



Current Electricity — NEET (UG) Pattern Chapter Test

FREE CHAPTER TEST · PHYSICS · PATTERN OF NEET (UG)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
30 minutes	120	30	

GENERAL INSTRUCTIONS

1. This question paper has THIRTY (30) multiple-choice questions. All questions are compulsory.
2. Each question has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Marking scheme: +4 for a correct answer, –1 for an incorrect answer, 0 if the question is not attempted.
4. Take the charge of an electron as 1.6×10^{-19} C. Use of a calculator, log tables or any other aid is not allowed.
5. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 30 minutes before you look at them.

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Topics covered: Drift velocity and current density · Resistance and resistivity · Temperature dependence of resistance · Colour code of resistors · Combination of resistors · Kirchhoff's rules · Wheatstone bridge and metre bridge · Potentiometer · Cells, emf and internal resistance · Electrical energy and power

PHYSICS (Q1–30) · Multiple choice · +4 / 0 / –1

Each question has FOUR options. ONLY ONE of them is correct.

1. A potential difference V applied across a metal wire produces a current I , and the free electrons drift with speed v . The wire is stretched uniformly to twice its length, and the same potential difference V is applied across it at the same temperature. The new drift speed and current are
- (1) v and $I/4$
 - (2) $v/2$ and $I/4$
 - (3) $v/2$ and $I/2$
 - (4) $v/4$ and $I/4$
2. When a potential difference of 4.0 V is applied across a metal wire of length 2.0 m , the free electrons drift with a speed of $2.0 \times 10^{-4}\text{ m/s}$. Taking the mass of an electron as $9.0 \times 10^{-31}\text{ kg}$, the mean relaxation time of the free electrons is
- (1) $2.8 \times 10^{-16}\text{ s}$
 - (2) $1.1 \times 10^{-15}\text{ s}$
 - (3) $5.6 \times 10^{-14}\text{ s}$
 - (4) $5.6 \times 10^{-16}\text{ s}$
3. The current density in a long straight wire of circular cross-section of radius R varies with the distance r from its axis as $J = J_0(1 - r/R)$. The current in the wire is
- (1) $\pi J_0 R^2/3$
 - (2) $\pi J_0 R^2/2$
 - (3) $2\pi J_0 R^2/3$
 - (4) $\pi J_0 R^2/6$
4. A uniform wire of resistance R is stretched uniformly until its radius becomes half its original value. It is then cut into four equal parts, and the four parts are connected in parallel. The resistance of the combination is
- (1) $R/4$
 - (2) $4R$
 - (3) R
 - (4) $16R$
5. Two wires A and B have equal masses. Wire A is twice as long as wire B; the density of the material of A is half, and its resistivity twice, that of the material of B. The ratio of their resistances $R_A : R_B$ is
- (1) $2 : 1$
 - (2) $8 : 1$
 - (3) $4 : 1$
 - (4) $16 : 1$

6. A conductor of resistivity $\pi \times 10^{-8} \Omega \text{ m}$ has the shape of a truncated cone of length 0.50 m; the radii of its two end faces are 1.0 mm and 2.0 mm. Treating the current as flowing parallel to the axis, the resistance between the end faces is

- (1) 2.5 m Ω
- (2) 2.2 m Ω
- (3) 1.25 m Ω
- (4) 5.0 m Ω

7. The resistance of a metal wire is 5.0 Ω at 50 $^{\circ}\text{C}$ and 6.0 Ω at 100 $^{\circ}\text{C}$. Taking $R_t = R_0(1 + \alpha t)$, where R_0 is its resistance at 0 $^{\circ}\text{C}$, the temperature coefficient of resistance α is

- (1) $4.0 \times 10^{-3} \text{ }^{\circ}\text{C}^{-1}$
- (2) $3.3 \times 10^{-3} \text{ }^{\circ}\text{C}^{-1}$
- (3) $2.5 \times 10^{-3} \text{ }^{\circ}\text{C}^{-1}$
- (4) $5.0 \times 10^{-3} \text{ }^{\circ}\text{C}^{-1}$

8. A carbon resistor, of temperature coefficient of resistance $-5.0 \times 10^{-4} \text{ }^{\circ}\text{C}^{-1}$, and a nichrome resistor, of temperature coefficient $+1.0 \times 10^{-4} \text{ }^{\circ}\text{C}^{-1}$, are connected in series. Their combined resistance is 60 Ω and does not change with small changes in temperature. The resistance of the nichrome resistor is

- (1) 10 Ω
- (2) 50 Ω
- (3) 12 Ω
- (4) 48 Ω

9. A carbon resistor with colour bands violet, green, black, gold is connected in parallel with another with colour bands brown, black, brown, gold. Allowing for the tolerance of each, the greatest possible resistance of the combination is

- (1) 45 Ω
- (2) 42.9 Ω
- (3) 47.3 Ω
- (4) 40.7 Ω

10. Five points are joined in pairs by identical resistors of resistance R , one resistor between every pair of points (ten resistors in all). The equivalent resistance between any two of the points is

- (1) $R/2$
- (2) $2R/5$
- (3) $R/4$
- (4) $3R/5$

11. An infinite ladder network is made of identical sections. Each section has a 1 Ω resistor in the upper line followed by a 2 Ω resistor connected across the two lines; the lower line has no resistance. The equivalent resistance between the two input terminals is

- (1) 1 Ω
- (2) 3 Ω
- (3) $(1 + \sqrt{3}) \Omega$
- (4) 2 Ω

12. Six resistors, each of resistance R , form the sides of a regular hexagon, and six more, each of resistance R , join every vertex to the centre of the hexagon. The equivalent resistance between two adjacent vertices is

- (1) $R/2$
- (2) $9R/20$
- (3) $11R/20$
- (4) $4R/5$

13. A uniform wire of resistance $16\ \Omega$ is bent into a circle. A straight wire of resistance $8\ \Omega$ is connected between the ends A and B of a diameter. C is the point of the circle midway between A and B along the circumference. The equivalent resistance between A and C is

- (1) $3\ \Omega$
- (2) $2\ \Omega$
- (3) $12/5\ \Omega$
- (4) $8/3\ \Omega$

14. Resistors of $2\ \Omega$, $3\ \Omega$ and $6\ \Omega$ are available. Using all three of them every time, connected in series, in parallel or in a mixed series-parallel arrangement, the number of different equivalent resistances that can be obtained is

- (1) 6
- (2) 7
- (3) 8
- (4) 9

15. Two batteries, of emf 12 V (internal resistance $1\ \Omega$) and 6 V (internal resistance $2\ \Omega$), are connected in parallel, positive terminal to positive terminal, and the combination is connected across a $4\ \Omega$ resistor. The current through the $4\ \Omega$ resistor is

- (1) $15/7\text{ A}$
- (2) 2 A
- (3) $18/7\text{ A}$
- (4) 3 A

16. Batteries of emf 10 V and 4 V , each of internal resistance $1\ \Omega$, are connected in parallel with like terminals joined, and the combination is connected across a $2\ \Omega$ resistor. The current through the 4 V battery is

- (1) 1.6 A , and the battery is discharging
- (2) 1.6 A , and the battery is being charged
- (3) 2.8 A , and the battery is being charged
- (4) 0.4 A , and the battery is discharging

17. Cells of emf 6 V and 2 V , each of internal resistance $1\ \Omega$, are connected in series with their positive terminals joined together, and the free terminals are connected across a $2\ \Omega$ resistor. The potential difference between the terminals of the 2 V cell is

- (1) 1 V
- (2) 3 V
- (3) 2 V
- (4) 4 V

18. In a network ABCD, the resistances are $AB = 1\ \Omega$, $BC = 2\ \Omega$, $CD = 1\ \Omega$, $DA = 2\ \Omega$ and $BD = 2\ \Omega$. An ideal 10 V battery is connected with its positive terminal to A and its negative terminal to C. The current in BD is

- (1) 1 A, from B to D
- (2) 1 A, from D to B
- (3) 0.5 A, from B to D
- (4) zero

19. Three branches are connected between two points X and Y. The first has an ideal 6 V cell in series with a $2\ \Omega$ resistor, the second an ideal 4 V cell in series with a $4\ \Omega$ resistor, and the third a $4\ \Omega$ resistor alone. Both cells have their positive terminals towards X. The current through the 4 V cell is

- (1) 0.5 A
- (2) 1 A
- (3) zero
- (4) 2 A

20. In a metre bridge, with a resistance X in the left gap and a resistance R in the right gap, the null point is 40 cm from the left end. When a $10\ \Omega$ resistor is connected in series with X, the null point moves to 60 cm from the left end. The value of X is

- (1) $12\ \Omega$
- (2) $6\ \Omega$
- (3) $10\ \Omega$
- (4) $8\ \Omega$

21. A Wheatstone bridge with arms P, Q, R and S is balanced ($P/Q = R/S$, with $P \neq Q$). Which one of the following changes upsets the balance?

- (1) Interchanging the cell and the galvanometer
- (2) Doubling the emf of the cell
- (3) Interchanging P and Q only
- (4) Replacing the galvanometer by one of different resistance

22. A potentiometer wire 10 m long has a resistance of $20\ \Omega$. It is connected in series with a $180\ \Omega$ resistor and a 4.0 V cell of negligible internal resistance. The balancing length for a thermocouple of emf 15 mV is

- (1) 3.75 cm
- (2) 75 cm
- (3) 18.75 cm
- (4) 37.5 cm

23. An unknown resistor X and a standard $10\ \Omega$ resistor are connected in series and carry a steady current. On a potentiometer, the potential difference across the standard resistor balances at 60 cm, and the potential difference across the series combination of X and the standard resistor balances at 84 cm. The value of X is

- (1) $14\ \Omega$
- (2) $4\ \Omega$
- (3) $7.1\ \Omega$
- (4) $2.9\ \Omega$

24. On a potentiometer, a cell of emf E_1 balances at 300 cm. When a second cell of emf E_2 ($E_2 < E_1$) is joined in series with it so that their emfs add, the combination balances at 500 cm. With the second cell reversed, the combination balances at

- (1) 100 cm
- (2) 200 cm
- (3) 150 cm
- (4) 50 cm

25. Twenty-four identical cells, each of emf 2.0 V and internal resistance $0.50\ \Omega$, are arranged in a number of identical parallel rows, each row having the same number of cells in series, so as to send the largest possible current through an external $3.0\ \Omega$ resistor. The largest current is

- (1) 4 A
- (2) 8 A
- (3) 2 A
- (4) 6 A

26. A cell delivers the same power, 4.0 W, to an external resistor of $4\ \Omega$ and to an external resistor of $9\ \Omega$, each connected to it alone. The greatest power the cell can deliver to any external resistor is

- (1) 4 W
- (2) 5 W
- (3) $25/6$ W
- (4) $50/9$ W

27. When a battery delivers a current of 2.0 A, its terminal voltage is 10.4 V; when it delivers 4.0 A, its terminal voltage is 8.8 V. The greatest power it can deliver to an external resistor is

- (1) 90 W
- (2) 22.5 W
- (3) 180 W
- (4) 45 W

28. A heater rated 1000 W, 220 V is connected to a 200 V supply through leads of total resistance $1.6\ \Omega$. Taking the resistance of the heater to be constant, the power developed in the heater is about

- (1) 826 W
- (2) 774 W
- (3) 800 W
- (4) 720 W

29. With one coil of an electric kettle, a quantity of water boils in 10 min; with the other coil alone, it boils in 15 min, on the same supply. If the two coils are connected in parallel across the same supply, the same water boils in (neglect heat losses)

- (1) 25 min
- (2) 12.5 min
- (3) 5 min
- (4) 6 min

30. Twelve identical cells, each of emf 1.5 V and internal resistance $0.5\ \Omega$, are meant to be connected in series across a $3\ \Omega$ resistor, but three of them are connected the wrong way round. The current in the resistor is

- (1) 2 A
- (2) 1 A
- (3) 1.5 A
- (4) 0.5 A

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(2)	(4)	(1)	(3)	(3)	(1)	(4)	(2)	(1)	(2)
Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(4)	(3)	(4)	(3)	(1)	(2)	(2)	(1)	(3)	(4)
Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
(3)	(4)	(2)	(1)	(1)	(3)	(4)	(2)	(4)	(2)

WORKED SOLUTIONS

Q1. Answer (2). $v = eE\tau/m$ with $E = V/L$: doubling the length halves the field, so the drift speed becomes $v/2$. Stretching to twice the length halves the area, so R becomes $4R$ and the current $I/4$. (Check: $I = neAv$, and both A and v are halved.) ' v and $I/4$ ' forgets that the field along the wire falls.

Q2. Answer (4). The field in the wire is $E = V/L = 2.0 \text{ V/m}$. From $v_d = eE\tau/m$, $\tau = m v_d/(eE) = 9.0 \times 10^{-31} \times 2.0 \times 10^{-4}/(1.6 \times 10^{-19} \times 2.0) = 5.6 \times 10^{-16} \text{ s}$. Taking E as 4.0 V/m (forgetting to divide by the length) gives $2.8 \times 10^{-16} \text{ s}$.

Q3. Answer (1). Take a thin ring of radius r and width dr : $dI = J \times 2\pi r dr$. $I = \int_0^R J_0(1 - r/R) 2\pi r dr = 2\pi J_0(R^2/2 - R^2/3) = \pi J_0 R^2/3$. $\pi J_0 R^2/2$ takes the average of J over the radius ($J_0/2$) as if it were the average over the area.

Q4. Answer (3). Halving the radius makes the area $A/4$; the volume is unchanged, so the length becomes $4L$. $R' = \rho(4L)/(A/4) = 16R$. Each of the four equal parts has resistance $4R$, and four of them in parallel give $4R/4 = R$.

Q5. Answer (3). With mass $m = dAL$, the area is $A = m/(dL)$, so $R = \rho L/A = \rho dL^2/m$. For equal masses, $R_A/R_B = (\rho_A/\rho_B)(d_A/d_B)(L_A/L_B)^2 = 2 \times \frac{1}{2} \times 4 = 4$, i.e. $4 : 1$. Forgetting that, for equal masses, the longer wire is also thinner gives $2 : 1$.

Q6. Answer (1). The radius grows linearly from a to b over the length L . A slice of thickness dx at radius r has resistance $\rho dx/(\pi r^2)$, and $dx = (L/(b - a)) dr$, so $R = (\rho L/\pi(b - a)) \int_a^b dr/r^2 = \rho L/(\pi ab) = \pi \times 10^{-8} \times 0.50/(\pi \times 1.0 \times 10^{-3} \times 2.0 \times 10^{-3}) = 2.5 \times 10^{-3} \Omega$. Using the area at the mean radius 1.5 mm gives $2.2 \text{ m}\Omega$, which is not correct for a taper.

Q7. Answer (4). $R_0(1 + 100\alpha)/R_0(1 + 50\alpha) = 6/5$ gives $5 + 500\alpha = 6 + 300\alpha$, so $\alpha = 1/200 = 5.0 \times 10^{-3} \text{ }^\circ\text{C}^{-1}$ (and $R_0 = 4.0 \Omega$). Dividing the change by the resistance at $50 \text{ }^\circ\text{C}$, $1/(5 \times 50) = 4.0 \times 10^{-3} \text{ }^\circ\text{C}^{-1}$, refers α to the wrong temperature.

Q8. Answer (2). For a small rise Δt the changes $R_C \propto C\Delta t$ and $R_N \propto N\Delta t$ must cancel: $R_C \times 5.0 \times 10^{-4} = R_N \times 1.0 \times 10^{-4}$, so $R_N = 5R_C$. With $R_C + R_N = 60 \Omega$, $R_C = 10 \Omega$ and $R_N = 50 \Omega$.

Q9. Answer (1). Violet (7), green (5), black ($\times 10^0$): $75 \Omega \pm 5\%$. Brown (1), black (0), brown ($\times 10^1$): $100 \Omega \pm 5\%$. The parallel resistance increases with each resistance, so the greatest value uses 78.75Ω and 105Ω : $78.75 \times 105/183.75 = 45 \Omega$. 42.9Ω is the nominal value and 40.7Ω the least possible; 47.3Ω wrongly adds 5% to the nominal combination.

Q10. Answer (2). Let the current I enter at A and leave at B , with $V_A = V$ and $V_B = 0$. The other three points are alike and are joined symmetrically to A and B , so they are all at $V/2$, and no current flows in the three resistors among them. The current leaving A is V/R (to B) + $3 \times (V/2)/R$ (to the others) = $5V/2R$, so $R_{AB} = 2R/5$. (For n points joined in this way the result is $2R/n$.)

Q11. Answer (4). Removing the first section leaves the same infinite ladder, so $R = 1 + 2R/(2 + R)$. Then $R(2 + R) = 2 + R + 2R$, i.e. $R^2 - R - 2 = 0$, and the positive root is $R = 2 \Omega$.

Q12. Answer (3). Let A and B be the adjacent vertices, with $V_A = V$ and $V_B = 0$. By mirror symmetry about the perpendicular bisector of AB , the centre is at $V/2$ and mirror-image vertices have potentials adding up to V . Let the other

neighbour of A be at p and the next vertex at q. Kirchhoff's current law at these two vertices: $3p - q = 3V/2$ and $4q - p = 3V/2$, so $p = 15V/22$. The current leaving A is V/R (to B) + $(V - 15V/22)/R$ (to its other neighbour) + $(V/2)/R$ (to the centre) = $20V/11R$, so $R_{AB} = 11R/20$. $9R/20$ is the resistance between a vertex and the centre, $4R/5$ between opposite vertices.

Q13. Answer (4). Each quarter of the circle is $4\ \Omega$. Let D be the point of the circle opposite C. Take $V_C = 0$ and let A, B and D be at potentials a, b and d. Kirchhoff's current law at D: $(d - a)/4 + (d - b)/4 = 0$, so $d = (a + b)/2$. At B: $b/4 + (b - d)/4 + (b - a)/8 = 0$, i.e. $5b - 2d - a = 0$, which gives $b = a/2$ and $d = 3a/4$. The current leaving A is $a/4$ (to C) + $(a - d)/4$ (to D) + $(a - b)/8$ (along the diameter) = $3a/8$, so $R_{AC} = 8/3\ \Omega$. Without the diameter wire it would be $4 \times 12/16 = 3\ \Omega$.

Q14. Answer (3). All three in series: $11\ \Omega$; all in parallel: $1\ \Omega$. One resistor in series with the other two in parallel: $2 + 2 = 4\ \Omega$, $3 + 1.5 = 4.5\ \Omega$, $6 + 1.2 = 7.2\ \Omega$. One resistor in parallel with the other two in series: $2 \parallel 9 = 18/11\ \Omega$, $3 \parallel 8 = 24/11\ \Omega$, $6 \parallel 5 = 30/11\ \Omega$. These eight values are all different.

Q15. Answer (1). Let V be the common terminal voltage. Kirchhoff's current law: $(12 - V)/1 + (6 - V)/2 = V/4$, so $15 = 1.75V$ and $V = 60/7\ \text{V}$. The current in the $4\ \Omega$ resistor is $V/4 = 15/7\ \text{A}$. (The equivalent cell has emf $(12/1 + 6/2)/(1/1 + 1/2) = 10\ \text{V}$ and internal resistance $2/3\ \Omega$; $10/(4 + 2/3) = 15/7\ \text{A}$.)

Q16. Answer (2). Common terminal voltage V: $(10 - V)/1 + (4 - V)/1 = V/2$, so $14 = 2.5V$ and $V = 5.6\ \text{V}$. The terminal voltage exceeds the $4\ \text{V}$ battery's emf, so current is driven into its positive terminal: $(5.6 - 4)/1 = 1.6\ \text{A}$ — it is being charged. $2.8\ \text{A}$ is the current in the $2\ \Omega$ resistor.

Q17. Answer (2). The emfs oppose: net emf $4\ \text{V}$, total resistance $1 + 1 + 2 = 4\ \Omega$, so the current is $1\ \text{A}$, driven by the $6\ \text{V}$ cell. It flows through the $2\ \text{V}$ cell from its positive to its negative terminal, i.e. it charges it, so its terminal voltage is $E + Ir = 2 + 1 \times 1 = 3\ \text{V}$. $E - Ir = 1\ \text{V}$ would hold only if it were discharging.

Q18. Answer (1). Take $V_A = 10\ \text{V}$ and $V_C = 0$. At B: $(10 - V_B)/1 = V_B/2 + (V_B - V_D)/2$. At D: $(10 - V_D)/2 = V_D/1 + (V_D - V_B)/2$. These give $2V_B - V_D/2 = 10$ and $4V_D - V_B = 10$, so $V_B = 6\ \text{V}$ and $V_D = 4\ \text{V}$. The current in BD is $(6 - 4)/2 = 1\ \text{A}$ from B to D. The bridge is not balanced ($AB/BC = 1/2$ but $AD/DC = 2$), so it is not zero.

Q19. Answer (3). Let V be the potential of X above Y. Kirchhoff's current law at X: $(6 - V)/2 + (4 - V)/4 = V/4$, so $3 + 1 = V(1/2 + 1/4 + 1/4)$ and $V = 4\ \text{V}$. The $4\ \text{V}$ branch then has $4\ \text{V}$ across it and $4\ \text{V}$ of emf: no current flows through it. The $6\ \text{V}$ cell sends $(6 - 4)/2 = 1\ \text{A}$, all of it through the $4\ \Omega$ resistor of the third branch.

Q20. Answer (4). $X/R = 40/60 = 2/3$ and $(X + 10)/R = 60/40 = 3/2$. Subtracting, $10/R = 3/2 - 2/3 = 5/6$, so $R = 12\ \Omega$ and $X = 8\ \Omega$.

Q21. Answer (3). Balance depends only on the ratio condition $P/Q = R/S$. It is unaffected by the emf of the cell and by the galvanometer's resistance, and the condition stays true when the cell and galvanometer are interchanged (it can be written $P/R = Q/S$). Interchanging P and Q alone needs $Q/P = R/S$, which fails since $P \neq Q$.

Q22. Answer (4). Current in the wire = $4.0/(20 + 180) = 0.020\ \text{A}$, so the potential drop along the wire is $0.020 \times 20 = 0.40\ \text{V}$ over $10\ \text{m}$, i.e. $0.40\ \text{mV/cm}$. Balancing length = $15/0.40 = 37.5\ \text{cm}$. Ignoring the series resistor (gradient $4.0\ \text{V}/10\ \text{m}$) gives $3.75\ \text{cm}$.

Q23. Answer (2). The same current flows through both resistors and the potentiometer draws none at balance, so the balancing lengths are in the ratio of the resistances: $(X + 10)/10 = 84/60 = 1.4$, giving $X = 4\ \Omega$. $7.1\ \Omega (= 10 \times 60/84)$ treats $84\ \text{cm}$ as the balancing length for X alone, inverted.

Q24. Answer (1). Lengths are proportional to emfs: $E_1 \leftrightarrow 300\ \text{cm}$ and $E_1 + E_2 \leftrightarrow 500\ \text{cm}$, so $E_2 \leftrightarrow 200\ \text{cm}$. With E_2 reversed, $E_1 - E_2 \leftrightarrow 300 - 200 = 100\ \text{cm}$.

Q25. Answer (1). With m rows of n cells ($mn = 24$), $I = nE/(R + nr/m)$. The current is largest when the internal resistance nr/m equals R: $n \times 0.5/m = 3$ with $mn = 24$ gives $m = 2$, $n = 12$. Then $I = 12 \times 2.0/(3 + 3) = 4\ \text{A}$. (Checking every arrangement: 1×24 gives $48/15\ \text{A}$, 2×12 gives $4\ \text{A}$, 3×8 gives $3.84\ \text{A}$, ...)

Q26. Answer (3). $E^2 R_1/(R_1 + r)^2 = E^2 R_2/(R_2 + r)^2$ gives $r^2 = R_1 R_2$, so $r = 6\ \Omega$. Then $4.0 = E^2 \times 4/(4 + 6)^2$, so $E = 10\ \text{V}$. The power is greatest when the external resistance equals r: $P_{\text{max}} = E^2/4r = 100/24 = 25/6\ \text{W}$.

Q27. Answer (4). $V = E - Ir$: $10.4 = E - 2r$ and $8.8 = E - 4r$ give $r = 0.8 \, \Omega$ and $E = 12 \, \text{V}$. The greatest power is delivered when $R = r$: $P_{\text{max}} = E^2/4r = 144/3.2 = 45 \, \text{W}$. $E^2/r = 180 \, \text{W}$ is the short-circuit power dissipated inside the battery.

Q28. Answer (2). $R = V^2/P = 220^2/1000 = 48.4 \, \Omega$. With the leads, $I = 200/(48.4 + 1.6) = 4.0 \, \text{A}$, so the heater develops $I^2R = 16 \times 48.4 = 774 \, \text{W}$. $826 \, \text{W}$ ignores the leads ($200^2/48.4$), and $800 \, \text{W}$ multiplies the supply voltage by the current, which also counts the power lost in the leads.

Q29. Answer (4). The heat needed is $H = V^2t/R$ for each coil, so $R \propto t$: $R_1 \propto 10$ and $R_2 \propto 15$. In parallel, the powers add: $1/t = 1/10 + 1/15 = 1/6$, so $t = 6 \, \text{min}$. In series the times add ($25 \, \text{min}$).

Q30. Answer (2). Each reversed cell cancels the emf of one correct cell: net emf $= (12 - 2 \times 3) \times 1.5 = 9 \, \text{V}$. The internal resistances all still add: $12 \times 0.5 = 6 \, \Omega$. $I = 9/(6 + 3) = 1 \, \text{A}$. With every cell the right way round it would be $18/9 = 2 \, \text{A}$.

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