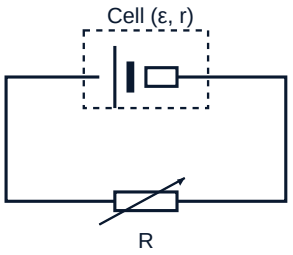
Topic: Current, Potential Difference, Resistance, and Ohm's Law

Instructions: Choose the best answer for each of the following 30 questions. Diagrams use strictly standard UK/BSI circuit symbols. All geometric configurations and connections are scientifically exact. Assume ideal components unless otherwise stated.

1 A real battery with electromotive force (EMF) $\mathcal{E}$ and internal resistance r is connected to a variable external resistor R. Which of the following expressions correctly defines the terminal potential difference, V, as a function of the external resistance?



A. $V = \mathcal{E} - \frac{\mathcal{E}}{R}r$

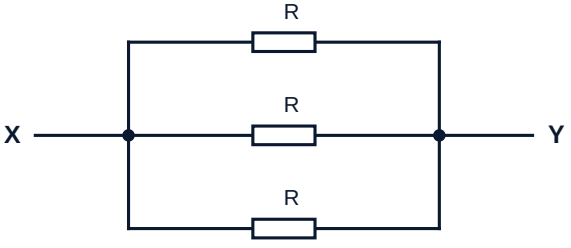
B. $V = \mathcal{E}\left(\frac{R}{R+r}\right)$

C. $V = \mathcal{E}\left(\frac{r}{R+r}\right)$

D. $V = I(R - r)$

---

2 A perfectly aligned parallel circuit is constructed with three identical resistors of resistance R. The main current I enters at terminal X and exits at terminal Y. What is the equivalent resistance of the entire network between X and Y?



A. $R/3$

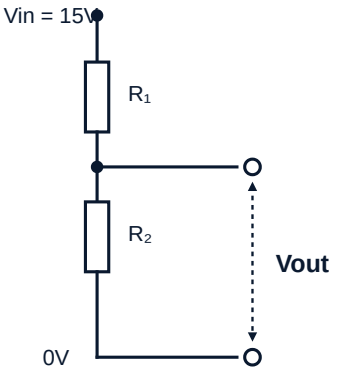
B. $3R$

C. $2R/3$

D. R

---

3 A precision voltage divider is built to provide a reference voltage. If the input voltage V_{in} is $15.0\ \text{V}$, $R_1 = 2.0\ \text{k}\Omega$, and $R_2 = 3.0\ \text{k}\Omega$, calculate V_{out} strictly assuming the output terminals draw absolute zero current.



A. $6.0\ \text{V}$

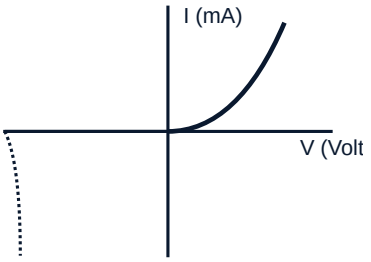
B. $7.5\ \text{V}$

C. $9.0\ \text{V}$

D. $10.0\ \text{V}$

---

4 The I-V characteristic curve of a semiconducting diode is represented theoretically. Which fundamental equation governs the exponential relationship in the forward bias region before the Ohmic approximation?



A. $I = I_0(e^{\frac{eV}{kT}} - 1)$

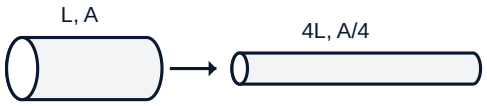
B. $V = I_0 e^{kT}$

C. $I = I_0 \ln(V)$

D. $I = nAve$

---

5 A highly uniform metallic cylinder is used as a resistive element. If it is stretched perfectly such that its length increases by a factor of 4 while conserving total volume, by what factor does its resistance increase?



A. 4

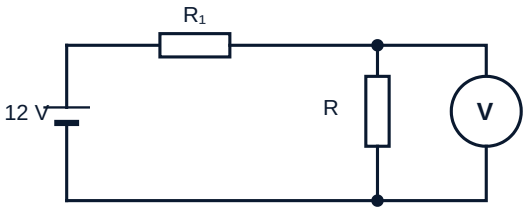
B. 8

C. 16

D. 64

---

6 Analyze the two-loop circuit diagram below. A non-ideal voltmeter with finite resistance $R_V = 10\ \text{k}\Omega$ is connected across the central resistor $R = 2.0\ \text{k}\Omega$. The ideal cell provides $12\ \text{V}$ and $R_1 = 4.0\ \text{k}\Omega$. Calculate the reading on the voltmeter.



A. $2.0\ \text{V}$

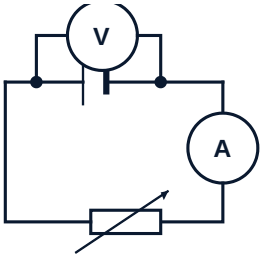
B. $3.5\ \text{V}$

C. $4.0\ \text{V}$

D. $6.0\ \text{V}$

---

7 An experiment is set up to determine the internal resistance of a cell using an ammeter, a voltmeter, and a variable resistor. Which configuration correctly places the ideal meters to accurately measure the terminal PD and current without systematic error?



A. Voltmeter in series with the cell.

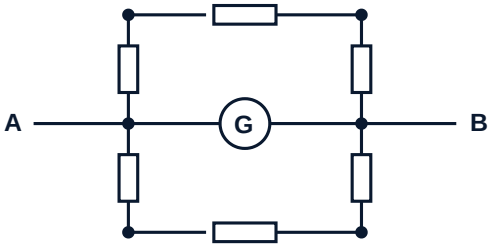
B. Voltmeter in parallel across the cell only.

C. Ammeter in parallel with the variable resistor.

D. Voltmeter across the variable resistor and ammeter combined.

---

8 A perfectly symmetric Wheatstone network is constructed as an H-bridge. Resistors in the vertical arms are $R_1 = R_2 = R_3 = R_4 = 10\ \Omega$. The central bridging component is a galvanometer G with an internal resistance of $50\ \Omega$. What is the total equivalent resistance between terminals A and B?



A. $5.0\ \Omega$

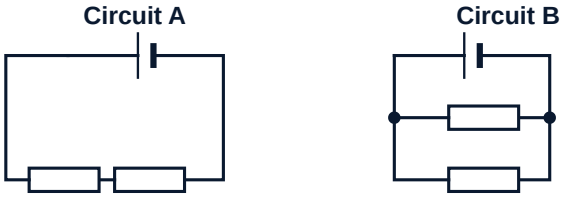
B. $10.0\ \Omega$

C. $20.0\ \Omega$

D. $25.0\ \Omega$

---

9 Two identical rectangular resistors of resistance R are connected in series to a source of EMF $\mathcal{E}$ in Circuit A, and in parallel to an identical source in Circuit B. Determine the exact ratio of the total power dissipated in Circuit A to Circuit B.



A. $1:4$

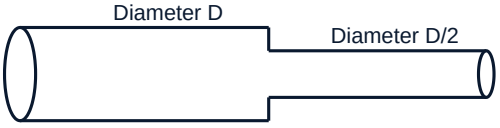
B. $1:2$

C. $2:1$

D. $4:1$

---

10 A current flows steadily through a composite wire consisting of two sections. Section 1 has diameter D and section 2 has diameter $D/2$. If the free electron drift velocity in section 1 is v_d, what is the drift velocity in section 2? (Assume the charge carrier density remains constant).



A. $v_d/4$

B. $v_d/2$

C. $2v_d$

D. $4v_d$

---

11 A heating element is rated at $240\ \text{V}$ and $1.5\ \text{kW}$. Due to high grid demand, the supply voltage drops to $220\ \text{V}$. Assuming the resistance of the element remains constant, calculate the percentage decrease in power output.

A. 8.3%

B. 16.0%

C. 18.4%

D. 24.0%

---

12 The resistivity of a copper alloy is $2.0 \times 10^{-8}\ \Omega\ \mathrm{m}$. A track on a printed circuit board has a thickness of $40\ \mu\mathrm{m}$, a width of $2.5\ \mathrm{mm}$, and a length of $20\ \mathrm{cm}$. What is the exact resistance of this track?

A. $0.040\ \Omega$

B. $0.20\ \Omega$

C. $4.0\ \Omega$

D. $40\ \Omega$

---

13 A non-ideal cell of EMF $9.0\ \mathrm{V}$ and internal resistance $2.0\ \Omega$ is connected to a variable load resistor R_L. What is the maximum possible power that can be transferred to R_L?

A. $4.5\ \mathrm{W}$

B. $10.1\ \mathrm{W}$

C. $18.0\ \mathrm{W}$

D. $40.5\ \mathrm{W}$

---

14 An uncharged capacitor is connected in series with a resistor and a DC supply. Immediately after the switch is closed, which of the following statements is physically correct?

A. The current in the circuit is zero.

B. The potential difference across the capacitor is equal to the supply EMF.

C. The current is determined solely by the supply EMF and the series resistor.

D. The potential difference across the resistor is zero.

---

15 Kirchhoff's First Law (the junction rule) is a direct consequence of the conservation of which physical quantity in classical electromagnetism?

A. Energy

B. Charge

C. Momentum

D. Mass

---

16 A moving-coil galvanometer has a full-scale deflection of $2.0\ \mathrm{mA}$ and an internal resistance of $50\ \Omega$. To convert it into a voltmeter reading up to $10\ \mathrm{V}$, what multiplier resistor must be connected, and how?

A. $4950\ \Omega$ in series

B. $5050\ \Omega$ in series

C. $0.01\ \Omega$ in parallel

D. $4950\ \Omega$ in parallel

---

17 In an experiment, the terminal PD V of a cell is plotted against the current I drawn from it. A linear graph with a negative slope is obtained. The mathematical interpretation of the magnitude of the slope is:

A. The electromotive force (EMF)

B. The external load resistance

C. The internal resistance of the cell

D. The short-circuit current

---

18 A Negative Temperature Coefficient (NTC) thermistor is placed in series with a fixed resistor and a constant DC voltage supply. If the ambient temperature increases, what happens to the potential difference across the fixed resistor?

A. Decreases

B. Increases

C. Remains unchanged

D. Fluctuates sinusoidally

---

19 A uniform wire with a total resistance of $36\ \Omega$ is bent into a perfect circle. What is the equivalent resistance between two points on the wire situated at opposite ends of a diameter?

A. $4.5\ \Omega$

B. $9.0\ \Omega$

C. $18.0\ \Omega$

D. $36.0\ \Omega$

---

20 Which of the following fundamental combinations defines the SI base units of the 'Volt'?

A. $\mathrm{kg\ m^2\ s^{-3}\ A^{-1}}$

B. $\mathrm{kg\ m^2\ s^{-2}\ A^{-1}}$

C. $\mathrm{kg\ m\ s^{-3}\ A^{-2}}$

D. $\mathrm{J\ C^{-1}}$

---

21 A superconducting loop with zero absolute resistance ($R = 0$) is energized with a steady current. The persistence of this current is fundamentally limited only by:

A. Internal collisions with the lattice structure

B. The self-inductance of the loop

C. Electromagnetic radiation due to curvature

D. Quantum tunneling of electrons

---

22 If the drift velocity of free electrons in a metallic conductor is v_d at a temperature T_1, how is the drift velocity affected if the temperature increases to T_2 while the macroscopic current is held strictly constant?

A. It increases because the electrons gain thermal kinetic energy.

B. It decreases because increased lattice vibrations impede flow.

C. It remains exactly the same.

D. It drops to zero momentarily.

---

23 If the current passing through an Ohmic resistor is increased by exactly 20%, the total power dissipated by the resistor increases by a factor of:

A. 1.20

B. 1.40

C. 1.44

D. 2.00

---

24 A completely discharged 12 V car battery (internal resistance $0.05\ \Omega$) is being charged by an alternator supplying a constant current of $40\ \text{A}$. What is the terminal potential difference across the battery during this process?

A. $10.0\ \text{V}$

B. $12.0\ \text{V}$

C. $14.0\ \text{V}$

D. $16.0\ \text{V}$

---

25 An electron is released from rest in a uniform electric field between two parallel plates. As it accelerates towards the positive plate, the electrical power delivered to the electron is:

A. Constant and non-zero

B. Zero

C. Linearly increasing with time

D. Inversely proportional to its velocity

---

26 The number density of conduction electrons in a metal is $n = 8.5 \times 10^{28}\ \text{m}^{-3}$. A wire of this metal with diameter $2.0\ \text{mm}$ carries a current of $5.0\ \text{A}$. What is the approximate drift velocity of the electrons? $(e = 1.6 \times 10^{-19}\ \text{C})$

A. $1.2 \times 10^{-5}\ \text{m s}^{-1}$

B. $1.2 \times 10^{-4}\ \text{m s}^{-1}$

C. $4.5 \times 10^{-4}\ \text{m s}^{-1}$

D. $3.0 \times 10^{8}\ \text{m s}^{-1}$

---

27 A wire of resistance R is stretched uniformly so that its radius is halved. Assuming the volume of the wire remains constant and the resistivity is unchanged, the new resistance will be:

A. $4R$

B. $8R$

C. $16R$

D. $32R$

---

28 Which of the following statements correctly distinguishes electromotive force (EMF) from potential difference (PD)?

A. EMF is a force measured in Newtons, while PD is measured in Volts.

B. EMF represents energy converted from non-electrical to electrical forms per unit charge.

C. PD is only present in open circuits, while EMF is only present in closed circuits.

D. EMF is always strictly lesser than the terminal PD of a discharging cell.

---

29 An infinite resistor ladder network is constructed from alternating series resistors R and parallel resistors $2R$. Which algebraic technique is required to find the equivalent resistance of the infinite ladder?

A. Integration over the length of the ladder.

B. Assuming the equivalent resistance of the ladder is R_{eq}, then adding one more repeating unit yields R_{eq} again.

C. Applying Kirchhoff's loop rule an infinite number of times.

D. Using the binomial expansion on the resistance matrix.

---

30 In the context of the Drude model for electrical conduction, the macroscopic resistance of a wire is a direct consequence of:

A. Electrons repelling each other due to Coulomb forces.

B. Electrons colliding inelastically with the vibrating lattice ions.

C. The quantum mechanical Pauli exclusion principle.

D. The relativistic mass increase of electrons at drift velocities.

---

31 A non-ideal voltmeter with resistance R_V is used to measure the PD across a resistor R in a circuit. To minimize the systematic error caused by the voltmeter drawing current, the relationship between R_V and R should be:

A. $R_V = R$

B. $R_V \ll R$

C. $R_V \gg R$

D. $R_V = 0$

Answer Key

Q1: **B**	Q2: **A**	Q3: **C**	Q4: **A**	Q5: **C**
Q6: **B**	Q7: **B**	Q8: **B**	Q9: **A**	Q10: **D**
Q11: **B**	Q12: **A**	Q13: **B**	Q14: **C**	Q15: **B**
Q16: **A**	Q17: **C**	Q18: **B**	Q19: **B**	Q20: **A**
Q21: **C**	Q22: **C**	Q23: **C**	Q24: **C**	Q25: **B**
Q26: **A**	Q27: **C**	Q28: **B**	Q29: **B**	Q30: **B**
Q31: **C**				