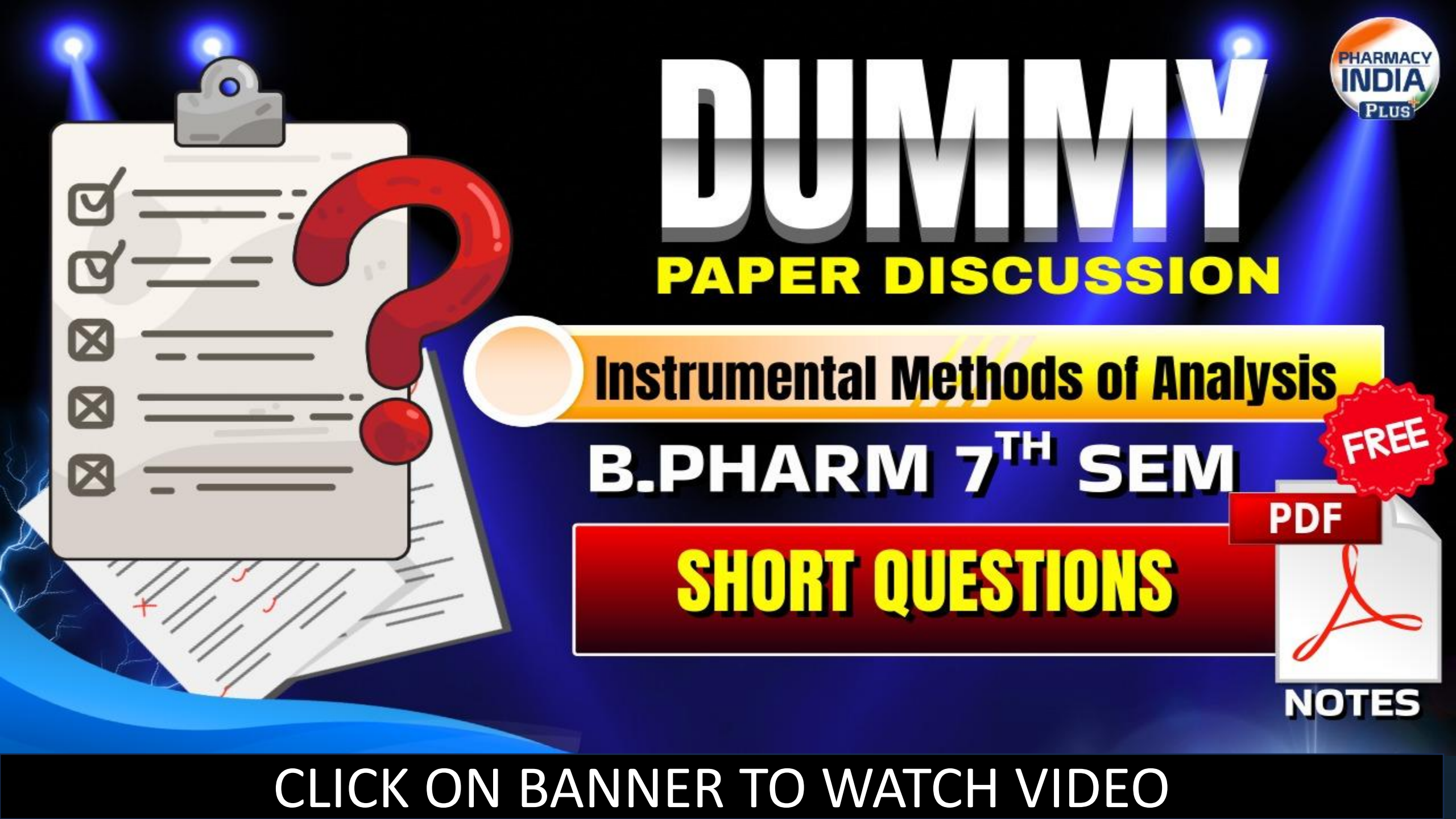
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1. Write short notes on PMT and its working.

Photomultiplier Tube (PMT):

- A highly sensitive light detector used in spectrophotometers, fluorimeters, and scintillation counters.

- **Working principle:**

- Incident light photons strike a photocathode, releasing electrons (photoelectric effect).

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- These electrons are accelerated and multiplied through a series of dynodes, each releasing more electrons.

- Finally, the amplified electron current is collected at the anode and measured as an electrical signal proportional to light intensity.

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3. Explain the light sources and detectors of IR region.

Light Sources in IR Region:

Globar Source – made of silicon carbide rod, heated electrically (~1000–1650 °C). Produces a continuous and stable IR spectrum, widely used in mid-IR instruments.

Nernst Glower – composed of rare-earth oxides (Zr, Y, Er). When heated (~1200 °C), it emits strong IR radiation. Requires an external heater to start conduction.

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Incandescent Wire Source – a tightly wound nichrome or platinum wire heated to high temperature. Used mainly for near-IR region (0.8–2.5 µm).

Lasers (e.g., CO_2 laser) – give intense monochromatic IR radiation, useful for high-resolution and specific studies.

Detectors in IR Region:

1. Thermal Detectors (respond to heating effect of IR radiation):

- **Thermocouple:** Generates a voltage when junctions are heated.

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- **Bolometer:** Resistance changes with temperature due to absorbed IR.
- **Thermistor:** Sensitive semiconductor resistor; resistance decreases with absorbed heat.
- **These are stable and work over a broad IR range, but have relatively slower response.**

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2. Photon Detectors (respond to incident photons directly):

- **Lead Sulfide (PbS):** Used for near-IR region (up to 3 µm).
- **Lead Selenide (PbSe):** More sensitive, works up to 4.5 µm.
- **Mercury Cadmium Telluride (HgCdTe):** Very sensitive, used for mid- and far-IR detection.
- These have high sensitivity and fast response, but limited wavelength range.

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14. Write the principle and instrumentation of atomic absorption spectroscopy with a neat sketch.

Principle of Atomic Absorption Spectroscopy (AAS):

- Free atoms in the ground state can absorb radiation of a specific wavelength characteristic of that element.
- The amount of absorption is directly proportional to the concentration of the element in the sample (Beer–Lambert's law).
- Thus, AAS is used for quantitative determination of metals.

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Instrumentation of AAS:

1. Radiation Source: Hollow Cathode Lamp (HCL) – emits sharp spectral lines specific to the element of interest.

2. Atomizer: Converts sample into free ground-state atoms. Types:

- Flame atomizer (e.g., air–acetylene flame).
- Graphite furnace (electrothermal atomizer).

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3. Monochromator: Isolates the specific wavelength of interest from lamp radiation.

4. Detector: Usually a photomultiplier tube (PMT) to measure transmitted light intensity.

5. Readout Device: Converts the detector signal into absorbance or concentration display.

Hollow Cathode Lamp → Chopper (optional) → Atomizer (Flame/Graphite furnace) → Monochromator → Detector (PMT) → Readout system

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10. Explain Plate and rate theory involved in chromatography.

1. Plate Theory:

- Proposes that the chromatographic column consists of a series of discrete, hypothetical layers called theoretical plates.
- In each plate, solute equilibrates between the stationary and mobile phases.
- The more plates a column has, the better the separation.

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- Column efficiency is expressed as the number of theoretical plates (N):

N=16 (Tr\W)^2

where tR = retention time, W = peak width.

2. Rate Theory:

- Explains band broadening (peak spreading) during chromatography using the Van Deemter equation:

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- H=A + B\u + C u

where,

- H = Height Equivalent to a Theoretical Plate (HETP)
- u = mobile phase velocity
- A = Eddy diffusion term (multiple flow paths)
- B/u = Longitudinal diffusion term (molecule spreading along column length)
- Cu = Resistance to mass transfer term

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7. Compare the working of dispersive IR and FTIR instruments. Explain working of FTIR in detail.

Feature	Dispersive IR	FTIR (Fourier Transform IR)
Source	IR source + monochromator (prism/grating)	IR source + interferometer
Wavelength Selection	Scans one wavelength at a time using monochromator	Measures all wavelengths simultaneously (multiplex advantage)
Speed	Slow (takes minutes per spectrum)	Very fast (seconds)

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Sensitivity	**Lower (limited signal-to-noise ratio)**	**Higher (Fellgett's advantage, multiplexing improves sensitivity)**
Resolution	Moderate	High resolution
Moving parts	Monochromator grating/prism rotates	Only moving mirror in interferometer
Data Output	Absorbance vs wavelength (after scanning)	Absorbance vs wavenumber (after Fourier transformation)

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- Working of FTIR (Fourier Transform Infrared Spectroscopy):

1. Source: A stable IR radiation source (like Globar).

2. Interferometer:

   - The Michelson interferometer is the heart of FTIR.
   - It splits the IR beam into two using a beam splitter.
   - One beam reflects off a fixed mirror, the other off a moving mirror.
   - The beams recombine to produce interference pattern (interferogram) that contains all IR frequencies simultaneously.

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3. Sample Interaction: The interferogram passes through the sample where specific frequencies are absorbed by molecular vibrations.

4. Detector: Records the modified interferogram (signal vs time/position of moving mirror).

5. Computer & Fourier Transformation: The interferogram is mathematically transformed (Fourier transform) to give the final spectrum (Intensity vs wavenumber).

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7. What is Finger Print region? Explainfundamental modes of vibrations in poly atomic molecules.

Fingerprint Region in IR Spectroscopy:

- The region of 400–1500 cm^{-1} in an IR spectrum is called the fingerprint region.
- It shows complex absorption bands due to bending vibrations and bond interactions in the molecule.
- These absorptions are highly specific for each compound → act like a "fingerprint" for identification, even if functional group peaks are similar.

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Fundamental Modes of Vibrations in Polyatomic Molecules:

In molecules, atoms vibrate about their equilibrium positions. The two main categories of vibrations are:

1. Stretching Vibrations: (change in bond length)

- Symmetric stretching: Bonds extend/contract together in phase.
- Asymmetric stretching: One bond lengthens while another shortens.

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2. Bending Vibrations: (change in bond angle)

- Scissoring: Two atoms move toward and away from each other like scissors.
- Rocking: Atoms move in the same direction, rocking back and forth.
- Wagging: Atoms move up and down out of the plane.
- Twisting: Atoms move in opposite directions out of the plane.

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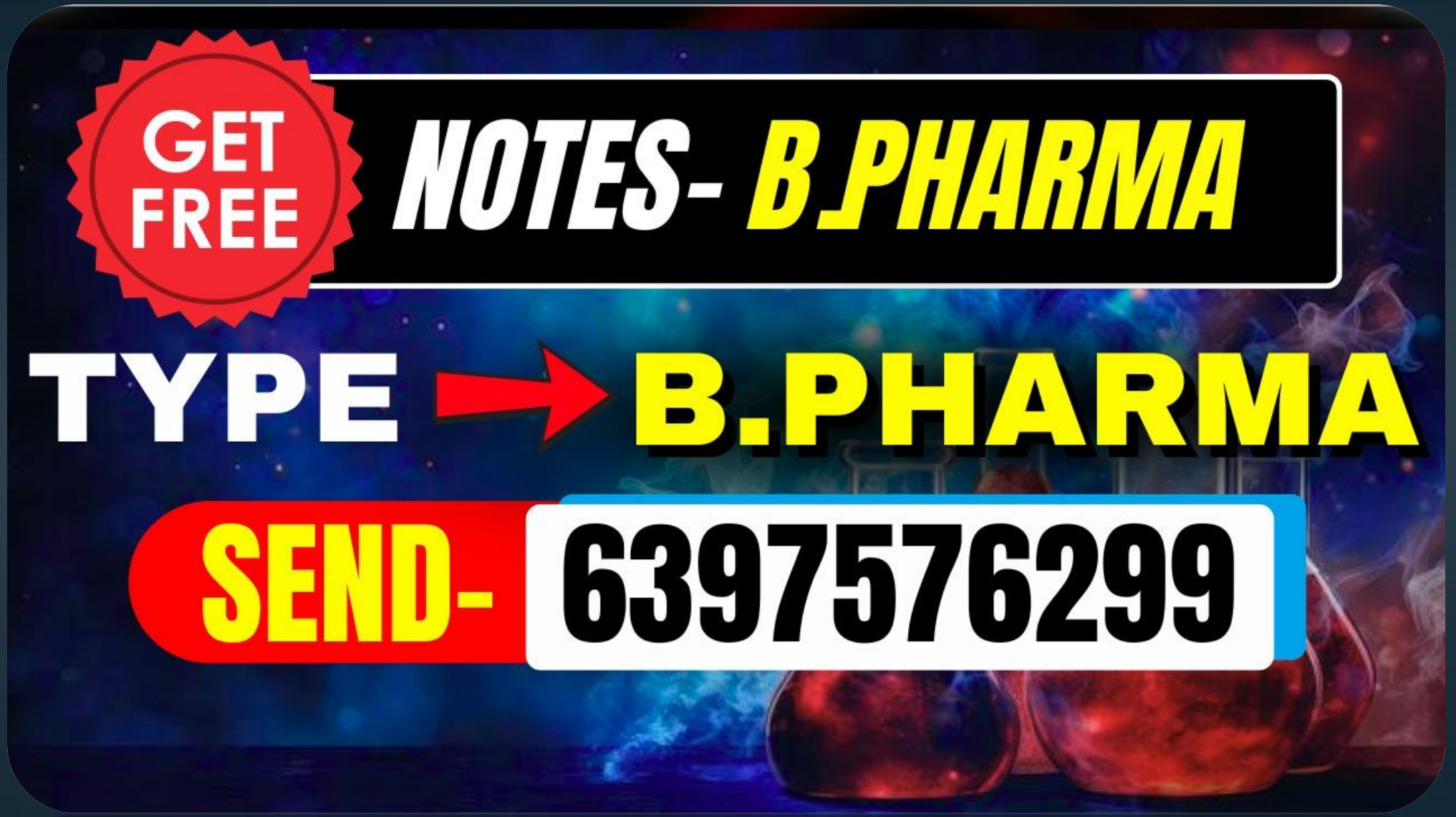

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