A-LEVEL PHYSICS • HOLIDAY HOMEWORK 假期作业

9 Electricity – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
charge carriers	载流子			
elementary charge	基本电荷			
drift velocity	漂移速度			
filament lamp	灯丝灯泡			
diode	二极管			
thermistor	热敏电阻			
light-dependent resistor	光敏电阻			

Recall

In **Part 1** you used $I = Q/t$, $V = W/Q$, electrical power, resistance, Ohm's law and resistivity. Part 2 looks at what actually flows (charge carriers, drift velocity), how real components behave, and components that sense their surroundings.

New ideas

Read these first. Each idea has a short worked example. Then do the Practice.

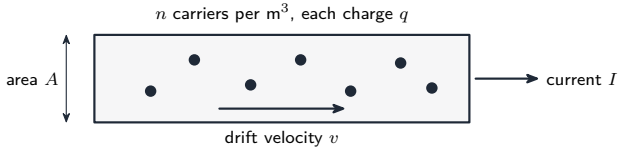
1 Charge and drift velocity

A current is a flow of **charge carriers** 载流子 (electrons in a metal). Charge comes in whole numbers of the **elementary charge** 基本电荷 $e = 1.6 \times 10^{-19}$ C: since $Q = It$, the number of electrons is $N = Q/e$.

The carriers drift slowly at a **drift velocity** 漂移速度 v, linked to the current by

$$I = nAvq,$$

where n is the number of carriers per m^3 and A is the area.

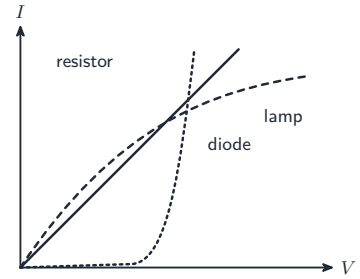


Worked example. A copper wire ($A = 1.0 \times 10^{-6}$ m^2, $n = 8.5 \times 10^{28}$ m^{-3}) carries 5.0 A: $v = \dfrac{I}{nAq} = \dfrac{5.0}{(8.5 \times 10^{28})(1.0 \times 10^{-6})(1.6 \times 10^{-19})} \approx 3.7 \times 10^{-4}$ m s^{-1} — under a millimetre per second.

Watch out: the drift velocity is tiny, yet a lamp lights instantly — because the electric *field* travels through the wire near light-speed and pushes every electron at once.

2 Real components

- A **filament lamp** 灯丝灯泡: as more current heats the filament, its resistance **rises**, so its I–V graph bends over (gets flatter).
- a **diode** 二极管: lets current flow one way only — almost none in reverse, and little until about 0.7 V forwards, then it rises sharply.

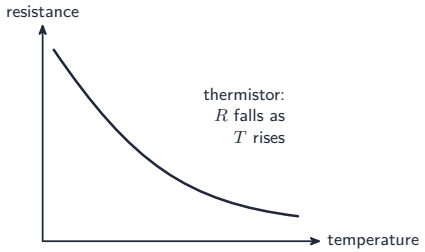


Worked example. Reading a diode's I–V graph: below about 0.7 V forwards almost no current flows; above it the current rises steeply; in reverse the current stays near zero.

3 Sensing components

- a **thermistor** 热敏电阻: its resistance **falls** as the temperature rises.
- a **light-dependent resistor** 光敏电阻 (LDR): its resistance **falls** as the light gets brighter.

Both are used in sensing circuits (a thermostat, a light-controlled lamp).



Worked example. On a cold night a thermistor's resistance is high; as a heater warms it, the resistance falls — a circuit can sense that change and switch the heater off.

Practice

9.1 A current of 2.0 A flows for 30 s. Find (a) the charge that passes, (b) the number of electrons ($e = 1.6 \times 10^{-19}$ C). [3]

9.2 A wire of area 2.0×10^{-6} m^2 carries 8.0 A, with $n = 8.5 \times 10^{28}$ m^{-3} and $q = 1.6 \times 10^{-19}$ C. Find the drift velocity. [2]

9.3 State what happens to the resistance of a filament lamp as the current through it increases, and why. [2]

9.4 State the key property of a diode in a circuit. [1]

9.5 State how the resistance of (a) a thermistor changes as it gets hotter, (b) an LDR changes as the light gets brighter. [2]

9.6 Using $I = nAvq$, explain *why* a thicker wire carrying the same current has a smaller drift velocity. [2]

9.7 Challenge. Explain why an LDR is a good component for a circuit that switches a light on automatically when it gets dark. [2]