Al- Mustaqbal University

College of Science

Medical Physics Department

Second Stage

Atomic physics

Lecture 4 : Mercury atom spectrum

Dr. Sarah Mahdi

B.Sc. Mohammed Jamal

B.Sc. Zahraa Bassim

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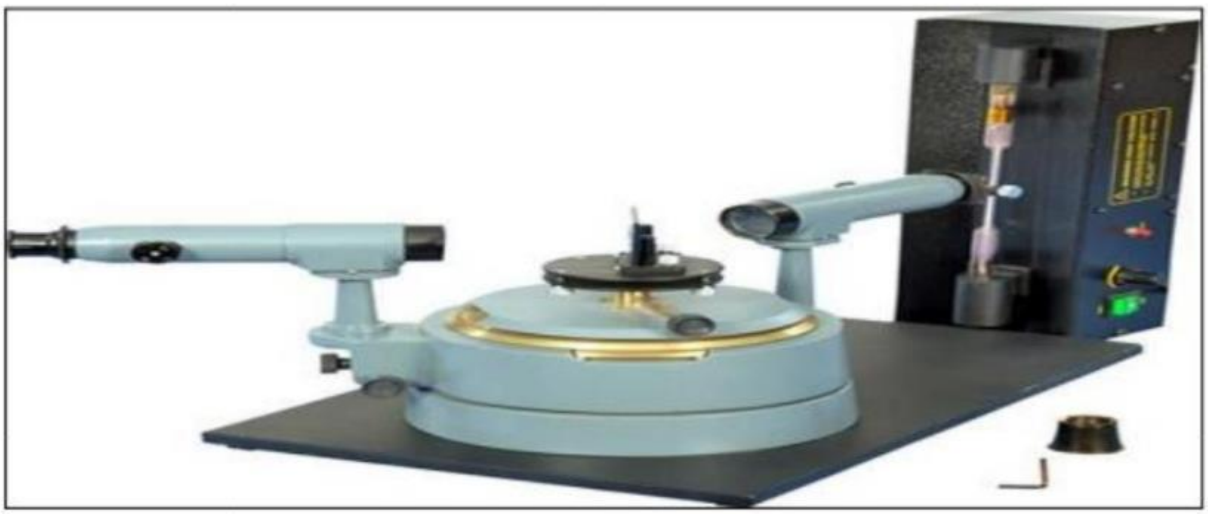
Mercury atom spectrum

The purpose of the experiment:-

1- Finding the wavelength value of the Mercury spectrum.
2- Finding the value of the Rydberg constant .

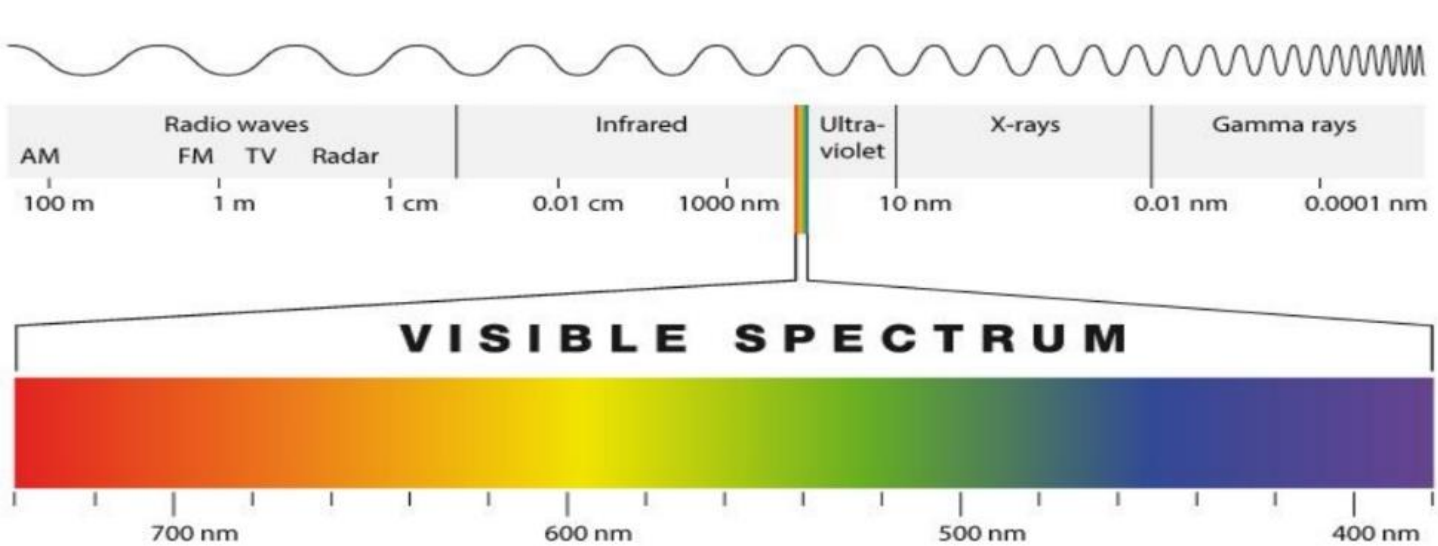
Used equipment's :-

power supply, Mercury lamp, spectrometer, diffraction grating.



Theory :-

Spectra means electromagnetic radiation, which has specific wavelengths from radio waves to X-ray waves, passing through the visible spectrum, etc.



These spectra are generally characterized as they are produced when a molecular or atomic group transitions from a quantum state with a certain energy level to a quantum state with a lower energy level.

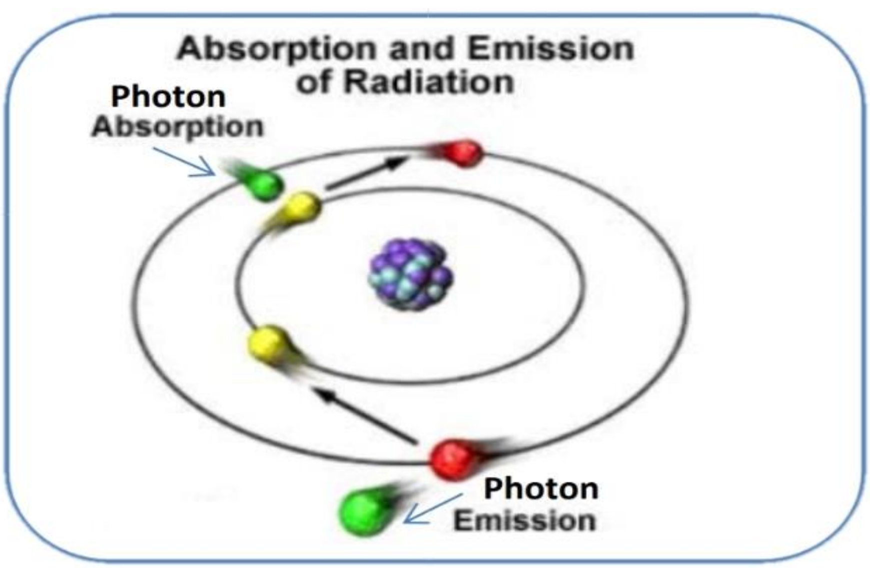
According to the conditions of the molecular or atomic group that radiates these spectra, they are divided into the following spectral groups.

1- Line spectrum.
2- Band spectrum.
3- Continuous spectrum.

There are two types of spectra: - emission spectrum and absorption spectrum.

The emission spectrum of any substance can be obtained by giving the atoms of the substance the appropriate energy to make them in an excited state. When the atoms become unstable, they try to return to the stable state by emitting energy in the form of photons.

The absorption spectrum is the appearance of black lines in special locations in the light. The absorption spectrum can be obtained by passing light emitted from a continuous source through a distilled gas or liquid, where it absorbs the wavelength energy emitted by the light. This spectrum consists of a series of black lines (representing the absorbed waves).



The visible spectrum is studied by passing light through a prism or diffraction grating, where it is decomposed into the spectral colors it consists of.

Spectrometer: It is a device used to measure optical properties across a specific range of the electromagnetic spectrum, and in particular it performs optical analysis to identify the components of materials, its function is to analyze the light resulting from a certain source into its monochromatic components**.**

A diffraction grating: is a regular pattern optical element that splits and deflects light into several light beams in several directions, and the directions of these new beams are determined by the spacing of the slits and the wavelength of the incident light.

Diffraction: is the deviation of light from its straight paths when it hits a grating or passes through a narrow slit, resulting in a redistribution of luminance intensity due to the superposition of secondary waves.

When light is emitted from an excited gas, we get a linear spectrum for that gas. When examining this linear spectrum, we find that it consists of lines separated from each other with distances that gradually decrease as their wavelength decreases, until the lines become crowded and aggregated, and we cannot distinguish them.

This spectrum has been explained using Bohr's atomic theory, in which it is assumed that there are concentric circular orbits with limited energy in the hydrogen atom, and this energy increases as the electron moves away from the nucleus. In addition, suppose that the energy for each orbit is equal to:

$$E_n = n\frac{h}{2\pi} \dots\dots (1)$$

Where (n) denotes the orbital number which is an integer. The electron in the atom can move from the orbit or (level) of the lowest energy to the orbit or (level) of the highest energy, by gaining energy equal to the difference between the energy of the two orbits, and in this we say that the atom is excited.

But when the electron goes down from a high energy level (m) to a low energy level (n) so that (n) represents the final level of the transition, in this case the atom radiates a photon (light) which is given the reciprocal of its wavelength from the following equation:

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n^2} - \frac{1}{m^2}\right) \ldots\ldots (2)$$

Where ($R_H = 1.0974 * 10^5 \ \ cm^{-1}$) is the Rydberg constant.

Through equation (2) that was reached by the scientist Rydberg, it is possible to calculate all the wavelengths for all the expected transitions from the atom, for all spectral groups of the atom of the element, where the group sequence depends on the value of the final level of electron transfer.

The following table summarizes the spectral groups of the hydrogen atom and the Rydberg equation for each group.

The Hydrogen Series

Names	Wavelength Ranges	Formulas	
Lyman	Ultraviolet	$\kappa = R_H\left(\frac{1}{1^2} - \frac{1}{m^2}\right)$	(m) $= 2, 3, 4, \ldots$
Balmer	Near ultraviolet and visible	$\kappa = R_H\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$	(m) $= 3, 4, 5, \ldots$
Paschen	Infrared	$\kappa = R_H\left(\frac{1}{3^2} - \frac{1}{m^2}\right)$	(m) $= 4, 5, 6, \ldots$
Brackett	Infrared	$\kappa = R_H\left(\frac{1}{4^2} - \frac{1}{m^2}\right)$	(m) $= 5, 6, 7, \ldots$
Pfund	Infrared	$\kappa = R_H\left(\frac{1}{5^2} - \frac{1}{m^2}\right)$	(m) $= 6, 7, 8, \ldots$

The spectrum series of the hydrogen atom is determined by the final quantum number (n), and since the initial quantum number (m) must be greater than the final quantum number, in order to generate excess energy as a result of the transition between one energy level and another, it is sent in the form of a photon.

- The jumps of the electron from the high energy levels to the first energy level (n=1) produce the Lyman series located in the ultraviolet (UV) region of the electromagnetic spectrum.
- Electron jumps from the upper excited levels to the second level (n=2) produce the Palmer chain located in the visible region and extending into the ultraviolet region of the electromagnetic spectrum.
- Electron jumps from higher levels to the third orbital (n = 3) produce the Paschen chain located in the infrared region of the electromagnetic spectrum
- There are also two other chains in the spectrum of the hydrogen atom, the Brackett chain and the Pfund.

Work steps :-

1- Place the lamp in front of the collector aperture of the spectrometer.
2- Rotate the spectrometer left and right until you see the spectral colors of the element used in the lamp.
3- Adjust the telescope so that the vertical hairline applies to each color separately, then find an angle reading in a table for each color from the right and left (θ_R, θ_L)
4- Find the wavelength from the equation:-

$$n\lambda = d\sin\theta_{av}$$

5- Draw the graphic relationship between $(\frac{1}{\lambda})$ on the y-axis and $(\frac{1}{m^2})$ on the x-axis.
6- From the diagram find (R_H).
7- Draw a graphic relationship between (λ) on the y-axis and $(\sin\theta_{av})$ on the x-axis. Find (d) the slope.

Table of accounts

Color	θ_R	θ_L	$\theta_{av} = \frac{\theta_R + \theta_L}{2}$	$\sin\theta_{av}$	$\lambda = \frac{d\sin\theta_{av}}{n}$	$\frac{1}{\lambda}$