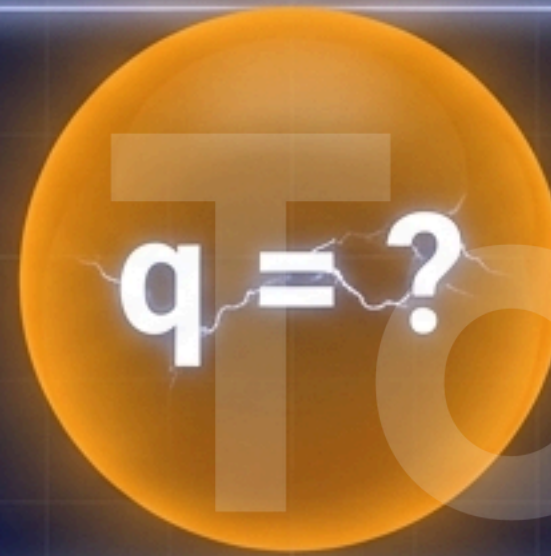


ATOMIC STRUCTURE: EXPERIMENTAL DEDUCTION



Millikan Oil Drop Experiment

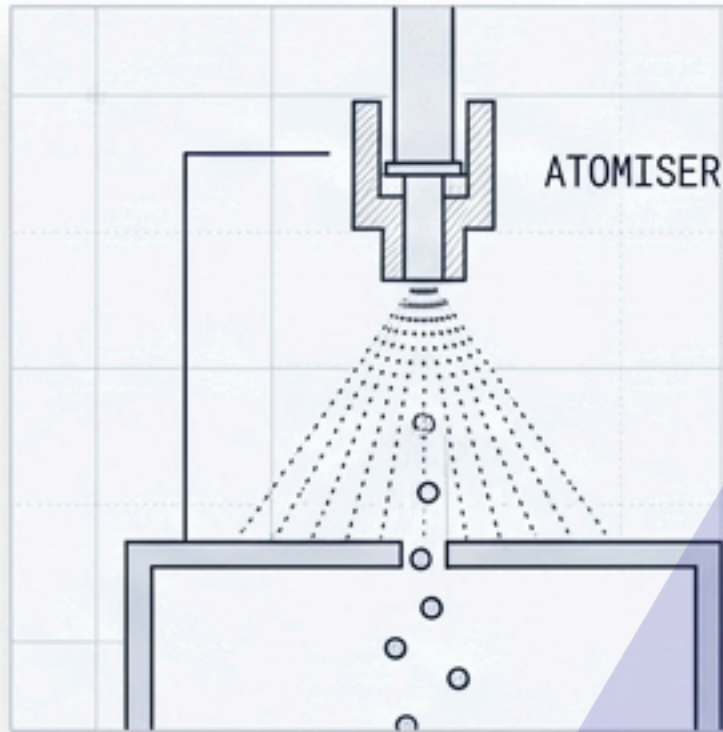
Isolating the fundamental charge of the electron (1906–14)



Mission Objective

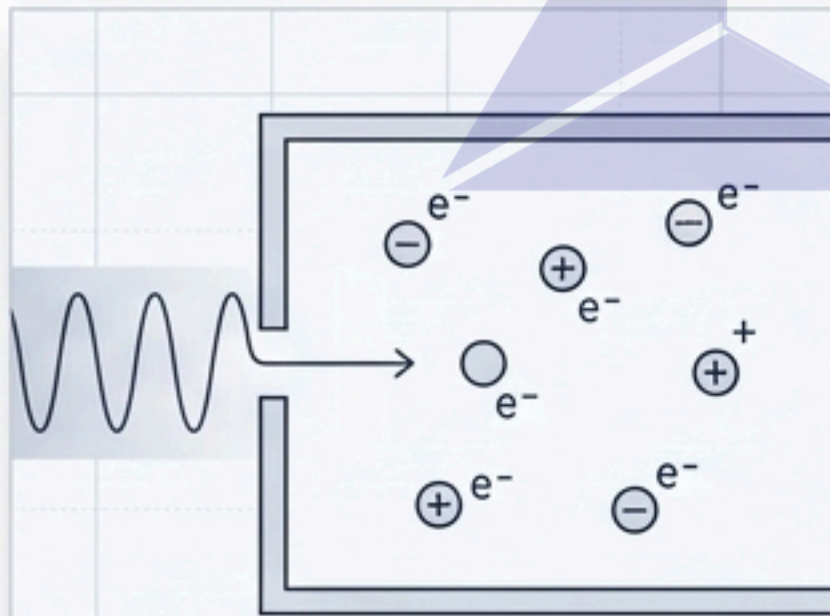
To measure the exact magnitude of electrical charge by controlling the physical motion of microscopic oil droplets.

The Apparatus Architecture



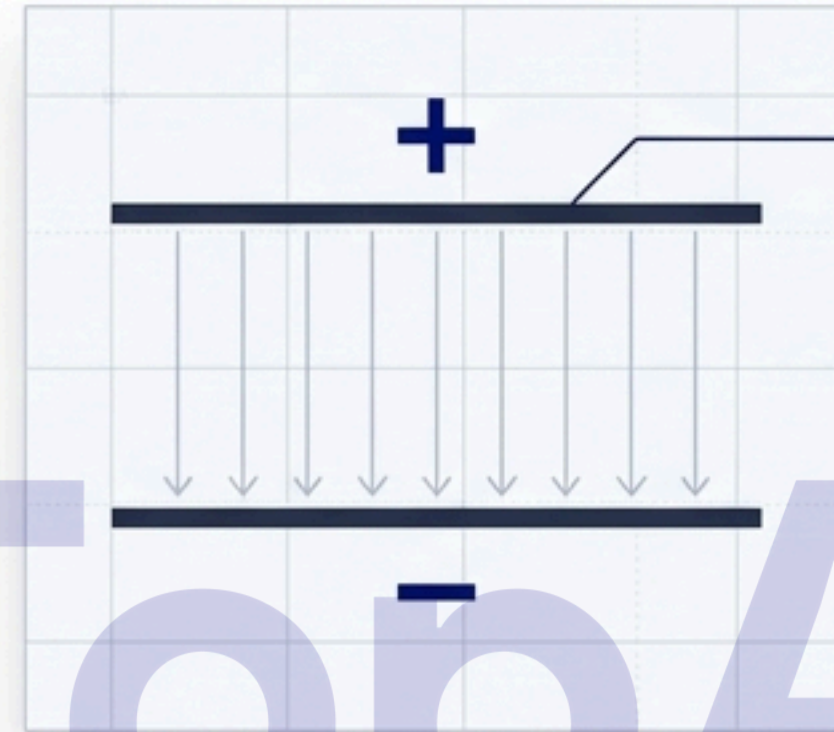
Atomiser

Produces a fine mist of oil droplets that enter the chamber through a tiny hole in the upper plate.



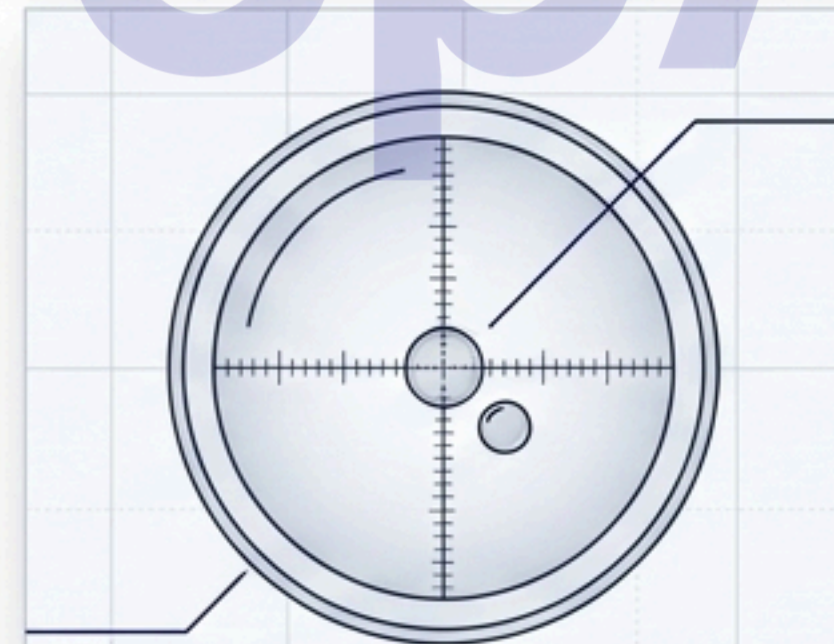
X-Ray Beam

Ionizes the air inside the chamber, providing electrons for the oil drops to capture.



Condenser Plates

Applies a tunable voltage to create a controlled electrical field between the plates.

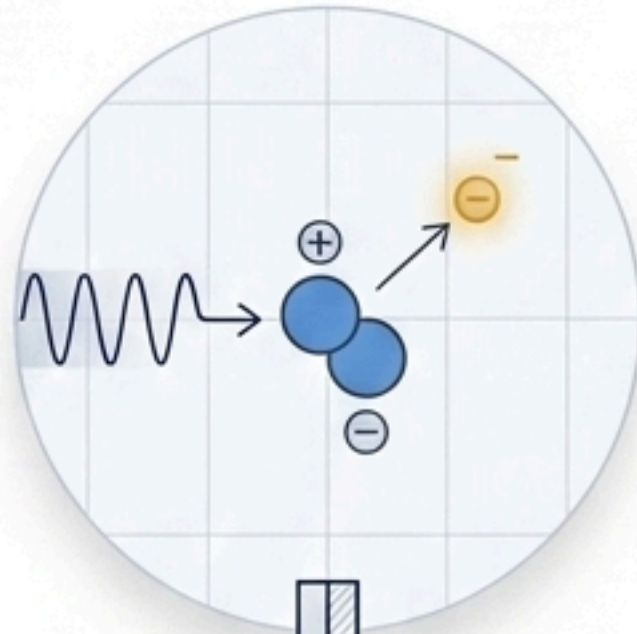


Telescope

Equipped with a micrometer eyepiece to accurately measure the rate of fall of individual droplets.

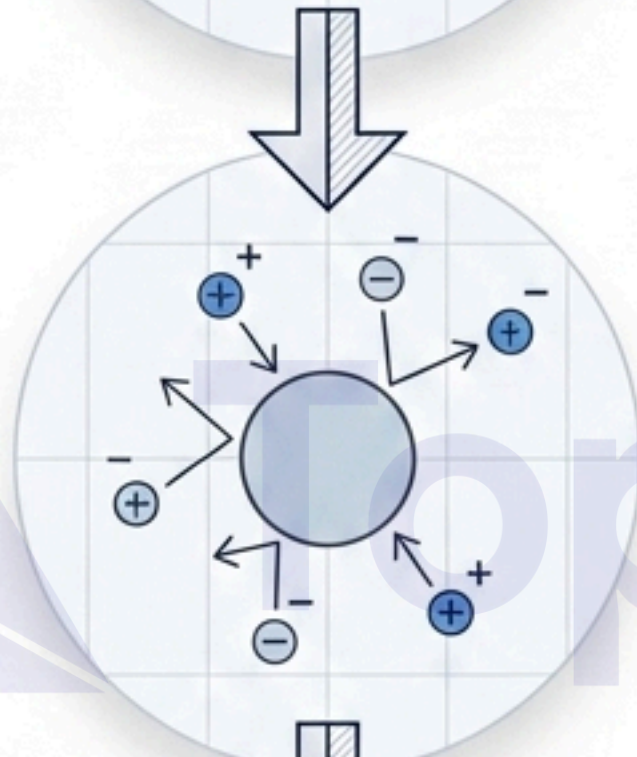
The Charging Mechanism: Role of X-Rays

Step 1: Ionization



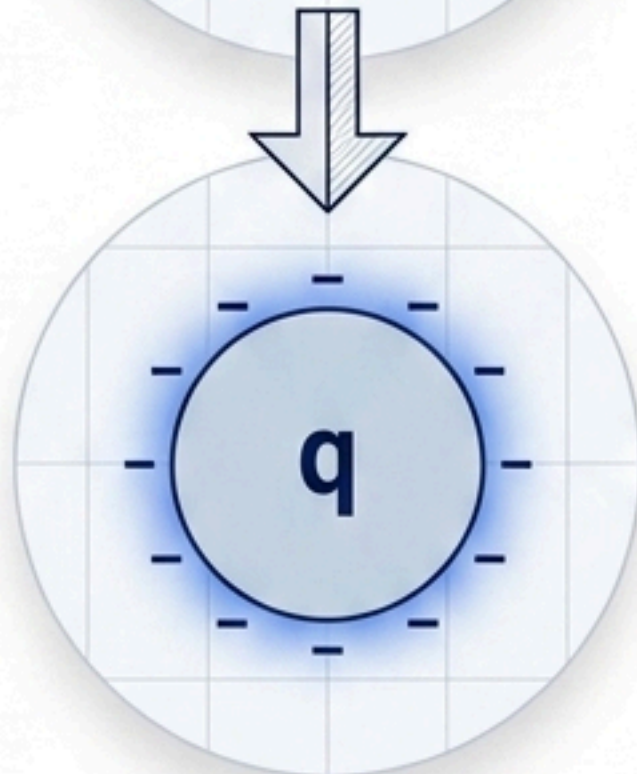
X-rays pass through the chamber, ionizing the air molecules.

Step 2: Collision



Gaseous ions collide with the falling oil mist.

Step 3: Acquisition



Oil droplets acquire a static electrical charge (q) from the collisions.



Condition: The charge acquired is entirely dependent on these random collisions, meaning different drops acquire different amounts of charge.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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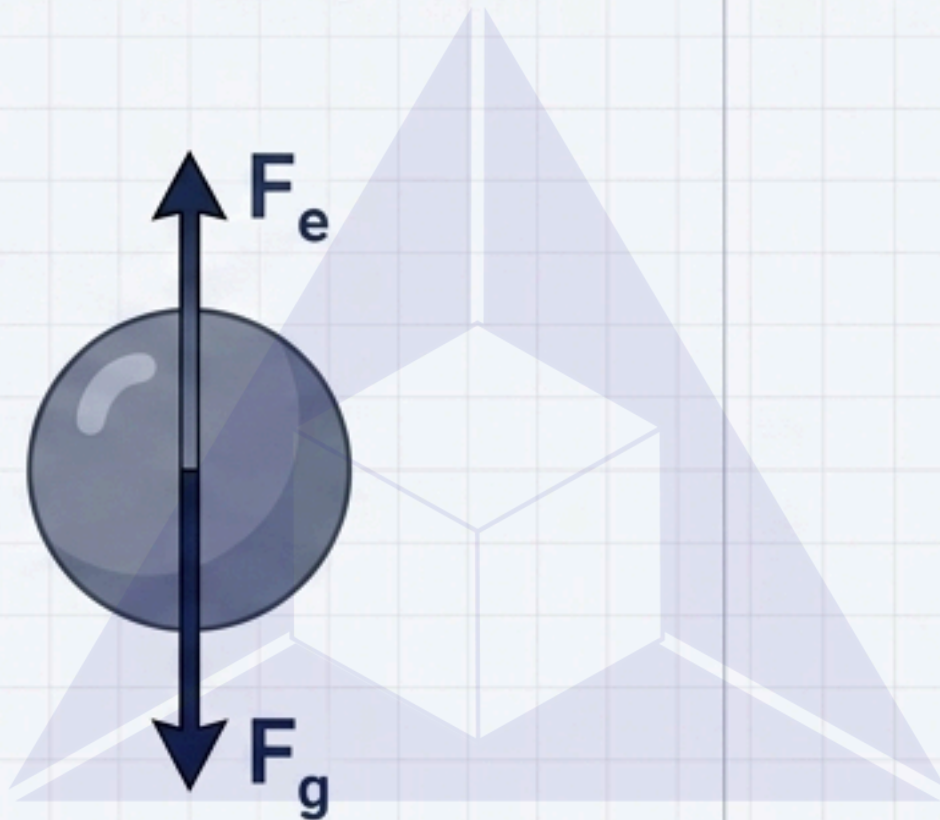
Key Highlights

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Motion Control Mechanics

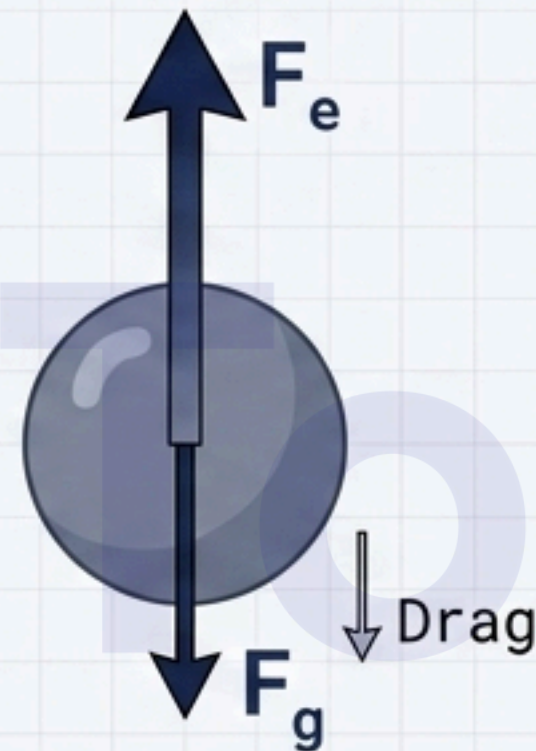
Stationary



$$F_e = F_g$$

Voltage tuned so electrostatic lift perfectly balances gravity.

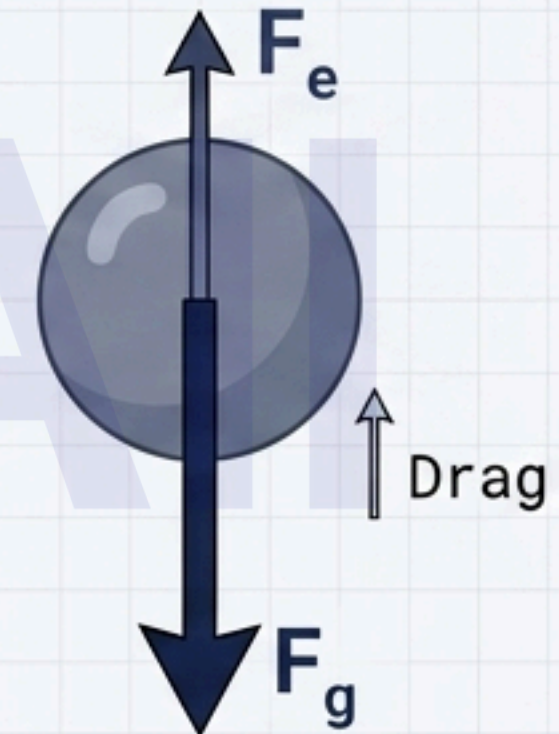
Accelerated (Upward)



$$F_e > F_g$$

High voltage applied; droplet overcomes gravity and accelerates upward.

Retarded (Downward Fall)

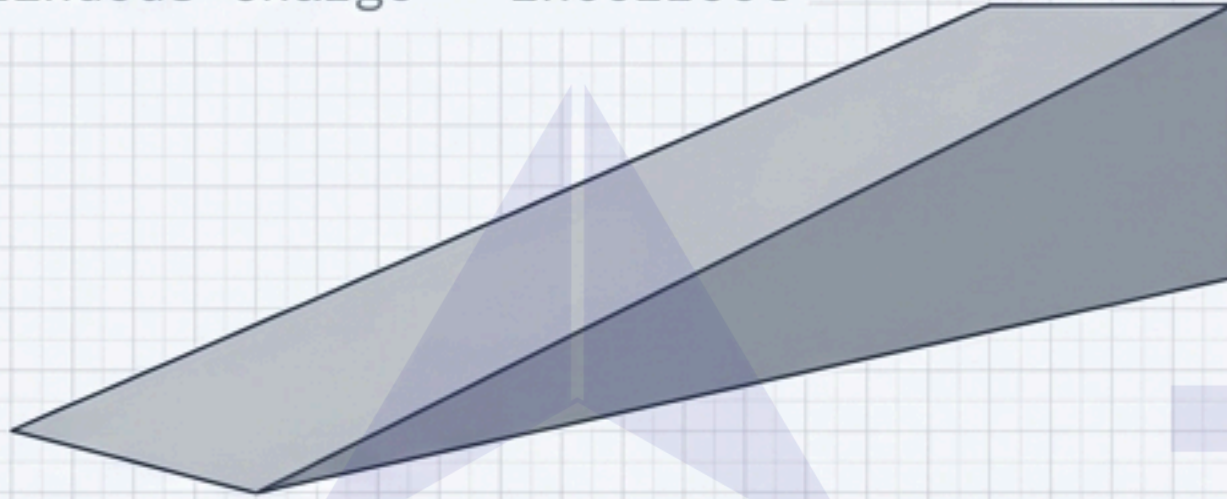


$$F_e < F_g$$

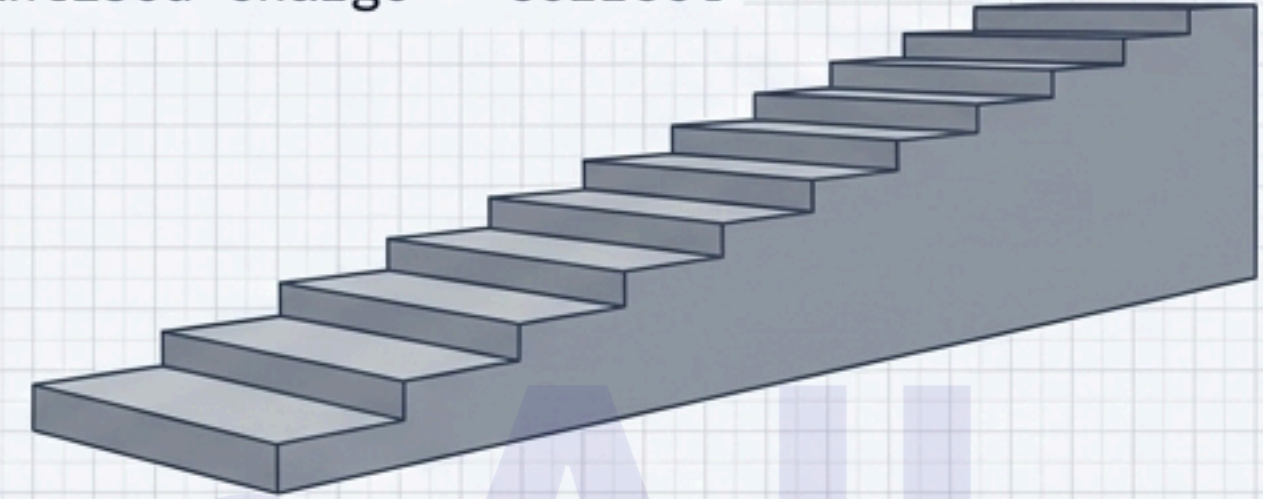
Low voltage applied; droplet falls, but slower than free-fall due to upward electric force.

The Discovery of Quantisation

✗ Continuous Charge - Incorrect



✓ Quantised Charge - Correct



$$q = ne$$

Total electrical charge
on the droplet.

Integer multiplier (1, 2, 3...)
representing the number of electrons.

The fundamental charge
of a single electron.

Millikan's accepted value of electrical charge:

$$e = -1.602176 \times 10^{-19} \text{ C}$$

Synthesizing the Electron's Mass (m_e)

Charge (e)

$$1.602176 \times 10^{-19} \text{ C}$$

÷

Charge-to-Mass Ratio (e/m_e)

$$1.758820 \times 10^{11} \text{ C kg}^{-1}$$

=

Mass of Electron (m_e)

$$9.1094 \times 10^{-31} \text{ kg}$$

By combining his exact charge measurement with Thomson's known ratio, Millikan allowed physics to finally weigh the electron.

JEE Diagnostic: Key Takeaways & Traps

Key Takeaways

- **Charge exists in packets:** Total charge (q) is always an integral multiple of e . It is never continuous.
- **Sub-atomic universality:** The value of e is a fundamental constant, regardless of the nature of the gas or oil used.

Exam Traps

- **TRAP 1: Fractional n .** The equation $q=ne$ requires n to be a whole integer. A charge of $1.5e$ or $2.7e$ is physically impossible.
- **TRAP 2: Ignoring the sign.** The calculated charge e is just a magnitude. Remember that an electron carries a negative charge (-1.6×10^{-19} C) in electrostatic calculations.



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