A-LEVEL PHYSICS • EXERCISE SHEET

9.1 Electric current

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

Objective

Build the skills to answer exam questions on **electric current** —charge carriers, $Q = It$, and the $I = Anvq$ equation.

You must be able to:

- explain current as a flow of **charge carriers** and that charge is **quantised**
- use $Q = It$
- use $I = Anvq$ to find **drift velocity**

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

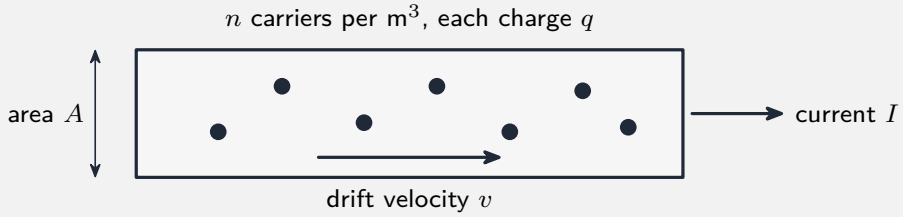
Current and charge

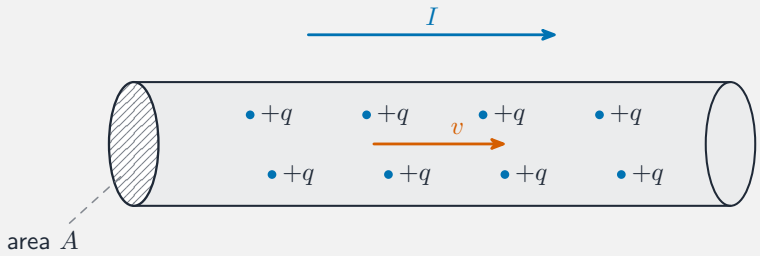
A current is a **flow of charge carriers**. Charge is **quantised**: every free charge is a multiple of $e = 1.60 \times 10^{-19}$ C. **Conventional current** flows opposite to the electrons in a wire.

$$I = \frac{Q}{t}, \qquad Q = It \quad (\text{unit A} = \text{C s}^{-1}).$$

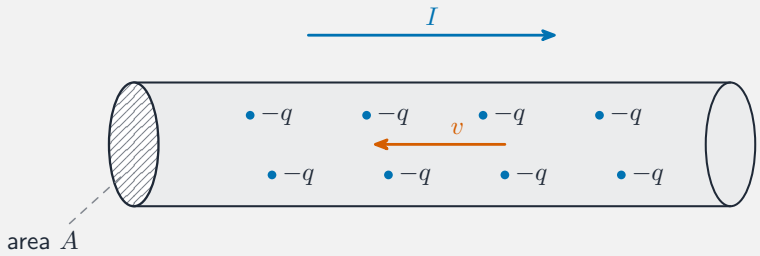
Worked example. 0.50 A for 2.0 min: $Q = It = 0.50 \times 120 = 60$ C; electrons $N = Q/e = 60/(1.6 \times 10^{-19}) \approx 3.8 \times 10^{20}$.

The drift-velocity equation





(a) positive carriers drift with I



(b) electrons drift against I

Charge carriers drift through a conductor

$$I = Anvq,$$

where A = area, n = number density of carriers, v = drift velocity, q = charge per carrier. Rearrange for the drift velocity: $v = \dfrac{I}{Anq}$.

2 Practice

Now apply the methods above.

2.1 State what an **electric current** is. [1]

2.2 A current of 0.50 A flows for 2.0 minutes. Find the **charge** that passes. [2]

2.3 State the value of the **elementary charge** e. [1]

2.4 State the direction of **conventional current** relative to the flow of electrons in a wire. [1]

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3 Exam-style questions

3.1 A current of 3.0 A flows for 10 s. The charge that passes is: [1]

- **A** 0.30 C
- **B** 3.0 C
- **C** 30 C
- **D** 300 C

3.2 Calculate the number of electrons in a charge of 60 C. ($e = 1.60 \times 10^{-19}$ C.) [2]

3.3 A copper wire of cross-sectional area 1.0×10^{-6} m^2 carries a current of 5.0 A. Copper has $n = 8.5 \times 10^{28}$ free electrons per m^3. Calculate the **drift velocity**. ($e = 1.6 \times 10^{-19}$ C.) [3]

3.4 State what is meant by "charge is **quantised**". [1]

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4 Go further

You are now ready for the real exam questions on this subtopic. Open the **9.1 Electric current** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/21 J25 —Q6 (current, then drift speed)
- 9702/24 J25 —Q5 (electric current, structured)
- 9702/22 M25 —Q6 (current, calculation)

- 9702/12 J25 —Q34 (charge, multiple choice)
- 9702/13 J25 —Q32 (charge carriers, multiple choice)

Solutions

2.1 A **flow of charge carriers** (the rate of flow of charge).

2.2 $Q = It = 0.50 \times (2.0 \times 60) = 0.50 \times 120 = 60$ C.

2.3 $e = 1.60 \times 10^{-19}$ C.

2.4 Opposite to the electron flow (conventional current is the direction positive charge would move).

3.1 C —$Q = It = 3.0 \times 10 = 30$ C.

3.2 $N = Q/e = 60/(1.60 \times 10^{-19}) = 3.75 \times 10^{20}$.

3.3 $v = \dfrac{I}{Anq} = \dfrac{5.0}{(1.0 \times 10^{-6})(8.5 \times 10^{28})(1.6 \times 10^{-19})} = 3.7 \times 10^{-4}$ m s^{-1}.

3.4 Charge comes only in **whole-number multiples** of the elementary charge e.