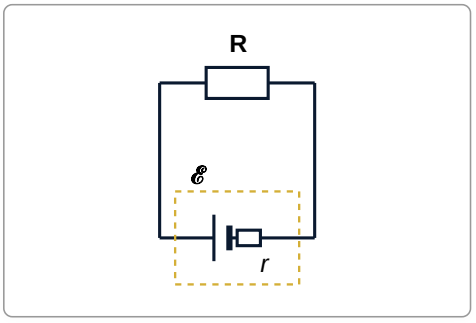
# One Mentor Academy

## BPhO Round 0 - Electricity & DC Circuits

Website: onementoracademy.com Email: contact@onementoracademy.com

**Instructions:** Attempt all 30 multiple-choice questions. Select the single best answer for each. Questions range from A-Level standard to challenging BPhO problem-solving extensions. Assume all connecting wires have zero resistance unless otherwise stated. BSI standard circuit symbols are used.

**1. A cell of electromotive force (EMF) $\mathcal{E} = 12\ \text{V}$ and unknown internal resistance $r$ is connected across a load resistor $R = 5.0\,\Omega$. A high-resistance voltmeter measures the terminal potential difference to be $10.0\ \text{V}$. What is the internal resistance $r$ of the cell?**



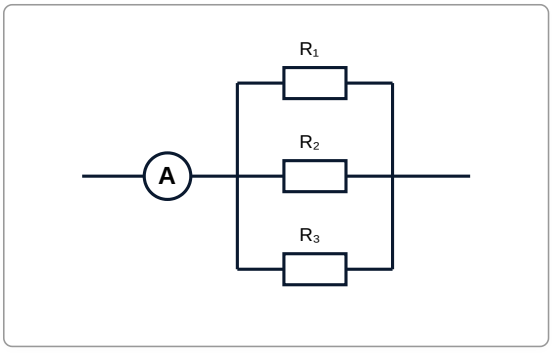

A $1.0\,\Omega$

B $1.2\,\Omega$

C $2.0\,\Omega$

D $2.4\,\Omega$

**2. Three resistors are connected in parallel as shown. An ideal ammeter reads the total current flowing into the combination. If $R_1 = 2\,\Omega$, $R_2 = 3\,\Omega$, and $R_3 = 6\,\Omega$, and the power supply provides a constant $12\ \text{V}$, what does the ammeter read?**



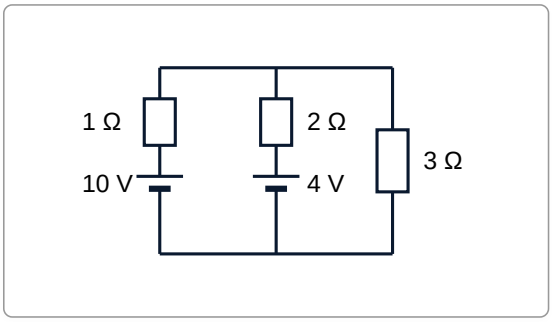

A $2.0\ \text{A}$

B $6.0\ \text{A}$

C $12.0\ \text{A}$

D $22.0\ \text{A}$

3. In the circuit below, two ideal cells of EMF $10\ \text{V}$ and $4\ \text{V}$ are connected in opposing parallel branches with resistors $1\,\Omega$ and $2\,\Omega$ respectively. They supply a common load of $3\,\Omega$. What is the potential difference across the $3\,\Omega$ resistor?



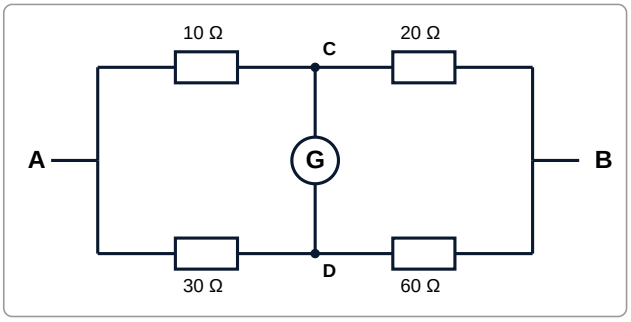

A $4.55\ \text{V}$

B $6.55\ \text{V}$

C $7.00\ \text{V}$

D $8.18\ \text{V}$

4. A Wheatstone bridge is set up as shown. The galvanometer $G$ reads zero current. What is the equivalent resistance of the entire circuit between the input nodes A and B? (Assume the galvanometer has finite resistance).



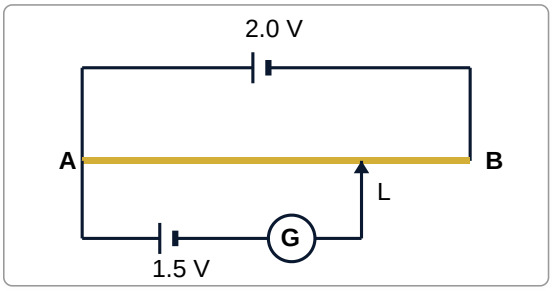

A $15.0\,\Omega$

B $22.5\,\Omega$

C $30.0\,\Omega$

D $120.0\,\Omega$

5. A potentiometer consists of a uniform wire AB of length $100\ \text{cm}$ and resistance $10\ \Omega$. It is connected in series with a driver cell of EMF $2.0\ \text{V}$ (negligible internal resistance). A test cell of EMF $1.5\ \text{V}$ balances against length $L$ of the wire. What is the balancing length $L$?



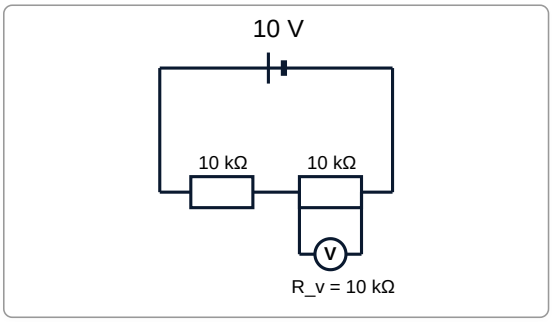

A $50\ \text{cm}$

B $60\ \text{cm}$

C $75\ \text{cm}$

D $85\ \text{cm}$

6. A $10\ \text{V}$ ideal power supply is connected across two $10\ \text{k}\Omega$ resistors in series. A non-ideal voltmeter with an internal resistance of $10\ \text{k}\Omega$ is placed across one of the resistors. What is the reading on the voltmeter?



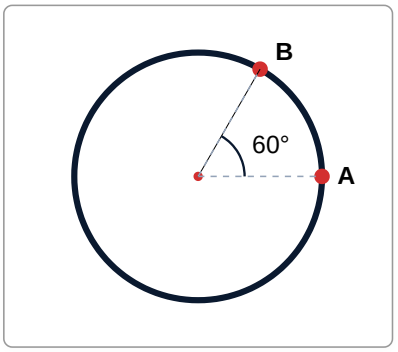

A $3.33\ \text{V}$

B $5.00\ \text{V}$

C $6.67\ \text{V}$

D $10.00\ \text{V}$

7. A uniform circular metallic wire of resistance $36\,\Omega$ forms a closed loop. What is the equivalent resistance measured between two points on the circumference that subtend an angle of $60^\circ$ at the geometric center?



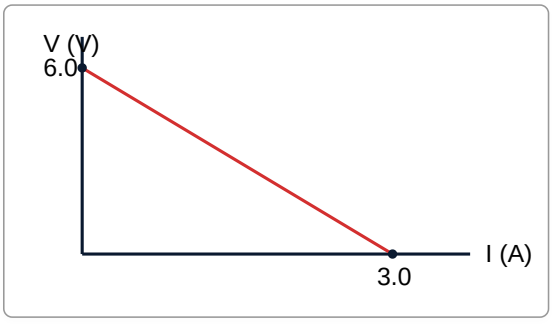

A $5\,\Omega$

B $6\,\Omega$

C $12\,\Omega$

D $30\,\Omega$

8. The graph below shows the terminal potential difference $V$ across a cell as a function of the current $I$ drawn from it. What is the electromotive force (EMF) and the internal resistance $r$ of the cell?



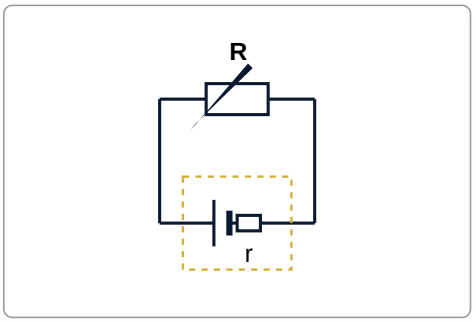

A EMF = 3.0 V, r = 2.0 Ω

B EMF = 6.0 V, r = 2.0 Ω

C EMF = 6.0 V, r = 0.5 Ω

D EMF = 9.0 V, r = 3.0 Ω

9. A cell of EMF $\mathcal{E}$ and fixed internal resistance $r$ is connected to a variable external resistor $R$. Which condition must be met for the maximum electrical power to be transferred from the cell to the external resistor $R$?



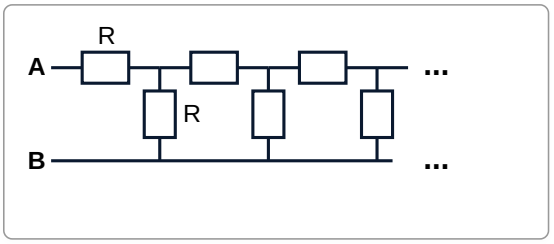

A $R = 0$

B $R = \frac{1}{2}r$

C $R = r$

D $R \to \infty$

10. An infinite ladder network is constructed from identical resistors, each of resistance $R$, as shown. What is the equivalent resistance of this infinite network measured between the input terminals A and B?




A $R$

B $2R$

C $\frac{1+\sqrt{5}}{2}R$

D $\frac{\sqrt{3}}{2}R$

11. Two resistors, $R$ and $2R$, are connected first in series and then in parallel across the same ideal voltage supply. What is the ratio of the total power dissipated in the series circuit to the total power dissipated in the parallel circuit?

A 1 : 9

B 1 : 6

C 2 : 9

D 2 : 3

12. Kirchhoff's First Law (Current Law) stating that the algebraic sum of currents meeting at a junction is zero is a direct consequence of the conservation of which physical quantity?

A Energy

B Momentum

C Charge

D Mass

13. A battery of EMF $9.0\ \mathrm{V}$ and internal resistance $1.5\ \Omega$ is connected to a $4.5\ \Omega$ external load resistor. What is the rate at which chemical energy is transformed into electrical energy in the battery?

A 10.1 W

B 13.5 W

C 15.0 W

D 18.0 W

14. In a circuit, $N$ identical cells each of EMF $\mathcal{E}$ and internal resistance $r$ are connected in series. By mistake, one single cell is connected with reversed polarity. What is the equivalent EMF and internal resistance of the combination?

A $(N-1)\mathcal{E}\text{and}Nr$

B $(N-2)\mathcal{E}\text{and}Nr$

C $(N-1)\mathcal{E}\text{and}(N-1)r$

D $(N-2)\mathcal{E}\text{and}(N-1)r$

15. A galvanometer has a coil resistance of $50\ \Omega$ and gives a full-scale deflection for a current of $2.0\ \mathrm{mA}$. To convert it into an ammeter reading up to $10\ \mathrm{A}$, a shunt resistor must be added. What is the approximate value of the required shunt resistance?

A $0.01\ \Omega$in parallel

B $0.01\ \Omega$in series

C $9.99\ \Omega$in parallel

D $250\ \Omega$in series

16. A wire of uniform cross-section and resistance $R$ is stretched uniformly until its length is doubled. Assuming the volume and the resistivity of the material remain perfectly constant, what is the new resistance of the wire?

A $R$

B $2R$

C $4R$

D $8R$

17. In a perfectly balanced Wheatstone bridge, swapping the positions of the galvanometer and the battery will cause the galvanometer to:

A Deflect to the left

B Deflect to the right

C Still read zero

D Burn out due to excessive current

18. Two cells of EMF $\mathcal{E}_1$ and $\mathcal{E}_2$ (where $\mathcal{E}_1 > \mathcal{E}_2$) and internal resistances $r_1$ and $r_2$ respectively are connected in parallel, with their positive terminals joined together. What is the equivalent EMF of this parallel combination?

A $\frac{\mathcal{E}_1 r_2 + \mathcal{E}_2 r_1}{r_1 + r_2}$

B $\mathcal{E}_1 + \mathcal{E}_2$

C $\frac{\mathcal{E}_1 + \mathcal{E}_2}{2}$

D $\mathcal{E}_1 - \mathcal{E}_2$

19. A non-ideal battery is being charged by an external power supply. If the battery has an EMF $\mathcal{E}$ and internal resistance $r$, and a charging current $I$ is flowing into its positive terminal, the terminal potential difference $V$ is given by:

A $V = \mathcal{E} - Ir$

B $V = \mathcal{E} + Ir$

C $V = Ir - \mathcal{E}$

D $V = \mathcal{E}$

20. An electric heater is designed to operate at $P$ watts on a $V$ volt mains supply. If the mains voltage drops to $\frac{V}{2}$, assuming the heater's resistance remains constant, what is the new power output?

A $P$

B $\frac{P}{\sqrt{2}}$

C $\frac{P}{2}$

D $\frac{P}{4}$

21. Which of the following components has a non-linear, non-ohmic current-voltage (I-V) characteristic that shows a decreasing resistance as the temperature of the component increases?

A Metallic conductor

B Filament lamp

C NTC Thermistor

D Ideal resistor

22. A closed circuit consists of a $12\ \mathrm{V}$ ideal battery and three $2\ \Omega$ resistors in series. What is the potential difference across any single $2\ \Omega$ resistor?

A 2 V

B 4 V

C 6 V

D 12 V

23. Four identical cells, each of EMF $1.5\ \mathrm{V}$ and internal resistance $0.1\ \Omega$, are connected in series to a $5.6\ \Omega$ load. What is the current flowing in the circuit?

A 0.25 A

B 0.75 A

C 1.00 A

D 1.50 A

24. Two wires of the same material have lengths in the ratio 1:2 and diameters in the ratio 2:1. If they are connected in series across a battery, what is the ratio of the potential differences across them?

A 1 : 2

B 1 : 4

C 1 : 8

D 8 : 1

25. The power transfer from a source to a load is maximized when the load resistance equals the internal resistance. At this maximum power transfer state, what is the efficiency of the circuit (useful power / total power)?

A 100%

B 75%

C 50%

D 25%

26. Kirchhoff's Second Law (Voltage Law) stating that the sum of EMFs equals the sum of potential drops in a closed loop is a fundamental consequence of the conservation of:

A Charge

B Momentum

C Energy

D Mass

27. A high-resistance voltmeter reads $6.0\ \mathrm{V}$ when connected across a cell in an open circuit. When a $4.0\ \Omega$ resistor is connected across the cell, the voltmeter reading drops to $4.8\ \mathrm{V}$. The internal resistance of the cell is:

A $0.5\ \Omega$

B $1.0\ \Omega$

C $1.2\ \Omega$

D $2.0\ \Omega$

**28. A uniform metallic wire is subjected to a constant potential difference. If the radius of the wire is halved while its length remains unchanged, the drift velocity of the free electrons will:**

A Increase by a factor of 4

B Increase by a factor of 2

C Remain unchanged

D Decrease by a factor of 4

**29. Two resistors made of the same material are connected in parallel. Resistor A has twice the length and half the cross-sectional area of Resistor B. What is the ratio of the current in A to the current in B?**

A 1 : 4

B 1 : 2

C 2 : 1

D 4 : 1

**30. Which of the following circuits is most theoretically appropriate for measuring the internal resistance of a sensitive standard cell without drawing any significant current from it?**

A Wheatstone Bridge

B Potentiometer

C Simple Ammeter-Voltmeter method

D Ohmmeter

## Answer Key

| | | | | |
|---|---|---|---|---|
| **1.** A | **2.** C | **3.** B | **4.** B | **5.** C |
| **6.** A | **7.** A | **8.** B | **9.** C | **10.** C |
| **11.** C | **12.** C | **13.** B | **14.** B | **15.** A |
| **16.** C | **17.** C | **18.** A | **19.** B | **20.** D |
| **21.** C | **22.** B | **23.** C | **24.** C | **25.** C |
| **26.** C | **27.** B | **28.** C | **29.** A | **30.** B |