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:

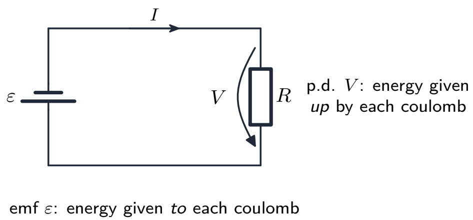
- define **potential difference** and use $V = W/Q$
- distinguish **e.m.f.** from **p.d.**
- use $P = VI = I^2R = V^2/R$

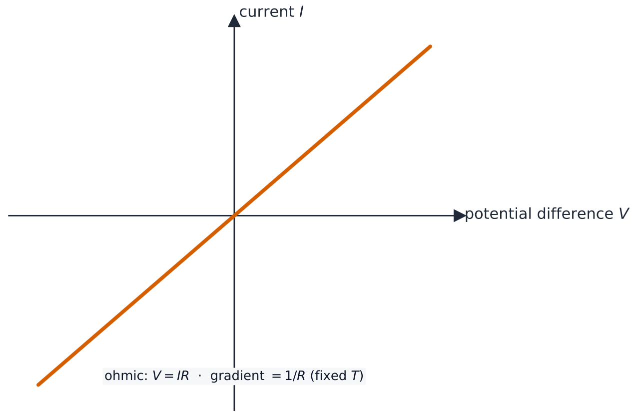
1 Worked examples

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 $360\ \Omega + 540\ \Omega = 900\ \Omega$

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

(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

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