Week 21

A-Level Physics

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

A-Level Physics Name: ____________ Score: ______

1. Conventional current points in the direction that:
   - ☐ positive charge would flow
   - ☐ electrons actually flow
   - ☐ the wire is thickest
   - ☐ no charge flows
2. Potential difference is the energy transferred per unit:
   - ☐ charge
   - ☐ time
   - ☐ current
   - ☐ length
3. A component has 12 V across it and 3.0 A through it. What is its resistance?

   ____________ Ω
4. The smallest free unit of charge is the ______ charge, $e = 1.6 \times 10^{-19}$ C.

   ____
5. One volt equals one joule per ______.

   ____
6. An ohmic conductor at constant temperature has:
   - ☐ current proportional to p.d.
   - ☐ current proportional to resistance
   - ☐ a constant current whatever the p.d.
   - ☐ zero resistance
7. A current of 2.0 A flows for 5.0 s. How much charge passes?

   ____________ C
8. Both e.m.f. and potential difference are measured in volts.

   ☐ True ☐ False
9. A filament lamp's resistance rises at higher voltage because:
   - ☐ the filament heats up

- ☐ the voltage falls
- ☐ the electrons run out
- ☐ it obeys Ohm's law

10. The charge that has flowed equals the area under an I–t graph.

☐ True ☐ False

A-Level Physics

1. **positive charge would flow**

   Conventional current is the flow of positive charge — opposite to the electron drift in a metal wire.

2. **charge**

   $V = \frac{W}{Q}$ — energy per unit charge, in joules per coulomb (volts).

3. **4 Ω**

   $R = \frac{V}{I} = \frac{12}{3.0} = 4.0\ \Omega$.

4. **elementary**

   All free charges are whole-number multiples of the elementary charge e.

5. **coulomb**

   $1\ \mathrm{V} = 1\ \frac{\mathrm{J}}{\mathrm{C}}$ — one joule of energy moved per coulomb of charge.

6. **current proportional to p.d.**

   Ohm's law: $I \propto V$, so $R = \frac{V}{I}$ is constant and the I–V graph is a straight line through the origin.

7. **10 C**

   $Q = It = 2.0 \times 5.0 = 10$ C.

8. **True**

   Yes — both are energy per unit charge (J/C). The difference is whether energy is given to, or taken from, the charge.

9. **the filament heats up**

   More current heats the filament; in a metal, more lattice vibration scatters electrons, so R increases.

10. **True**

    Yes — current is the rate of flow of charge, so the area (current × time) gives the total charge.

A-LEVEL PHYSICS • EXERCISE SHEET

9.1 Electric current

Name: ____________ Class: ________ Date: __________ **Total: 25 marks**

KEY WORDS charge carrier 载流子 • number density 数密度 • electric current 电流 • elementary charge 基本电荷 • conventional current 常规电流

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.

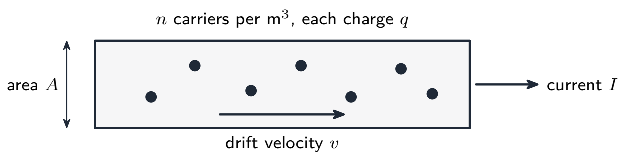
■ Current and charge

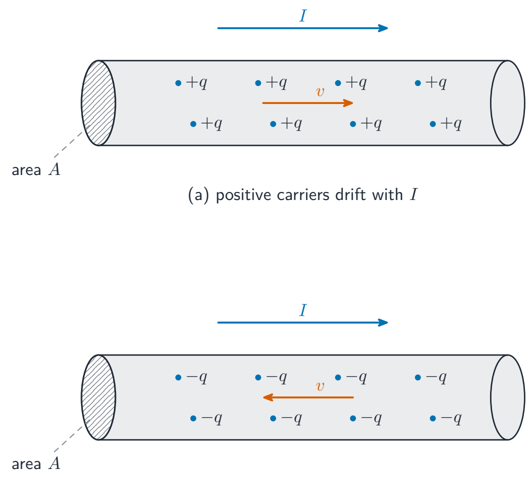
A current is a **flow of charge carriers**. Charge is **quantised**: every free charge is a multiple of $e = 1.60 \times 10^{-19}$ C. **Conventional current** flows opposite to the electrons in a wire.

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

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]

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]

3.5 A cylindrical copper wire P has length 0.32 m and resistance 4.4 mΩ. The current in it is 0.75 A. The wire contains 3.1×10^{22} free electrons in total. The resistivity of copper is 1.8×10^{-8} Ω m and the elementary charge is 1.6×10^{-19} C.

(a) **Calculate** the potential difference between the ends of the wire. [2]

(b) **Show that** the cross-sectional area of the wire is about 1.3×10^{-6} m^2. [2]

(c) **Show that** the number density of free electrons in the copper is about 7.4×10^{28} m^{-3}. [2]

(d) **Determine** the average drift speed of the electrons, and comment on its size. [3]

(e) A second wire Q is made from the **same volume** of copper, but drawn out so that it is longer and thinner than P. **State and explain** how the resistance of Q compares with that of P. [4]

Solutions

Each answer shows the steps, then the **result**.

2.1

- a current is a **flow of charge carriers** (the rate of flow of charge)

2.2

- $I = 0.50$ A, $t = 2.0$ min $= 120$ s
- $Q = It$

$$Q = (0.50 \text{ A})(120 \text{ s}) = \mathbf{60} \text{ C}$$

2.3

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

2.4

- **opposite** to the electron flow (the direction positive charge would move)

3.1 C

- $Q = It$

$$Q = (3.0 \text{ A})(10 \text{ s}) = \mathbf{30} \text{ C}$$

- **A** divides instead of multiplying; **B** drops a factor of 10; **D** uses $t = 100$ s

3.2

- $Q = 60$ C, $e = 1.60 \times 10^{-19}$ C
- $N = Q/e$

$$N = \frac{60 \text{ C}}{1.60 \times 10^{-19} \text{ C}} = \mathbf{3.75 \times 10^{20}}$$

3.3

- $I = 5.0$ A, $A = 1.0 \times 10^{-6}$ m^2, $n = 8.5 \times 10^{28}$ m^{-3}, $q = e = 1.6 \times 10^{-19}$ C
- $I = Anvq$, so $v = I/(Anq)$

$$v = \frac{5.0 \text{ A}}{(1.0 \times 10^{-6} \text{ m}^2)(8.5 \times 10^{28} \text{ m}^{-3})(1.6 \times 10^{-19} \text{ C})} = \mathbf{3.7 \times 10^{-4}} \text{ m s}^{-1}$$

3.4

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

3.5

(a) $I = 0.75$ A, $R = 4.4$ m$\Omega = 4.4 \times 10^{-3}$ Ω

- $V = IR$

$$V = (0.75 \text{ A})(4.4 \times 10^{-3} \ \Omega) = \mathbf{3.3 \times 10^{-3}} \text{ V}$$

(b) $R = \rho L/A$, so $A = \rho L/R$

$$A = \frac{(1.8 \times 10^{-8}\ \Omega\,\mathrm{m})(0.32\ \mathrm{m})}{4.4 \times 10^{-3}\ \Omega} = 1.31 \times 10^{-6}\ \mathrm{m}^2 \approx \mathbf{1.3 \times 10^{-6}\ m^2}$$

(c) number density = total number / volume, and $V = AL$

$$n = \frac{3.1 \times 10^{22}}{(1.31 \times 10^{-6}\ \mathrm{m}^2)(0.32\ \mathrm{m})} = \mathbf{7.4 \times 10^{28}\ m^{-3}}$$

(d) $I = nAvq$, so $v = I/(nAq)$

$$v = \frac{0.75\ \mathrm{A}}{(7.4 \times 10^{28}\ \mathrm{m}^{-3})(1.31 \times 10^{-6}\ \mathrm{m}^2)(1.6 \times 10^{-19}\ \mathrm{C})} = \mathbf{4.8 \times 10^{-5}\ m\ s^{-1}}$$

- about 0.2 mm every four seconds: the electrons crawl, while the *signal* travels near c

(e) Q has the **same volume**, so making it longer forces it to be thinner: L **increases** and A **decreases**

- $R = \rho L/A$, so both changes raise R
- **Q has a greater resistance than P**

32 What is a possible charge on a particle?

A 6.40×10^{-20} C

B 4.00×10^{-19} C

C 1.12×10^{-18} C

D 9.11×10^{-18} C

A-Level Physics: **w25 14**

35 A wire carries a current of 5.6 A.

What is the number of conduction electrons that pass a point on the wire in a time of 20 s?

A 1.8×10^{18} **B** 2.2×10^{19} **C** 3.5×10^{19} **D** 7.0×10^{20}

A-Level Physics: **s25 12**

34 A resistor of resistance 200 Ω is connected to a supply that has a p.d. of 4.00 V.

How many electrons enter the resistor in 4.00 s?

A 3.13×10^{16} **B** 1.25×10^{17} **C** 5.00×10^{17} **D** 1.25×10^{21}

A-Level Physics: **s25 13**

4 A sample of material has cross-sectional area A and length L. The temperatures at the two sides of the sample are T_1 and T_2. Thermal energy Q is transferred through the sample in time t.

These quantities are related by

$$\frac{Q}{t} = \frac{k \times A \times (T_1 - T_2)}{L}$$

where k is a constant.

What are the SI base units of k?

A kg m s^{-3} °C^{-1} **B** kg m s^{-3} K^{-1} **C** kg m s^{-1} °C^{-1} **D** kg m s^{-1} K^{-1}

32 The current I in a metallic conductor of cross-sectional area A is given by

$$I = Anve$$

where e is the elementary charge and v is the mean drift velocity of the conduction electrons.

What is represented by the letter n in the equation?

A density of conduction electrons

B number of conduction electrons per unit time

C number of conduction electrons per unit volume

D volume of conduction electrons

A-Level Physics: **s25 14**

29 The resistance of a lamp is 10 Ω and the potential difference across it is 6.0 V.

How many electrons pass through the lamp in a time of 24 hours?

A 5.2×10^4 **B** 9.0×10^{19} **C** 5.4×10^{21} **D** 3.2×10^{23}

A-Level Physics: **m25 12**

30 Two cylindrical conductors, X and Y, are made from the same material. The conductors have equal lengths, but Y has a smaller diameter than X.

X and Y are connected in series to a cell.

Which row compares the number of charge carriers per unit time passing through X and through Y and compares the average drift speed of the charge carriers in X and in Y?

	number of charge carriers per unit time	average drift speed of charge carriers
A	Y greater than X	Y greater than X
B	Y same as X	Y same as X
C	Y greater than X	Y same as X
D	Y same as X	Y greater than X

6 A cylindrical copper wire P of length 0.24 m is shown in Fig. 6.1.

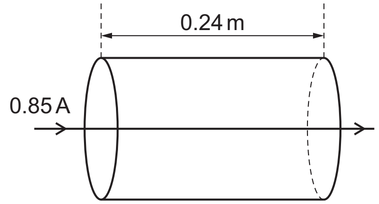


Fig. 6.1 (not to scale)

The current in the wire is 0.85 A.
The resistance of the wire is 3.3 mΩ.
The **total** number of charge carriers N in the wire is 2.6×10^{22}.
The resistivity of copper is 1.8×10^{-8} Ω m.

(a) Calculate the potential difference between the two ends of the wire.

potential difference = ... V [2]

(b) (i) Show that the cross-sectional area of the wire is 1.3×10^{-6} m^2.

[2]

(ii) Show that the number density of charge carriers in the wire is 8.3×10^{28} m^{-3}.

[1]

(iii) Calculate the average drift speed of the charge carriers (electrons) in the wire.

average drift speed = ... m s^{-1} [2]

(c) A different copper wire Q has the same volume as wire P, but non-uniform radius, as shown in Fig. 6.2.

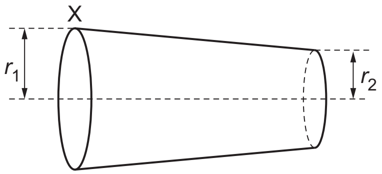


Fig. 6.2 (not to scale)

The radius r_1 at end X of wire Q is the same as the radius of wire P. Radius r_2 is less than r_1.

(i) State and explain how the resistance of wire Q compares with the resistance of wire P.

....

....

....

....

....

....

.... [4]

Name: A-Level Physics: **m25 22**

(ii) On Fig. 6.3, sketch a graph of the variation of the average drift speed of the charge carriers with distance from end X of wire Q.

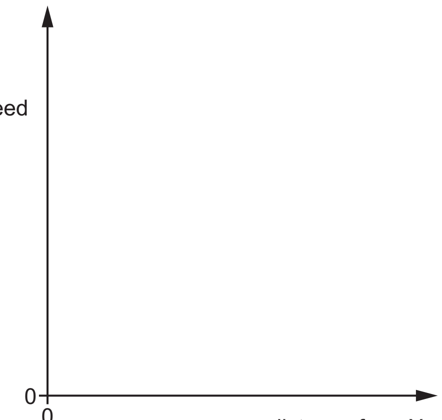


Fig. 6.3

[2]

[Total: 13]

A-LEVEL PHYSICS • EXERCISE SHEET

9.2 Potential difference and power

Name: ____________ Class: ________ Date: __________ **Total: 25 marks**

KEY WORDS potential difference 电势差 • power 功率 • resistance 电阻 • energy 能量 • volt 伏特

Objective

Build the skills to answer exam questions on **potential difference and power**.

You must be able to:

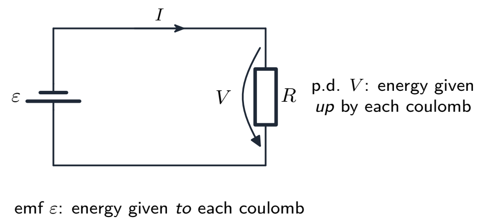
- define **potential difference** and use $V = W/Q$
- distinguish **e.m.f.** from **p.d.**
- use $P = VI = I^2R = V^2/R$

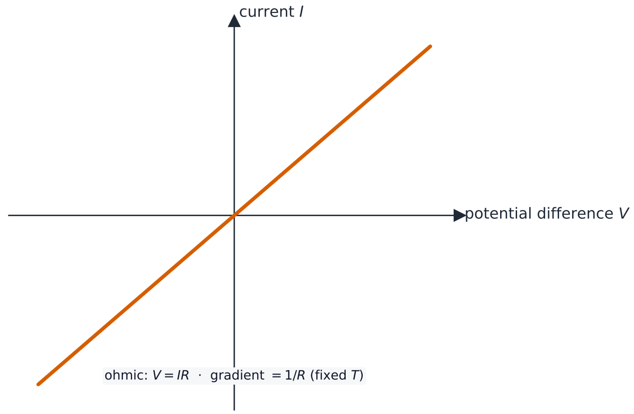
1 Worked examples

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.

Potential difference and e.m.f.

Potential difference is the energy transferred **per unit charge**: $V = W/Q$ (unit $\mathrm{V} = \mathrm{J\ C^{-1}}$).





The I-V graph of an ohmic conductor

e.m.f. is the energy given **to** each coulomb by the source; **p.d.** is the energy given **up** by each coulomb in a component. Same formula, opposite direction of energy transfer.

Power

$$P = \frac{W}{t} = VI = I^2R = \frac{V^2}{R}.$$

Pick the form with the quantities you know. Energy: $E = Pt$.

Worked example. A kettle "2.4 kW, 240 V": $I = P/V = 10$ A; $R = V^2/P = 24\ \Omega$.

2 Practice

Now apply the methods above.

2.1 Define **potential difference**. [1]

2.2 State the difference between **e.m.f.** and **p.d.** [1]

2.3 Write the **three** forms of the electrical power equation. [2]

2.4 A 12 V supply drives a current of 2.0 A. Find the **power**. [1]

3 Exam-style questions

3.1 A lamp has 240 V across it and a current of 0.50 A. Its power is: [1]

- **A** 120 W
- **B** 480 W
- **C** 0.50 W
- **D** 240 W

3.2 A kettle is marked "2.4 kW, 240 V". Calculate (a) the current it draws, (b) its resistance. [4]

3.3 A 10 Ω and a 20 Ω resistor are each connected, separately, across the **same** 12 V supply. State which dissipates **more power**, and why. [2]

3.4 A 60 W lamp runs for 5.0 minutes. Calculate the **energy** transferred. [2]

3.5 A battery of negligible internal resistance supplies 9.0 V to a circuit that splits into two parallel branches. The **upper** branch contains a 150 Ω resistor in series with an unknown resistor R. The **lower** branch contains a 360 Ω resistor in series with a 540 Ω resistor. The battery delivers a total current of 0.040 A.

(a) **Define** the electric potential difference across a component. [1]

(b) **Determine** the charge that passes through the battery in 3.0 minutes. [2]

(c) **Calculate** the current I_2 in the **lower** branch. [2]

(d) **Calculate** the current I_1 in the **upper** branch. [1]

(e) **Determine** the resistance R. [2]

(f) **Determine** the total power delivered by the battery, and the power dissipated in the 150 Ω resistor. [3]

Solutions

Each answer shows the steps, then the **result**.

2.1

- the **energy transferred per unit charge** as charge passes through a component ($V = W/Q$)

2.2

- **e.m.f.** is energy given **to** each coulomb by the source; **p.d.** is energy given **up** by each coulomb in a component

2.3

- $P = VI$, $P = I^2R$, $P = V^2/R$

2.4

- $P = VI$

$$P = (12\ \text{V})(2.0\ \text{A}) = \mathbf{24}\ \text{W}$$

3.1 A

- $P = VI$

$$P = (240\ \text{V})(0.50\ \text{A}) = \mathbf{120}\ \text{W}$$

- **B** multiplies V by 2; **C** is $V \times I$ with a dropped 240; **D** quotes the voltage as a power

3.2

(a) $P = 2.4$ kW $= 2400$ W, $V = 240$ V

- $I = P/V$

$$I = \frac{2400\ \text{W}}{240\ \text{V}} = \mathbf{10}\ \text{A}$$

(b) $R = V^2/P$

$$R = \frac{(240\ \text{V})^2}{2400\ \text{W}} = \mathbf{24}$$

3.3

- the 10 Ω resistor dissipates more power
- at the same voltage $P = V^2/R$, so the **smaller** resistance gives the **larger** power

3.4

- $P = 60$ W, $t = 5.0$ min $= 300$ s
- $E = Pt$

$$E = (60\ \text{W})(300\ \text{s}) = \mathbf{1.8 \times 10^4}\ \text{J}$$

3.5

(a) the **energy transferred** to the component **per unit charge** passing through it

(b) $I = 0.040$ A, $t = 3.0$ min $= 180$ s

- $Q = It$

$$Q = (0.040\text{ A})(180\text{ s}) = \mathbf{7.2}\text{ C}$$

(c) the lower branch has the full 9.0 V across 360 Ω + 540 Ω = 900 Ω

$$I_2 = \frac{9.0\text{ V}}{900\ \Omega} = \mathbf{0.010}\text{ A}$$

(d) branch currents add to the battery current

$$I_1 = 0.040\text{ A} - 0.010\text{ A} = \mathbf{0.030}\text{ A}$$

(e) the upper branch also has 9.0 V across it

$$R_{\text{upper}} = \frac{9.0\text{ V}}{0.030\text{ A}} = 300\ \Omega$$

- $R = 300\ \Omega - 150\ \Omega = \mathbf{150}$

(f) $P_{\text{total}} = VI$

$$P_{\text{total}} = (9.0\text{ V})(0.040\text{ A}) = \mathbf{0.36}\text{ W}$$

- in the 150 Ω resistor use the **branch** current I_1, not the battery current

$$P = I_1^2 R = (0.030\text{ A})^2(150\ \Omega) = \mathbf{0.135}\text{ W}$$

Name: A-Level Physics: **w25 11**

31 There is a potential difference V across a resistor of resistance R. The current in the resistor is I.

Which equation gives the power P dissipated by the resistor?

A $P = V^2 I$ **B** $P = \frac{V^2}{I}$ **C** $P = V^2 R$ **D** $P = \frac{V^2}{R}$

A-Level Physics: **w25 12**

32 The current in a resistor of constant resistance is 8.0 mA. The power dissipated by the resistor is P.

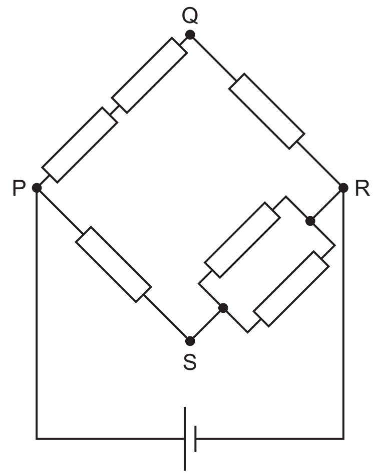
The current in the resistor is increased to 12.0 mA.

What is the new power dissipated by the resistor?

A $0.44P$ **B** $0.67P$ **C** $1.5P$ **D** $2.3P$

A-Level Physics: **s25 11**

34 The diagram shows six identical resistors connected in a circuit.



In which branch of the circuit is the most power dissipated?

A PQ **B** QR **C** RS **D** SP

A-Level Physics: **s25 14**

30 What is equivalent to one volt?

A one coulomb per second

B one joule per coulomb

C one joule per second

D one joule second per coulomb squared

6 **(a)** Define electric potential difference across a component.

....

.... [1]

(b) A circuit contains four resistors and a battery of electromotive force (e.m.f.) 8.0 V with negligible internal resistance. When the variable resistor has resistance *R*, the currents in the circuit are 0.030 A, I_1 and I_2, as shown in Fig. 6.1.

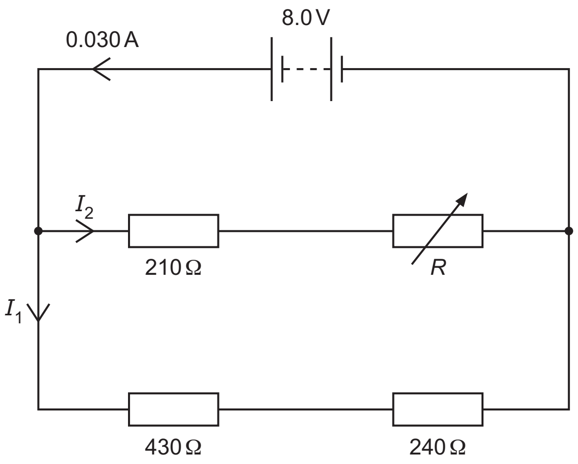


Fig. 6.1

(i) Determine the charge passing through the battery in a time of 4.0 minutes.

charge = ... C [2]

(ii) Calculate I_1.

I_1 = ... A [2]

(iii) Calculate I_2.

I_2 = ... A [1]

(iv) Determine *R*.

R = ... Ω [2]

(c) The variable resistor in **(b)** is fitted with a scale so that its resistance can be accurately determined.
The resistor of resistance 240 Ω is now replaced by a new resistor X of unknown resistance.
A galvanometer is connected as shown in Fig. 6.2.

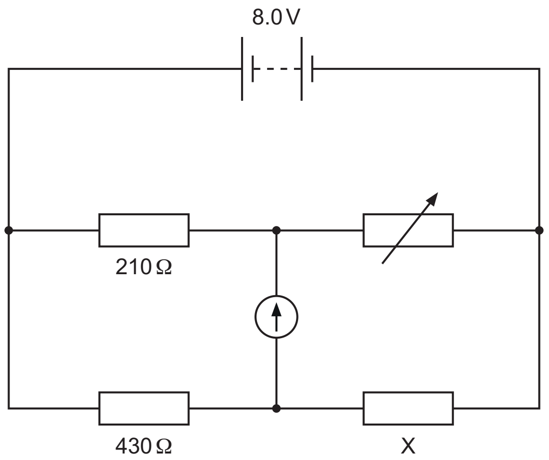


Fig. 6.2

With reference to ratios of resistances, explain how this circuit can be used to determine the resistance of X.

....

....

....

....

.... [2]

[Total: 10]

A-LEVEL PHYSICS • EXERCISE SHEET

9.3 Resistance and resistivity

Name: ____________ Class: ________ Date: __________ **Total: 17 marks**

KEY WORDS thermistor 热敏电阻 • diode 二极管 • filament lamp 灯丝灯泡 • resistance and resistivity 电阻率 • resistance 电阻

Objective

Build the skills to answer exam questions on **resistance and resistivity 电阻率** — Ohm's law, I–V characteristics, and **measuring** resistivity.

You must be able to:

- define **resistance** and state **Ohm's law**
- sketch the I–V graphs of a **metal wire**, a **filament lamp** and a **diode**
- use $R = \rho L/A$, getting A from a **diameter** ($A = \pi d^2/4$)
- describe the **circuit and steps** to measure the resistivity of a wire

1 Worked examples

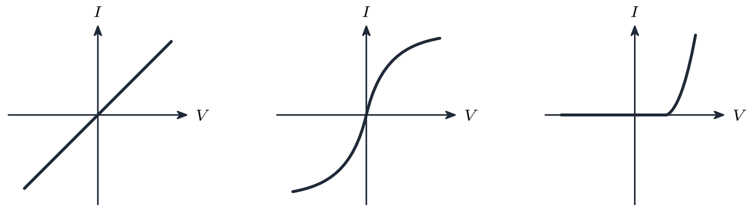
Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

Resistance and Ohm's law

$$R = \frac{V}{I}\ (\Omega).$$

Ohm's law: for a metal at constant temperature, $I \propto V$, so R is constant (a straight-line I–V graph).

I–V characteristics



ohmic conductor　filament lamp　diode

A **filament lamp**'s resistance **rises** as current increases: more current heats the filament, raising its temperature and resistance, so the graph flattens.

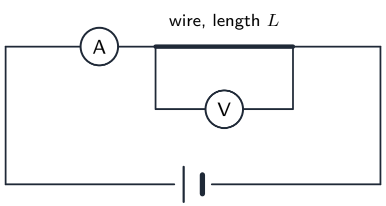
Resistivity, LDR, thermistor

$$R = \frac{\rho L}{A}.$$

An **LDR**'s resistance **falls** as light gets brighter; a **thermistor**'s resistance **falls** as temperature rises.

Measuring resistivity

A very common experiment: find ρ for a wire. Connect an **ammeter in series** with the wire and a **voltmeter across** it:



1. Read V and $I \to$ resistance $R = V/I$.
2. Measure the **diameter** $d \to$ area $A = \pi d^2/4$ (use the radius $d/2$).
3. Measure the length $L \to \rho = \dfrac{RA}{L}$.

Worked example. $V = 1.5$ V, $I = 0.45$ A $\to R = 3.33\ \Omega$. Diameter $d = 0.40$ mm $\to A = \pi(0.20 \times 10^{-3})^2 = 1.26 \times 10^{-7}$ m^2. Length $L = 0.80$ m: $\rho = \dfrac{RA}{L} = \dfrac{(3.33)(1.26 \times 10^{-7})}{0.80} = 5.2 \times 10^{-7}\ \Omega\,\mathrm{m}$.

2 Practice

Now apply the methods above.

2.1 Define **resistance**. [1]

2.2 State **Ohm's law**. [1]

2.3 A component has 6.0 V across it and 0.30 A through it. Find its **resistance**. [2]

2.4 A wire has diameter 0.50 mm. Calculate its cross-sectional **area** in m^2. [2]

2.5 State what happens to a **thermistor's** resistance as its temperature **rises**. [1]

3 Exam-style questions

3.1 Which component has a **straight-line** I–V graph through the origin? [1]

- **A** a filament lamp
- **B** a diode
- **C** a metal wire at constant temperature
- **D** a thermistor

3.2 Explain why the **resistance** of a filament lamp **increases** as the current increases. [2]

3.3 A student measures the resistivity of a metal wire.

(a) Draw a circuit, using an ammeter and a voltmeter, to measure the **resistance** of the wire. [2]

(b) The readings are $V = 1.5$ V and $I = 0.45$ A; the wire has length 0.80 m and diameter 0.40 mm. Calculate the **resistivity** of the metal. [4]

3.4 State what happens to the resistance of an **LDR** as the light intensity **increases**.[1]

Solutions

Each answer shows the steps, then the **result**.

2.1

- resistance = p.d./current ($R = V/I$)

2.2

- the current is **proportional** to the p.d. (at constant temperature)

2.3

- $V = 6.0$ V, $I = 0.30$ A
- $R = V/I$

$$R = \frac{6.0\text{ V}}{0.30\text{ A}} = \mathbf{20}$$

2.4

- $d = 0.50$ mm $= 5.0 \times 10^{-4}$ m
- $A = \pi d^2/4$

$$A = \frac{\pi(5.0 \times 10^{-4}\text{ m})^2}{4} = \mathbf{2.0 \times 10^{-7}}\text{ m}^2$$

2.5

- it **decreases**

3.1 C

- a straight line through the origin means $I \propto V$, so R is constant — Ohm's law, which holds for a **metal wire at constant temperature**
- **A** a filament heats and R rises, so the graph bends; **B** a diode conducts one way only; **D** a thermistor's R falls as it warms

3.2

- a larger current **heats** the filament, raising its temperature
- a hotter metal has a **higher resistance** (ions vibrate more and impede the electrons)

3.3

(a) ammeter in **series** with the wire

- voltmeter connected **across** (in parallel with) the wire; a cell drives the current

(b) $V = 1.5$ V, $I = 0.45$ A

- $R = V/I$

$$R = \frac{1.5\text{ V}}{0.45\text{ A}} = 3.33\ \Omega$$

- $d = 0.40$ mm $= 4.0 \times 10^{-4}$ m; $A = \pi d^2/4$

$$A = \frac{\pi(4.0 \times 10^{-4}\text{ m})^2}{4} = 1.26 \times 10^{-7}\text{ m}^2$$

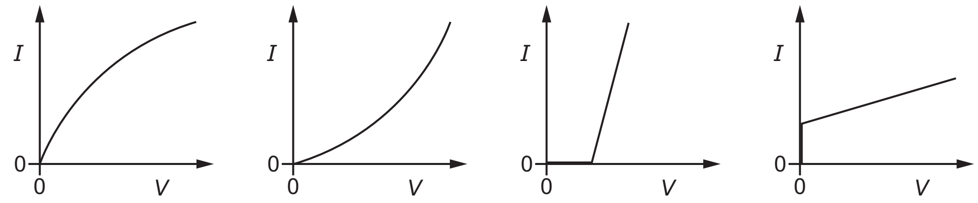
- $\rho = RA/L$

$$\rho = \frac{(3.33\ \Omega)(1.26 \times 10^{-7}\ \mathrm{m}^2)}{0.80\ \mathrm{m}} = \mathbf{5.2 \times 10^{-7}}\ \ \mathrm{m}$$

3.4

- it **decreases**

33 The graphs show possible current–voltage (I–V) characteristics for a filament lamp and for a semiconductor diode.



P Q R S

Which row identifies the I–V graphs for the lamp and for the diode?

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

A-Level Physics: **w25 12**

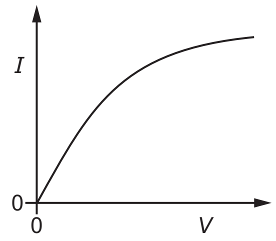
33 A piece of wire X has resistivity ρ, length L and cross-sectional area A. Wire X has a resistance R.

A second piece of wire Y is made of a different metal. It has the same resistance as X but has twice the length of X.

Which row gives possible values for the resistivity and the cross-sectional area of Y?

	resistivity	cross-sectional area
A	$\frac{1}{2}\rho$	$\frac{1}{2}A$
B	$\frac{1}{2}\rho$	A
C	ρ	$\frac{1}{2}A$
D	2ρ	A

32 Which component has the I–V graph shown?



A filament lamp

B metallic conductor at constant temperature

C resistor of fixed resistance

D semiconductor diode

34 A copper wire of length 2 m has a circular cross-section. There is a constant current in the wire when it is connected to a mobile phone in order to charge the battery.

The wire has a fault. A 1 m length of the wire has half the diameter of the other 1 m length.

The power dissipated in the thicker length of wire is P.

What is the power dissipated in the thinner length of wire?

A $\frac{1}{4}P$ **B** $\frac{1}{2}P$ **C** $2P$ **D** $4P$

5 A student uses a circuit containing an ammeter, a voltmeter and a cell to take measurements to determine the resistance of a length of nichrome wire.

(a) **(i)** Define resistance.

....

.... [1]

(ii) Draw a circuit diagram to show how the components should be connected. Use the symbol for a resistor to represent the nichrome wire.

[2]

(b) The student also measures the length and the diameter of the wire. Table 5.1 shows the measurements recorded for each quantity.

Table 5.1

quantity	measurement
length	(0.864 ± 0.001) m
diameter	(0.496 ± 0.002) mm
voltmeter reading	(1.38 ± 0.02) V
ammeter reading	(0.276 ± 0.001) A

(i) Show that the resistance of the wire is 5.00 Ω.

[1]

(ii) Calculate, to three significant figures, the resistivity ρ of the nichrome.

ρ = ... Ωm [3]

(iii) Calculate the percentage uncertainty in ρ.

percentage uncertainty = ... % [2]

(iv) Determine the absolute uncertainty in ρ.

absolute uncertainty = ... Ωm [1]

[Total: 10]

32 Which expression gives the definition of resistance?

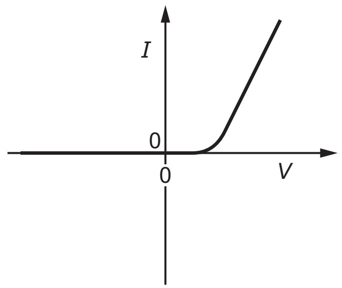
A current divided by potential difference

B current multiplied by potential difference

C potential difference divided by current

D resistivity multiplied by length

33 The graph shows the I–V characteristic of an electrical component.



What is the component?

A a filament lamp

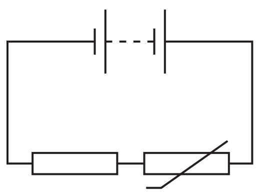
B a metallic conductor at constant temperature

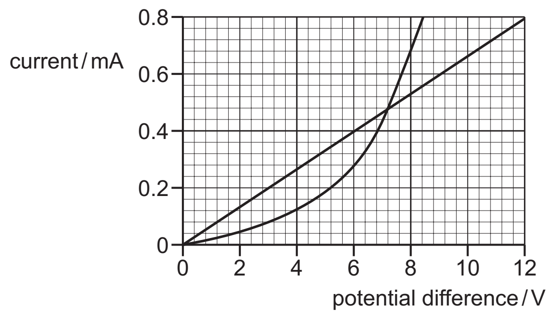
C a resistor

D a semiconductor diode

35 The diagram shows a circuit containing a thermistor, a fixed resistor and a battery.

The graph shows the I–V characteristics of both components.



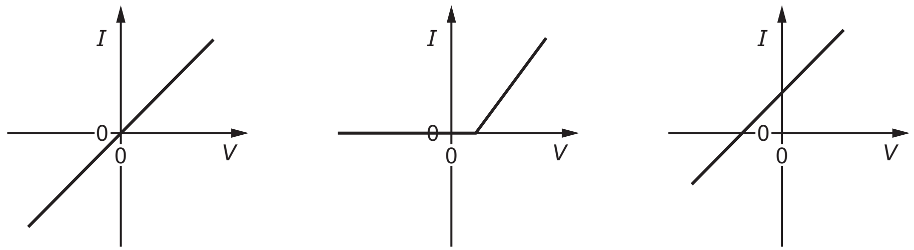


The battery has an e.m.f. of 12 V and negligible internal resistance.

What is the current in the fixed resistor?

A 0.36 mA **B** 0.40 mA **C** 0.48 mA **D** 0.80 mA

33 The I–V characteristics for three electrical components are shown.

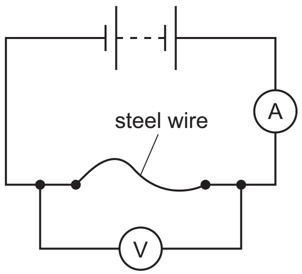


1 2 3

Which components obey Ohm's law?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 1 only

34 A steel wire with a length of 2.20 m is connected to a battery as shown.



The reading on the voltmeter is 1.50 V and the reading on the ammeter is 4.90 A.

The resistivity of steel is $6.90 \times 10^{-7}\,\Omega\,m$.

What is the diameter of the steel wire?

A 1.76×10^{-4} m **B** 3.52×10^{-4} m **C** 1.26×10^{-3} m **D** 2.51×10^{-3} m

7 A nichrome resistance wire has length 150 cm, cross-sectional area $2.45 \times 10^{-7}\,m^2$ and resistivity $1.12 \times 10^{-6}\,\Omega\,m$.

(a) Calculate, to three significant figures, the resistance of the wire.

resistance = ... Ω [3]

(b) The nichrome wire forms part of a potentiometer circuit together with a cell of electromotive force (e.m.f.) 1.2 V and negligible internal resistance, as shown in Fig. 7.1.

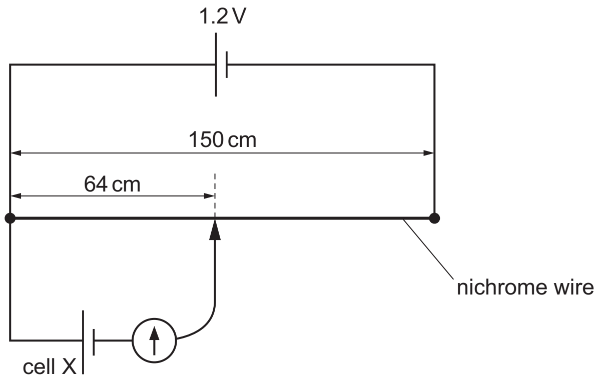


Fig. 7.1 (not to scale)

The circuit is used to determine the e.m.f. of cell X.

The galvanometer is used in a null method to find the null point 64 cm from the left-hand end of the nichrome wire.

(i) Explain what is meant by a null method.

....

.... [1]

(ii) Calculate the e.m.f. of cell X.

e.m.f. = ... V [2]

(iii) The cell of e.m.f. 1.2V is replaced by a new cell with the same e.m.f. but with an internal resistance that is **not** negligible.

State and explain the effect, if any, of the internal resistance of the new cell on the position of the null point.

....

....

....

.... [2]

[Total: 8]

5 **(a)** **(i)** State and explain the effect, if any, on the resistance of a filament wire in a lamp as the current in the wire decreases.

....

.... [1]

(ii) On Fig. 5.1, sketch the I–V characteristic of a filament lamp.

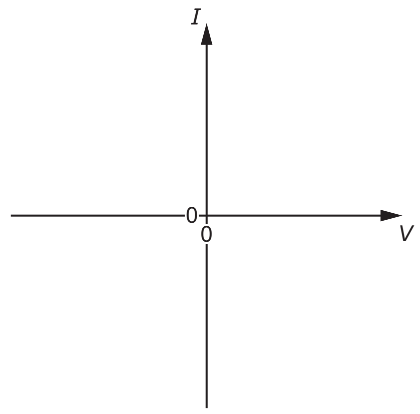


Fig. 5.1

[2]

(b) A battery of electromotive force (e.m.f.) E and negligible internal resistance is connected in parallel with two filament lamps A and B, as shown in Fig. 5.2.

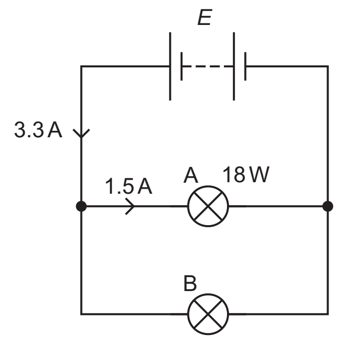


Fig. 5.2

The current in the battery is 3.3A and the current in lamp A is 1.5A. The power dissipated in lamp A is 18W.

(i) Calculate the e.m.f. *E* of the battery.

E = ... V [2]

(ii) The filament wire of lamp B has a cross-sectional area of $1.4 \times 10^{-9}\,m^2$. The number of free (conduction) electrons per unit volume in the metal of the filament wire is $3.4 \times 10^{28}\,m^{-3}$.

Calculate the average drift speed of the free electrons in the filament wire of lamp B.

average drift speed = ... $m\,s^{-1}$ [3]

[Total: 8]