

Day One - Charge

Ordinary matter is made up of atoms that have positively charged nuclei and negatively charged electrons surrounding them. The magnitude of the charge on one proton or electron is called the elementary charge "e". Charge is quantized as a multiple of the electron or proton charge:

$$\begin{aligned}\text{proton charge: } e &= 1.602 \times 10^{-19} \text{ Coulombs} \\ \text{electron charge: } e &= -1.602 \times 10^{-19} \text{ Coulombs}\end{aligned}$$

One coulomb (C) of charge represents an excess or deficit of 6.24×10^{18} electrons.

The quantity of charge (Q) on an object is equal to the number of elementary charges on the object (N) multiplied by the elementary charge (e).

$$Q = Ne$$

Example 1:

How much charge does the capacitor hold if it has 4.5 billion elementary charges?

Answer:

$$\begin{aligned}Q &= ? \\ N &= 4.5 \times 10^9 \text{ elementary charges} \\ e &= -1.602 \times 10^{-19} \text{ Coulombs}\end{aligned}$$

$$\begin{aligned}Q &= Ne \\ Q &= 4.5 \times 10^9 \times -1.602 \times 10^{-19} \\ Q &= -7.209 \times 10^{-10}\end{aligned}$$

Example 2:

If an object has 4 coulombs of charge stored, how many elementary charges are present?

Answer:

$$N = ?$$

$$Q = 4 \text{ Coulombs}$$

$$e = -1.602 \times 10^{-19} \text{ Coulombs}$$

$$N = Q/e$$

$$N = 4 / 1.602 \times 10^{-19} \text{ [Note: you can remove the - from the charge]}$$

$$N = 2.5 \times 10^{19} \text{ electrons}$$

Example 3:

How many electrons must be removed from a charged pair of wool socks with a $-1 \mu\text{C}$ charge to give it a charge of $+2.3 \mu\text{C}$?

Answer:

$$Q_i = -1 \mu\text{C} \text{ (Excess electrons)}$$

$$Q_f = +2.3 \mu\text{C} \text{ (Deficit electrons)}$$

$$N = ?$$

$$e = -1.602 \times 10^{-19} \text{ Coulombs}$$

$$Q_t = Q_f - Q_i \quad Q_t = +2.3 \mu\text{C} - (-1 \mu\text{C})$$

$$Q_t = +2.3 \mu\text{C} + 1 \mu\text{C}$$

$$Q_t = +3.3 \mu\text{C}$$

$$N = Q/e$$

$$N = 3.3 \times 10^{-4} / -1.602 \times 10^{-19}$$

$$N = 2.05 \times 10^{15} \text{ electrons}$$

Fundamental Law of Electric Charge:

Opposite electric charges attract each other. Similar electric charges repel each other. Charged object attract some neutral objects.

Day Two – Current

Current is the rate flow of electric charges. The unit of electric charge is the coulomb). The unit for current is the ampere. We use the term amps for short. An amp is the amount of electrical current that exists when a number of electrons having one coulomb of charge move past a given point in one second. One coulomb equals 6,240,000,000,000,000 electrons. That's a lot of electrons moving past a given point in a second.

In physics we describe the flow of current *conventionally*. The flow of positive hole charges is the result of the flow of electrons. Although it is electrons that are the mobile charge carriers responsible for electric current in conductors such as wires, in physics it has been the convention to take the direction of electric current as if it were the positive charges that are moving. As electrons move through the wires a positive hole charge moves in the opposite direction. This positive hole charge is created when the electron moves away from the atom, making the atom momentarily positive.

$$i = \frac{Q}{t} = \frac{\text{coulombs}}{\text{second}} = \text{ampere}$$

I is the current, Q is the quantity of charge, and t is the time. 1 ampere = 6.24×10^{18} elementary charges per second.

Example 1: How much current is flowing if 8 coulombs of charge flow past a point in 6 seconds?

Answer:

$$I = ?$$

$$Q = 8 \text{ coulombs}$$

$$t = 6 \text{ seconds } I = Q/t$$

$$I = 8/6$$

$$I = 1.33 \text{ A}$$

Example 2: If the fuse can withstand 10 Amps and the object it is connected to can provide a continuous 20 coulombs, how long should it take to flow through the fuse if you want the maximum amount of current to pass through the fuse and you do not want the fuse to blow?

Answer:

$$I = 10 \text{ Amps}$$

$$Q = 20 \text{ coulombs}$$

$$t = ?$$

$$I = Q/t$$

$$t = Q/I$$

$$I = 20/10$$

$$I = 2 \text{ seconds}$$

Therefore, 20 coulombs will flow through the fuse every 2 seconds.

Two types of current exist. Direct current (DC) involves the continuous flow of electrons in the same direction. Batteries produce direct current. Alternating current (AC) is the

second type of current. It involves a periodic reversal in the direction of electron flow. The outlets in your house provide alternating current. Direct current is constant, non-changing. Alternating current is measured at the maximum (peak) to the minimum of the cycle. Another measurement of alternating current is frequency. Ex: 60 Hz. This means that the waveform oscillates through 60 cycles per second.