is given by

$$E_n = -\frac{13.6\,\text{eV}}{n^2}$$

Guided Practice (leader - student) [10mins]

Electron Microscope

Electrons are accelerated by $3450\,\mathrm{V}$ in an electron microscope. Estimate the maximum possible resolution of the microscope.

Solution

$\lambda = 20.9\,\mathrm{pm}$

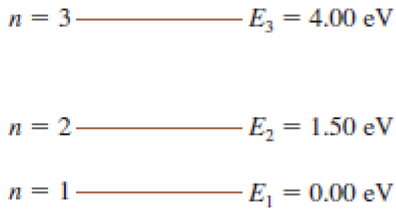
Group Activity (student - student) [10mins]

Atomic Spectra

The figure below shows the energy-level diagram for a simple atom. What wavelengths appear in the atom's

a. Emission spectrum

b. Absorption spectrum



Solution

(a) For $2 \rightarrow 1$, $\lambda = 828\,\text{nm}$. For $3 \rightarrow 2$, $\lambda = 497\,\text{nm}$. For $3 \rightarrow 1$, $\lambda = 311\,\text{nm}$

(b) For $1 \rightarrow 2$, $\lambda = 828\,\text{nm}$. For $1 \rightarrow 3$, $\lambda = 311\,\text{nm}$. There is no absorption for the $2 \rightarrow 3$ transition.

Group Activity (student - student) [10mins]

Atomic Spectra

Determine the wavelengths of all the possible photons that can be emitted from the $n = 4$ state of a hydrogen atom.

Solution

For $4 \to 1,\ \lambda = 97.26\,\mathrm{nm}.$ For $4 \to 2,\ \lambda = 486\,\mathrm{nm}.$ For $4 \to 3,\ \lambda = 4876\,\mathrm{nm}$