Modern Physics

Millikan's oil drop experiment

Problem 1.- Certain drop measured by Millikan produced the following charges at different times:

25.41×10^{-19} C	17.47×10^{-19} C	12.70×10^{-19} C
20.64×10^{-19} C	19.06×10^{-19} C	14.29×10^{-19} C

Find the quantized value of *e* from these results.

Solution: To find the quantized value we look for the maximum common denominator, that is, we want the maximum value that yields integers when we divide the charges by that constant. Working with a spreadsheet program yields e=**1.58×10^{-19}C**

Problem 2.- In the Millikan experiment, recall that the Stokes equation gives you a retarding force of $F = -bv = -6\pi\eta rv$ and the weight of the particle is $mg = \frac{4}{3}\pi r^3\rho$, based on this, which droplets fall faster in the absence of an electric field, the small ones or the large ones?

Solution: Notice that the weight scales with the cube of the radius, while the viscous force scales with the radius alone, so **large droplets will fall faster**.

Problem 3.- In the Millikan experiment you measure a terminal velocity of 1.3mm/s and knowing that the density of oil is 900kg/m^3 and the viscosity of air is 1.82kg/ms, calculate the radius of the droplet, its mass and the parameter *b* in Stokes equation.

Solution: The radius:

$$r = 3\sqrt{\frac{\eta v_t}{2g\rho}} = 3\sqrt{\frac{(1.82\times10^{-5}\,\text{kg/ms})(1.3\times10^{-3}\,\text{m/s})}{2(9.8\,\text{m/s}^2)(900\,\text{kg/m}^3)}} = 3.47\times10^{-6}\,\text{m}$$

The mass of the droplet will be the volume of the droplet times the density:

$$m = \frac{4}{3}\pi r^3\rho = \frac{4}{3}(3.14159)(3.47\times10^{-6}\,\text{m})^3(900\,\text{kg/m}^3) = 1.58\times10^{-13}\,\text{kg}$$

$$b = 6\pi\eta = 6(3.14159)(1.82\times10^{-5}\,\text{kg/ms})(3.47\times10^{-6}\,\text{m}) = 1.19\times10^{-9}\,\text{kg/s}$$