Electrical charge and current

4.2.1.2 · Electricity · revision notes

What an electric current is, why a circuit needs a source of potential difference, and the equation Q = I t. Expect definitions, questions on the current being the same all round a series loop, and 2 to 3 mark calculations, often with a time to convert into seconds.

Key facts

- Current = rate of flow of electrical charge
- I = Q ÷ t and t = Q ÷ I
- Charge flows only in a closed circuit with a source of potential difference
- 1 mA = 0.001 A; 1 minute = 60 s; 1 hour = 3600 s
- Q = I t: charge flow (C) = current (A) × time (s)
- 1 A = 1 C of charge passing a point each second
- Current is the same at every point in a single closed loop

Notes

What current is

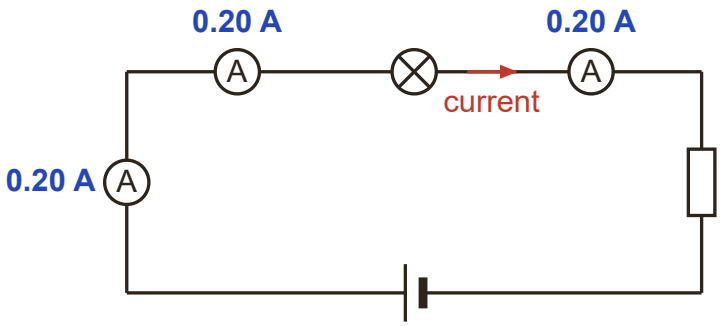
- An **electric current** is a flow of electrical charge.
- The size of the current is the **rate of flow of charge**: how much charge passes a point each second.
- In metal wires the charge is carried by electrons, which are negatively charged.
- Charge is measured in **coulombs (C)**. Current is measured in **amperes (A)**, usually called amps.

What a circuit needs

- For charge to flow, the circuit must be a **closed** loop, with no gaps.
- The circuit must include a **source of potential difference**, such as a cell, a battery or a power supply. The potential difference is what makes the charge flow.
- Opening a switch makes a gap, so the current stops everywhere in that loop.

Current in a single loop

- In a single closed loop (a series circuit) the current is the **same at every point**.



In one loop every ammeter gives the same reading.

- Charge is not used up by the components. The charge that leaves the cell each second is the same as the charge that returns to it. Energy is transferred to the components, but no charge is lost.
- So two ammeters placed anywhere in the same loop give the same reading.

The equation Q = I t

- charge flow = current × time: **Q = I t**, with Q in coulombs, I in amperes and t in seconds.
- A current of 1 A means 1 coulomb of charge passes a point every second.
- Rearranged: I = Q ÷ t and t = Q ÷ I.
- Convert first: minutes × 60 = seconds, hours × 3600 = seconds, milliamps ÷ 1000 = amps.

How to answer each type of question

Calculate the charge that flows 2 marks **Grade 4**

1. Write Q = I t.
2. Check the time is in seconds and the current is in amps.
3. Substitute, calculate and give the unit C (coulombs).

Example. A current of 0.40 A flows through a lamp for 90 s.
Calculate the charge that flows through the lamp.

Model answer.

Q = 0.40 × 90 (1)
Q = 36 C (1)

Rearrange Q = I t, with a unit conversion

3 marks | Grade 5

1. Convert the time to seconds (or mA to A) first.
2. Rearrange: I = Q ÷ t or t = Q ÷ I.
3. Substitute and give the answer with its unit.

Example. A charge of 720 C flows through a heater in 4.0 minutes.
Calculate the current in the heater.

Model answer.

t = 4.0 × 60 = 240 s (1)

I = Q ÷ t = 720 ÷ 240 (1)

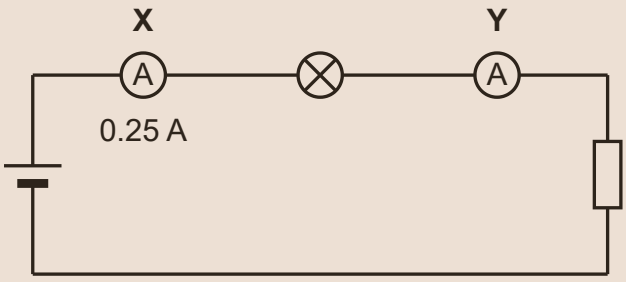
I = 3.0 A (1)

State and explain the current at different points in a loop

2 marks | Grade 5

1. Check whether the ammeters are in the same single loop.
2. If they are, the readings are equal.
3. Give the reason: the current is the same at every point in a single closed loop; charge is not used up.

Example. A cell, a lamp and a resistor are connected in series. Ammeter X is between the cell and the lamp. Ammeter Y is between the lamp and the resistor. Ammeter X reads 0.25 A.



(a) State the reading on ammeter Y.
(b) Give a reason for your answer.

Model answer.

(a) 0.25 A (1)

(b) The current is the same at every point in a single closed loop / charge is not used up by the lamp (1)

Don’t lose marks

- ✕ Leaving the time in minutes or hours instead of converting to seconds.
- ✕ Forgetting to change mA to A (divide by 1000).

- Saying the current is 'used up' by a lamp, so it is smaller after the lamp. In a single loop it is the same everywhere.
- Defining current as 'the amount of charge' or 'the speed of the electrons'. It is the RATE of flow of charge.

More tips

Memory tricks

- Formula triangle: Q on top, I and t underneath. Cover the one you want to find.
- Think of current as coulombs per second: 3 A means 3 C passes every second.
- Sense check: a bigger current or a longer time must give more charge.

Exam technique

- Write the equation, then substitute, then give the answer with its unit. Each step can earn a mark.
- Practise using Q = I t and rearranging it to find charge, current or time.
- When asked to define current, use the words 'rate of flow of (electrical) charge'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **State that current is a flow of charge**
Electric current is a flow of electrical charge around a closed circuit.

Grade 3 — **Give the units of charge, current, time**
Charge in coulombs (C), current in amperes (A) and time in seconds (s).

Grade 4 — **State what a circuit needs for current**
A closed circuit (complete loop) that includes a source of potential difference, such as a cell.

Grade 4 — **Calculate charge using Q = I t**
Multiply the current in amps by the time in seconds to get the charge in coulombs.

Grade 5 — **State that current is the same around a loop**
In a single closed loop the current has the same value at every point.

Grade 5 — **Rearrange Q = I t and convert units**
Use I = Q ÷ t or t = Q ÷ I, converting minutes to seconds and mA to A first.

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