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:

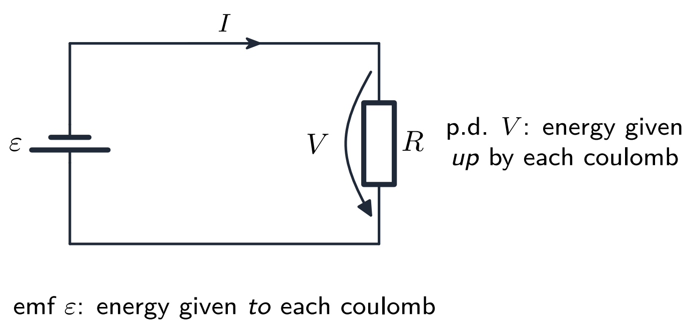
- define **potential difference** and use $V = W/Q$
- distinguish **e.m.f.** from **p.d.**
- use $P = VI = I^2R = V^2/R$

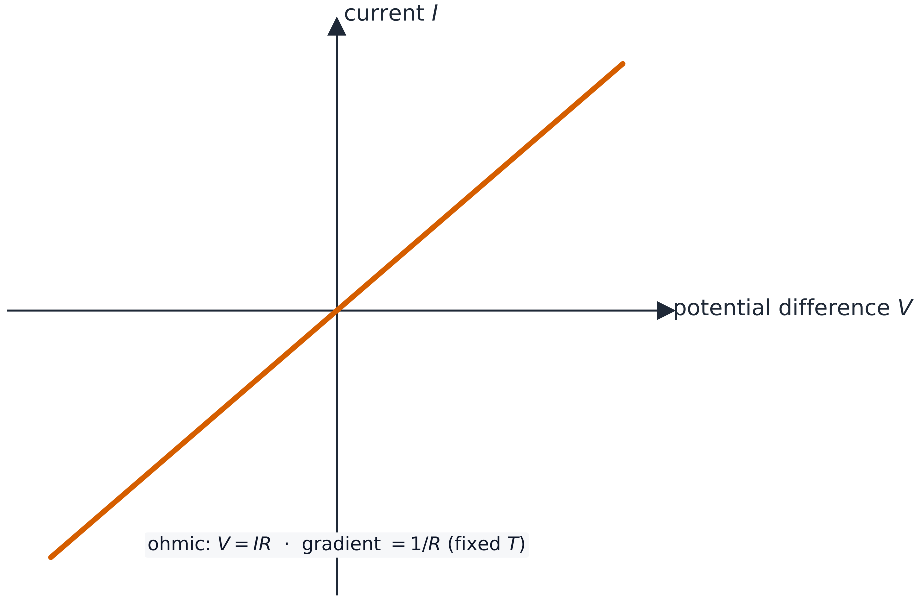
1 Worked examples

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

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 $P = VI = 12 \times 2.0 = 24$ W.

3.1 **A** — $P = VI = 240 \times 0.50 = 120$ W.

3.2 (a) $I = P/V = 2400/240 = 10$ A. (b) $R = V^2/P = 240^2/2400 = 24\ \Omega$.

3.3 The 10 Ω resistor; at the same voltage $P = V^2/R$, so the **smaller** resistance gives the **larger** power.

3.4 $E = Pt = 60 \times (5.0 \times 60) = 60 \times 300 = 1.8 \times 10^4$ J.

3.5 (a) The **energy transferred** to the component **per unit charge** passing through it.
(b) $Q = It = 0.040 \times 3.0 \times 60 = 7.2$ C.
(c) The lower branch has the full 9.0 V across $360 + 540 = 900\ \Omega$, so $I_2 = \dfrac{9.0}{900} = 0.010$ A.
(d) The branch currents add to the battery current: $I_1 = 0.040 - 0.010 = 0.030$ A.
(e) The upper branch also has 9.0 V across it, so its total resistance is $\dfrac{9.0}{0.030} = 300\ \Omega$; $R = 300 - 150 = 150\ \Omega$.
(f) $P_{\text{total}} = VI = 9.0 \times 0.040 = 0.36$ W; in the 150 Ω resistor $P = I_1^2R = (0.030)^2 \times 150 = 0.135$ W. (Use the **branch** current there, not the battery current — the commonest slip.)