

Electricity

22 Charge and Current

Electric charge is a property of matter. There are two types of electric charge, which are conventionally labelled **positive** and **negative**. Two objects that have the same charge exert **repulsive** forces on each other. Two objects that have opposite charges exert **attractive** forces on each other.

Electric charge is measured in **coulombs** (C) and has the symbol Q .

Electric charge is **quantised**, which means any object can only have an integer multiple of a certain value of charge. The smallest value of the magnitude of charge an object can have is equal to the magnitude of the charge of an **electron**, which is approximately 1.60×10^{-19} C. Electrons are negatively charged. If a neutral object loses electrons, it becomes more **positively** charged. If a neutral object gains electrons, it becomes more **negatively** charged.

Current is the **rate of flow of charge**. Current can be caused by the flow of electrons, ions or other charged particles. When we give a direction, we give the direction a positive ion would go. Accordingly electrons, which are negatively charged, actually move in the opposite direction to the arrow on the circuit diagram.

The equation relating electric charge, current and time is:

$$\text{electric charge} = \text{electric current} \times \text{time} \quad Q = It$$

In an electric circuit, electric current flows from the **positive** terminal of a power supply to the **negative** terminal or **ground**, or from the **ground** to a **negative** terminal.

Electric current is measured in amperes (A) and has the symbol I .

Example 1 – If a charge of 105 C flows in 15 s, calculate the current.
Current = charge / time = $105 \text{ C} / 15 \text{ s} = 7.0 \text{ A}$ (2sf)

Number of electrons used to carry charge = charge / charge of one electron

Number of electrons which flow past a point in one second = charge flow in one second / charge of one electron = current / charge of one electron

Example 2 – Calculate the number of electrons which are required to carry a charge of 105 C.

Number of electrons = charge / charge of one electron =
 $105 \text{ C} / 1.6 \times 10^{-19} \text{ C} = 6.6 \times 10^{20}$ (2sf)

Assume here electrons have a charge of $-1.60 \times 10^{-19} \text{ C}$:

22.1 A 3.00 A appliance has 360 C of charge flow through it.

- (a) How long was the appliance operating?
- (b) How many electrons passed through the appliance in this time?

22.2 -1.00 coulomb is the charge of how many electrons?

22.3 If two electrons are removed from an atom, what is the charge of the resulting cation (a positively charged ion)?

22.4 Work out the missing measurements from the following table, where each row is a separate question.

Charge	Current	Time
(a)	2.50 A	900 ms
350 mC	(b)	20.0 s
900 μC	18.0 μA	(c)
(d)	3.0 A	10 s
(e)	0.60 A	60 s
60 C	1.9 A	(f)
1 260 C	0.50 A	(g)
110 C	(h)	25 s
$3.3 \times 10^4 \text{ C}$	(i)	$6.0 \times 10^3 \text{ s}$

- 22.5 An appliance draws a current of 9.00 A.
- (a) How much charge flows in 5.0 minutes of operation?
 - (b) How many electrons flow in 5.0 minutes?
- 22.6 5.40×10^{21} electrons flow through another appliance in 3.0 minutes.
- (a) How much charge flows through this appliance?
 - (b) What is the current drawn by this appliance?
- 22.7 A car headlamp bulb draws 1.9 A from the battery. How much charge flows through the bulb in 5.0 minutes?
- 22.8 How much charge flows through a lamp in 2.0 minutes if it carries a steady current of 0.30 A?
- 22.9 What current flows through a resistor if 1 260 C of charge moves through it in 5.0 minutes?
- 22.10 How long would a charge of 600 C take to move round a circuit at a steady rate of 12 C/s?

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Additional Charge and Current Questions – with more on-line

- 22.11 With a steady current of 5.0 C/s, how long would it take to move 200 C of charge through a resistor?
- 22.12 In an electric circuit, an ammeter, in series with a $2\,700\ \Omega$ resistor, reads 4.5 mA. How many coulombs of charge pass through the resistor in a time of 5.0 minutes?
- 22.13 How long has a lamp been switched on if it draws 2.5 A from its power supply and 75 C of charge has passed through it?
- 22.14 In part of an electronic circuit, a component is charged in 9.0 s by an average current of 5.0 mA. How much charge is delivered to the component in this time?
- 22.15 Car batteries are rated in units called amp-hours. This is the time in hours for which the battery can supply a 1 A current. What quantity is measured in this unit?