Physical Experiment II

Prelab Report

Lab Title: The Millikan Oil Drop Experiment

Name (in Chinese): 曹城玮

UESTC ID: 2024300901016

Instructor: 吴静

Teaching Assistant: 吴振宇

Date: 2025.10.16

Score:

Score

Answers to Questions (20 points)

Answers to Questions

1. (1) What forces act on the oil droplet when it is stationary in an electrostatic field? If the field is removed and it reaches its terminal speed, what forces would be acting on it?

Answer:

- **When stationary in an electrostatic field:**

  According to Figure 3.11-2 in the lab manual, the oil droplet is subjected to three forces in this state:
  - F_E **(Electric force):** The upward electric force.
  - F_g **(Gravitational force):** The downward gravitational force.
  - F_b **(Buoyant force):** The upward buoyant force exerted by the air.

  In this equilibrium state, the upward forces (electric force and buoyant force) are balanced by the downward force (gravity).

- **When the field is removed and it reaches terminal speed (falling):**

  According to Figure 3.11-3 in the lab manual, the droplet is also subjected to three forces in this state:
  - F_v **(Viscous resistance):** The upward viscous resistance exerted by air.
  - F_g **(Gravitational force):** The downward gravitational force.
  - F_b **(Buoyant force):** The upward buoyant force.

  In this state, the droplet falls at a constant velocity, and the upward forces (viscous resistance and buoyant force) are again balanced by the downward force (gravity).

2. (2) An oil droplet in a Millikan apparatus is determined to have a mass of 3.3×10^{-15} kg. It is observed to float between two parallel plates separated by a distance of 0.95 cm with 340 V of potential difference between them. Determine how many excess (extra) electrons are on the droplet.

Answer:

When the oil droplet is "floating" (stationary), the upward electric force F_E balances the downward gravitational force F_g. (The manual states that the buoyant force may be neglected).

The equilibrium equation is:

$$q\frac{V}{d} = mg$$

Given Data:

- Mass $m = 3.3 \times 10^{-15}\ \mathrm{kg}$
- Voltage $V = 340\ \mathrm{V}$
- Plate separation $d = 0.95\ \mathrm{cm} = 0.0095\ \mathrm{m}$
- Gravitational acceleration $g = 9.79\ \mathrm{m/s^2}$ (from manual Table 3.11-1)
- Elementary charge $e = 1.602 \times 10^{-19}\ \mathrm{C}$ (from manual section 3.11.6)

1. Calculate the total charge q on the droplet:
Rearranging the equilibrium equation:

$$q = \frac{mgd}{V}$$

$$q = \frac{(3.3 \times 10^{-15}\ \mathrm{kg}) \times (9.79\ \mathrm{m/s^2}) \times (0.0095\ \mathrm{m})}{340\ \mathrm{V}}$$

$$q = \frac{3.070155 \times 10^{-16}\ \mathrm{J}}{340\ \mathrm{V}}$$

$$q \approx 9.03 \times 10^{-19}\ \mathrm{C}$$

2. Calculate the number of excess electrons n:
The total charge q is an integer multiple of the elementary charge e, i.e., $q = ne$.

$$n = \frac{q}{e}$$

$$n = \frac{9.03 \times 10^{-19}\ \mathrm{C}}{1.602 \times 10^{-19}\ \mathrm{C}} \approx 5.63$$

According to the lab manual, the result should be rounded to the nearest integer.

$$n = 6$$

Therefore, there are **6** excess electrons on the droplet.

3. (3) What is Stokes' law?

Answer:

According to section 3.11.3 of the lab manual, Stokes' law describes the viscous resistance experienced by a spherical object moving through a fluid.

Its formula is:

$$F_v = 6\pi r\eta v$$

Where:

- F_v is the viscous resistance.
- r is the radius of the oil drop.
- η is the coefficient of viscosity of the air.
- v is the terminal velocity of the oil drop.