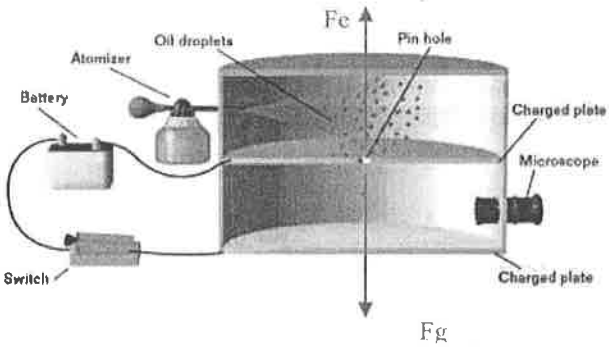
Measuring Charge

IB 11

Robert Millikan's Oil Drop Experiment

In 1909, Robert Millikan performed an experiment at the University of Chicago in which he observed the motion of tiny oil droplets between two parallel metal plates. The oil droplets were charged by friction in an atomizer and allowed to pass through a hole in the top plate. Initially the droplets fell due to their weight. The top plate was given a positive charge as the droplets fell, and the droplets with a negative charge were attracted back upward toward the positively charged plate. By turning the battery on and off, Millikan was able to watch individual oil droplets for many hours as they were suspended in mid-air and alternately rose and fell. By analyzing many measurements, he was able to make an important conclusion about electric charge.



Conclusion: Electric charge is quantized + occurs in integer multiples of a base unit. Found the charge of a single electron = -1.6×10^{-19} C

Sample data for the charge on each oil droplet:

$q = -3.2 \times 10^{-19}$ C = 2 e.c

$q = -6.4 \times 10^{-19}$ C = 4 e.c

$q = -4.8 \times 10^{-19}$ C = 3 e.c.

1. An object has acquired a charge of -3.2×10^{-17} C. How many excess electrons are on the object?

$-3.2 \times 10^{-17}\text{C} \times \frac{1\text{ e.c.}}{-1.6 \times 10^{-19}\text{C}} = 200\text{e}^- = 2.0 \times 10^{2}\text{ e.c.}$

2. A glass rod loses 2500 electrons after being rubbed with silk. What is the charge on the rod? The silk?

$2500\text{ e.c.} \times \frac{-1.6 \times 10^{-19}\text{C}}{1\text{ e.c.}} = \oplus 4.0 \times 10^{-16}\text{ C}$ $\quad -4.0 \times 10^{-16}\text{ C}$

3. How many elementary charges are in one coulomb of charge?

$\frac{1\text{ e.C}}{1.6 \times 10^{-19}\text{C}} = \frac{6.25 \times 10^{18}\text{ e.c.}}{\text{C}}$

$-5.6\text{C} \times \frac{6.25 \times 10^{18}\text{ e.c.}}{1\text{C}}$

4. Which of the following charges are possible for an object to have?

a) -8.0×10^{-19} C b) 4.8×10^{-17} C c) -5.6×10^{-19} C d) 1.6×10^{-20} C e) -5.6 C

5 e.c. 3×10^{2} e.c. x not a possibility x not a possibility 35×10^{18} e.c.

5. How can you determine if a charge is possible?

Initial State	Conduction	Final State
+10 -10 Total charge: Ø e.c.	loses 10e⁻ Charge transfer? yes	Ø Ø Total charge: Ø e.c.
-30 -10 Total charge: ⊖40 e.c.	loses 10e⁻ Charge transfer? yes	-20 -20 Total charge: ⊖40 e.c.
+25 +15 Total charge: ⊕40 e.c.	loses 5e⁻ Charge transfer? yes	20 20 Total charge: ⊕40 e.c.

spheres are touching