Republic of Iraq
Ministry of Higher Education & Scientific research
Al-Mustaqbal University
Science College
Biochemistry Department

Introduction in Chemistry

For

First Year Student/course 2

Lecture 2

By

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Atomic spectra

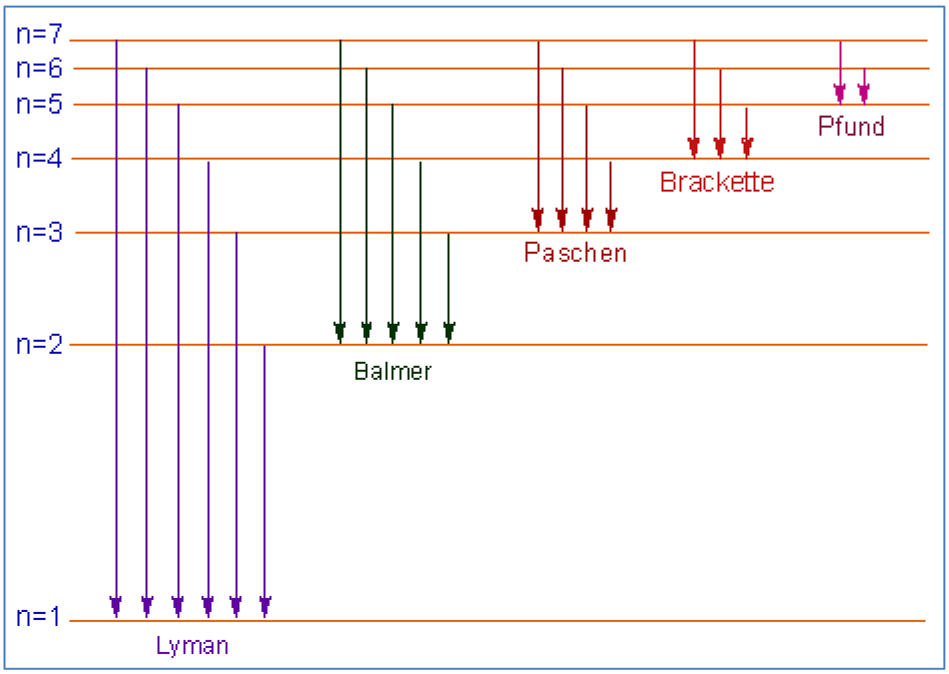
1- If an electrical discharge occurs through an element in its gaseous state and under reduced pressure, light is emitted from the excited gas atoms. When this light is analyzed using a prism, a series of lines known as the line spectrum is obtained.

2- Each atom has a unique emission spectrum that is used for its identification, and the hydrogen atom's spectrum is one of the simplest spectra.

Hydrogen spectra

- A hydrogen atom is stable when its electron is in the first orbit (n=1).
- The electron can absorb specific amounts of energy to move to higher orbits, making the atom excited.
- The atom returns to stability when the electron transitions from a higher to a lower energy level.
- The energy lost during this transition equals the difference between the two energy levels.
- This lost energy is emitted as light radiation (photons).
- The frequency of the emitted photons depends on the level of excitation of the atom.
- Scientists focused on studying the **hydrogen atom spectrum** due to its simple structure.
- Significant discoveries followed in this field.

- In **1885**, **Johann Balmer** observed the **visible spectrum** of hydrogen, which corresponds to electron transitions to the **n=2n = 2 energy level** (Balmer series).
- **Lyman** discovered another series of hydrogen spectral lines in the **ultraviolet range** (Lyman series).
- **Paschen** and **Brackett** discovered two additional series in the **infrared range** of the electromagnetic spectrum (Paschen and Brackett series).



The Rydberg equation is given below.

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^{\,2}} - \frac{1}{n_i^{\,2}} \right)$$

Where, n_f is final state and n_i is initial state.

$R_H = 1.097 \times 10^7\ m^{-1}$ = Rydberg constant

Here are some **important mathematical equations** related to the hydrogen atom spectrum and electronic transitions:

1- $\nu = 1/\lambda$ Relationship Between Wavenumber and Wavelength

2- $\nu = \nu/c$ Relationship Between Wavenumber and frequency

3- $1/\lambda = R\,(1/n1 - 1/n2\,)$ Relationship Between Wavelength and Rydberg Constant

4- $\lambda = c/\nu \longrightarrow \nu = c/\lambda$ Relationship Between Wavelength, Frequency, and Speed of Light

$n_1 = 1$ Lyman series	$n_2 = 2, 3, 4...$ ultraviolet
$n_1 = 2$ Balmer series	$n_2 = 3, 4, 5...$ visible
$n_1 = 3$ Paschen series	$n_2 = 4, 5, 6...$ infrared
$n_1 = 4$ Barackett series	$n_2 = 5, 6, 7...$ infrared
$n_1 = 5$ Pfund series	$n_2 = 6, 7, 8...$ infrared

Lyman	ليمان :	$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$	$n = 2, 3, \ldots\ldots$
Balmer	بالمر :	$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$	$n = 3, 4, \ldots\ldots$
Paschen	باشن :	$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right)$	$n = 4, 5, \ldots\ldots$

Q1: What is the wavelength and what is the name of the series when the electron in a hydrogen atom transitions from the third shell to the second shell?

Solution

When an electron in a **hydrogen atom** transitions from **the third shell (n=3)** to **the second shell (n=2)**, it corresponds to the **Balmer series**, which is in the **visible range** of the spectrum.

To calculate the wavelength:

We use the **Rydberg equation** to calculate the wavelength:

$1/\lambda= R\ (1/n_1^2 – 1/n_2^2)$

$1/\lambda = 109677\ (1/(2)^2 – 1/(3)^2$

$1/\lambda = 109677\ (1/4) – (1/9)$

$\lambda = 1/\ 1535478$

$\lambda = 0.00000651$ cm

Q2: What is the frequency (ν\nu) when the electron in a hydrogen atom transitions from the third shell to the second shell in the Lyman series? Given that the speed of light is 3×10^{10} cm

solution

Step 1: Calculate the wavelength using the Rydberg equation

We can use the **Rydberg equation** to calculate the wavelength for the transition

$$1/\lambda= R\ (1/n_1^2 – 1/n_2^2\ )$$

Where:

- RH=109677cm−1 (Rydberg constant)
- n_1=1 (final energy level for Lyman series)
- n_2=3 (initial energy level)

Substituting the values:

$$1/\lambda = 109677\ (1/(1)^2 - 1/(3)^2$$

$$1/\lambda = 109677\ (1/1) - (1/9)$$

$$\lambda = 1/\ 9761253$$

$$\lambda = 0.000001024 \text{ cm}$$

$$\nu = c/\ \lambda$$

$$\nu = 3x10^{10} \text{ cm}/0.000001024\text{cm}$$

$$\nu\ \approx 2.93 \text{ x } 10^{17}$$

Q3: What is the frequency (ν\nuν) when the electron in a hydrogen atom transitions from the fifth shell to the third shell in the **Paschen series**?