Physics · Electric Current and Electromagnetism · Electric Current, Ohm's Law and Kirchhoff's Laws

Electric Current and Ohm's Law

thanawiya-archive.com

157	3	72
questions	sets	pages

Contents

Multiple choice questions (110 questions) — Questions · p. 2 — Answers · p. 53

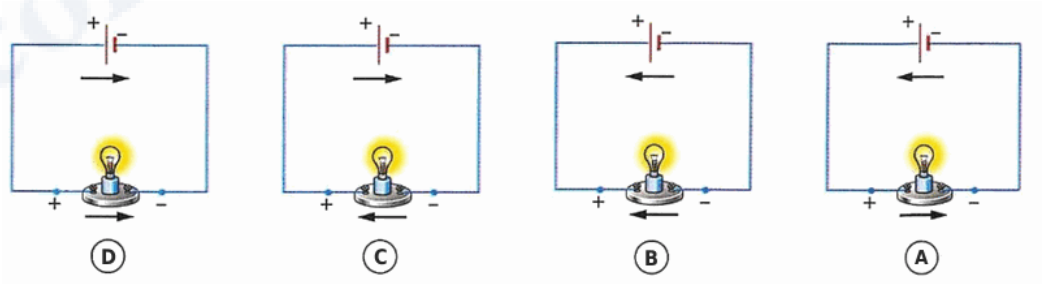
Essay questions (22 questions) — Questions · p. 36 — Answers · p. 66

Past exam questions (25 questions) — Questions · p. 43 — Answers · p. 69

Click a question number to jump to its answer, and an answer number to go back to the question.

Multiple choice questions — 110 questions

1 In which of the following electric circuits does the direction of the arrows correctly show the conventional direction of the current?



2 The opposite figure shows part of an electric circuit carrying a direct current (I). Which of the two ammeters in the figure has the greater reading?



(A) Ammeter A_1
(B) Ammeter A_2
(C) Both ammeters have the same reading
(D) The answer cannot be determined

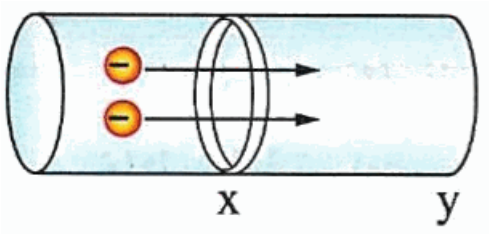
3 If the electric current in a conductor is 2 A, then:
the quantity of charge passing through a cross-section of the conductor in 10 s is .....

(A) 0.2 C
(B) 8 C
(C) 12 C
(D) 20 C

4 If the electric current in a conductor is 2 A, then:
the time needed for a charge of 4 mC to pass through a cross-section of the conductor is .....

(A) 2 ms
(B) 4 ms
(C) 6 ms
(D) 8 ms

5 In the opposite figure, a negative charge of 2 μC passes through cross-section x of a conductor in 4 ms. The magnitude and direction of the conventional current are .....

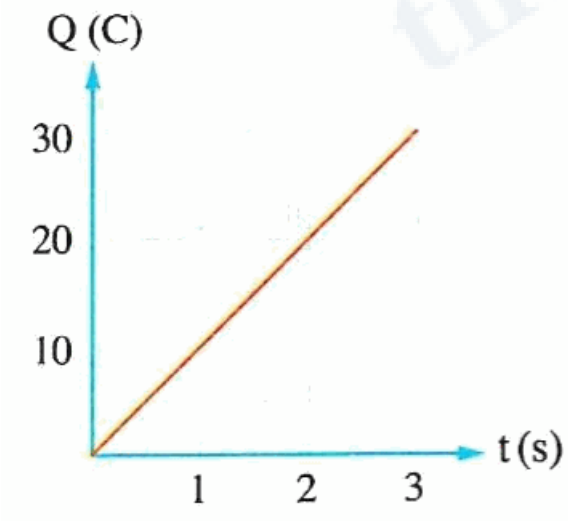


(A) 8 mA, from x to y
(B) 8 mA, from y to x
(C) 0.5 mA, from x to y
(D) 0.5 mA, from y to x

6 If the rate of flow of free electrons through a cross-section of wire x is 10^{20} electron/s and through a cross-section of wire y is 2×10^{20} electron/s, then the ratio between the currents in the two wires (I_x/I_y) equals .....

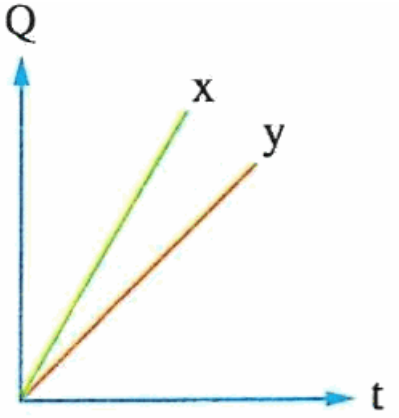
(A) *1/1*
(B) *2/1*
(C) *1/2*
(D) *1/4*

7 The opposite graph shows the relation between the quantity of charge (Q) passing through a cross-section of a conductor in a DC circuit and time (t). The direct current is .....



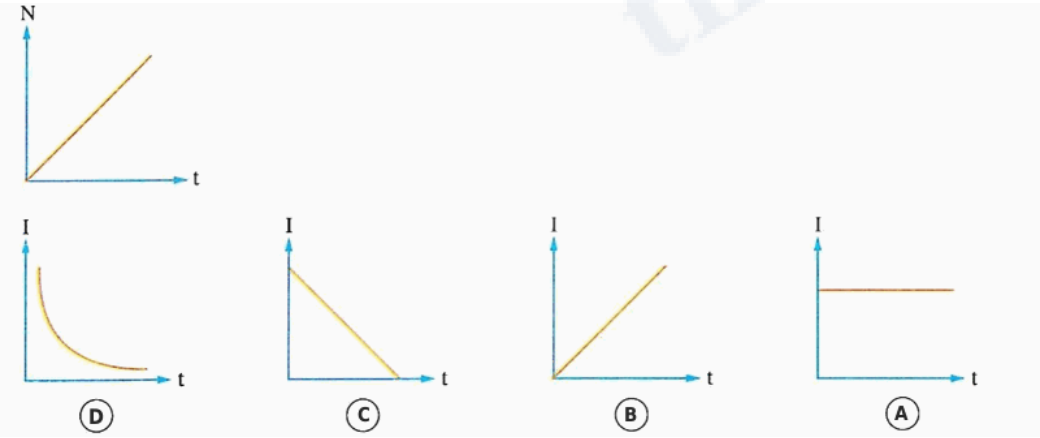
(A) 2 A
(B) 10 A
(C) 50 A
(D) 250 A

8 The opposite graph shows the relation between the charge (Q) passing through cross-sections of two conductors x, y and time (t). The ratio between the currents in the two conductors (I_x/I_y) is .....

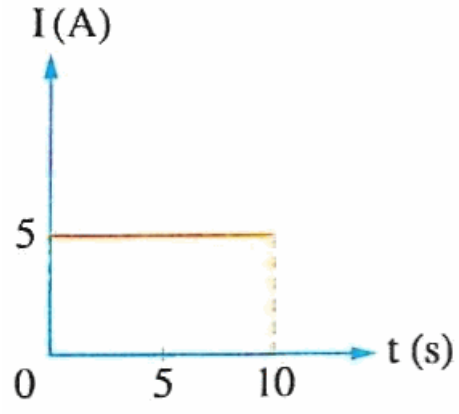


(A) greater than one
(B) less than one
(C) equal to one
(D) The answer cannot be determined

9 The opposite graph shows the relation between the number of electrons (N) passing through a certain cross-section of a conductor in a circuit carrying a current and time (t). The graph that represents the relation between the current (I) in this conductor and time (t) is .....

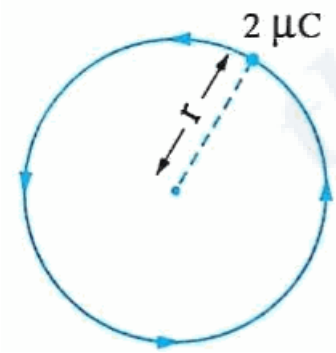


10 The opposite graph shows the relation between the current (I) in a conductor and the time of its flow (t). The quantity of charge passing through a cross-section of the conductor in 10 s equals .....



(A) 5 C (B) 10 C (C) 15 C (D) 50 C

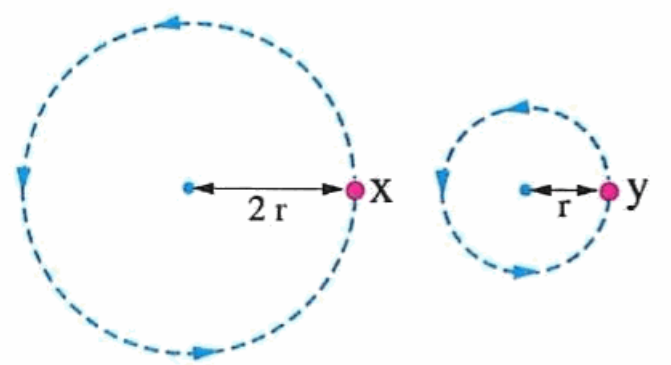
11 The opposite figure shows a charge of 2 μC revolving with a frequency of 1000 Hz in a uniform circular path. The current produced by the revolving charge equals .....



(A) 5 mA (B) 2 mA (C) 500 A (D) 2000 A

12 In the two opposite figures, two particles x, y carrying charges Q, 2Q respectively revolve in two circular paths. The ratio between the currents produced by the revolving particles (I_x/I_y), if they revolve:

with the same frequency, equals .....

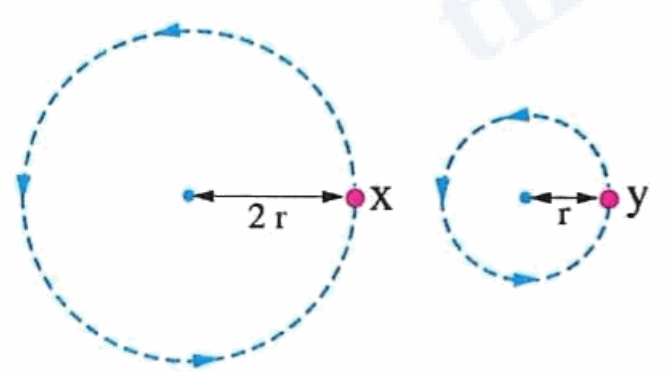


(A) *1/1* (B) *1/2* (C) *2/1* (D) *1/4*

---

13 In the two opposite figures, two particles x, y carrying charges Q, 2Q respectively revolve in two circular paths. The ratio between the currents produced by the revolving particles (I_x/I_y), if they revolve:

with the same linear speed, equals .....



(A) *1/1* (B) *1/2* (C) *2/1* (D) *1/4*

---

14 According to Bohr's model of the hydrogen atom, the electron moves in a circular path of radius 0.53 Å with a speed of 2.2×10^6 m/s. The electric current produced by the motion of the electron equals .....

(A) 3.141 mA (B) 6.282 mA (C) 1.166 mA (D) 1.057 mA

---

15 In an electric circuit, the battery is a source of .....

(A) positive charges (B) negative charges

(C) electrical conductivity (D) electrical energy

16 The ends of a metal conductor are connected to a DC source to form a closed circuit. Which of the following statements is correct about the motion of the free electrons inside and outside the source?

(A) They vibrate in their places without moving to new places

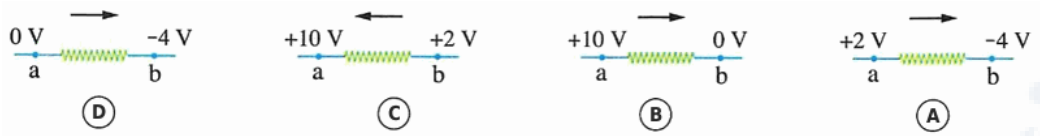
(B) Inside the source they move towards the terminal of higher potential

(C) Outside the source they move towards the terminal of lower potential

(D) Outside the source they move towards the terminal of higher potential

---

17 In which of the following cases does the arrow show the direction of motion of the free electrons through the resistor between points a, b?



---

18 In the opposite figure, the work done to move a charge of 4 C between points x, y is .....



(A) 20 J (B) 40 J (C) 60 J (D) 80 J

---

19 The potential difference between two points when a work of 30 J is needed to move a charge of 10 C between them equals .....

(A) 0.3 V (B) 3 V (C) 30 V (D) 300 V

---

20 If the work done to move a charge of 5 C between two points in a conductor is 100 J, and this charge passes through a cross-section of the conductor in 1 s, then:
the potential difference between the two points equals .....

(A) 0.05 V (B) 5 V (C) 10 V (D) 20 V

---

21 If the work done to move a charge of 5 C between two points in a conductor is 100 J, and this charge passes through a cross-section of the conductor in 1 s, then:
the current in the conductor equals .....

(A) 2.5 A (B) 5 A (C) 7 A (D) 12 A

---

22 If the work done to move a charge of 5 C between two points in a conductor is 100 J, and this charge passes through a cross-section of the conductor in 1 s, then:
the number of free electrons passing through a cross-section of the conductor in 2 s equals ..... electrons.

(A) 4.22×10^{18} (B) 1.56×10^{19} (C) 6.25×10^{19} (D) 1.25×10^{19}

23 The coulomb equals the quantity of electric charge that .....

(A) if it passes through a cross-section of a conductor in 5 s, the current in the conductor is 50 A

(B) if it passes through a cross-section of a conductor in 50 s, the current in the conductor is 0.5 A

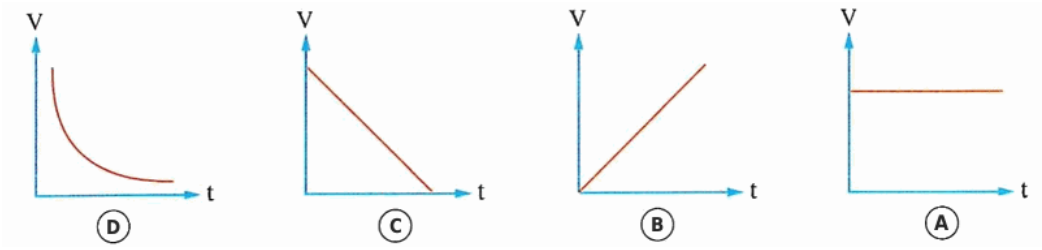
(C) needs a work of 5 J to move it between two points with a potential difference of 0.5 V

(D) needs a work of 0.05 J to move it between two points with a potential difference of 0.05 V

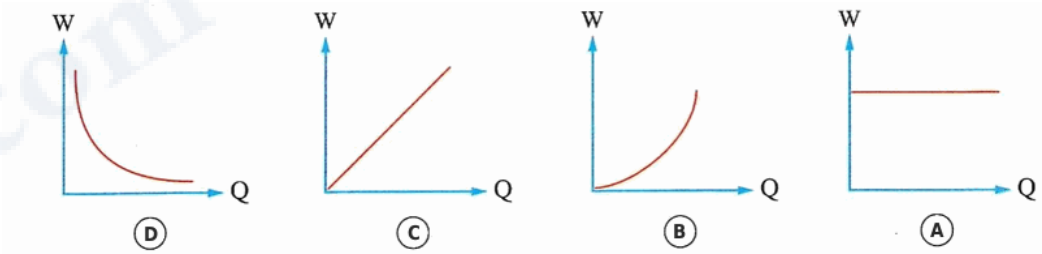
24 If the work done to move 10^{20} electrons between the ends of conductor A is 10 J, and the work done to move 4×10^{20} electrons between the ends of conductor B is 20 J, then the ratio between the potential differences across the two conductors (V_A/V_B) equals .....

(A) 1/2 (B) 2/1 (C) 1/4 (D) 4/1

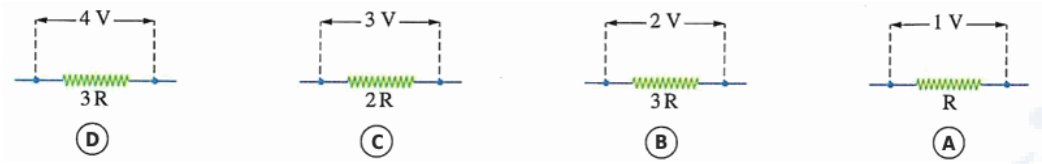
25 Which of the following graphs represents the relation between the potential difference (V) across a conductor carrying a direct current and time (t)?



26 Which of the following graphs represents the relation between the work done (W) to move an electric charge between two points with a constant potential difference and the quantity of this charge (Q)?

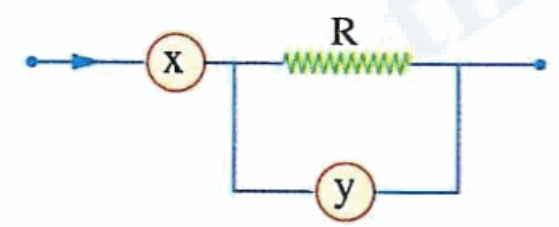


27 In which of the following cases is the current in the resistor the greatest?



28 The opposite figure shows part of an electric circuit. If devices x, y are connected correctly, then:

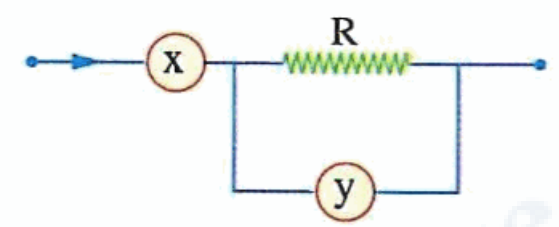
these two devices are respectively .....



(A) ammeter, ammeter
(B) ammeter, voltmeter
(C) voltmeter, ammeter
(D) voltmeter, voltmeter

29 The opposite figure shows part of an electric circuit. If devices x, y are connected correctly, then:

the units of the quantities measured by device x and device y respectively are .....

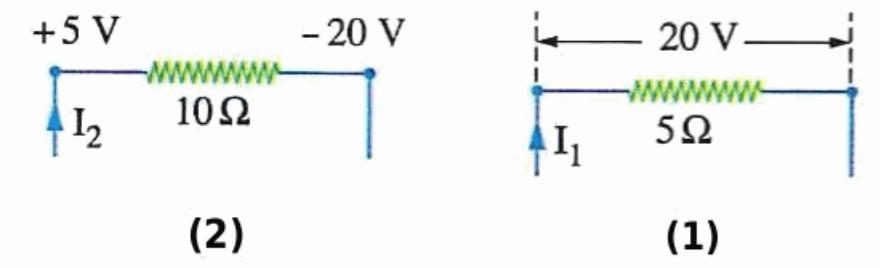


(A) coulomb/second, volt
(B) coulomb/second, ampere
(C) ohm/coulomb, volt
(D) ohm/coulomb, ampere

30 If 6.25×10^{18} electrons pass in two seconds through a cross-section of a conductor with a potential difference of 12 V across its ends, then the resistance of this conductor equals .....

(A) 24 Ω (B) 12 Ω (C) 6 Ω (D) 3.84 Ω

31 The two opposite figures (1), (2) show parts of two electric circuits carrying currents I_1, I_2 respectively. The ratio between the two currents (I_1/I_2) equals .....

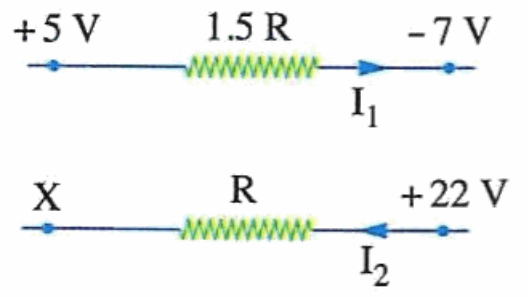


(A) *4/1* (B) *1/4* (C) *8/5* (D) *5/8*

32 A conductor of resistance 10 Ω carries a current of 0.5 A. If the same conductor carries a current of 1 A at the same temperature, its resistance equals .....

(A) 2.5 Ω (B) 5 Ω (C) 10 Ω (D) 20 Ω

33 The two opposite figures show two conductors, each carrying an electric current. If the ratio between the two currents (I_1/I_2) is *1/3*, then the potential of point X equals .....



(A) 2 V (B) 24 V (C) -2 V (D) -24 V

34 The opposite figure shows an electric circuit carrying a current (I). One of the following changes is made to it:

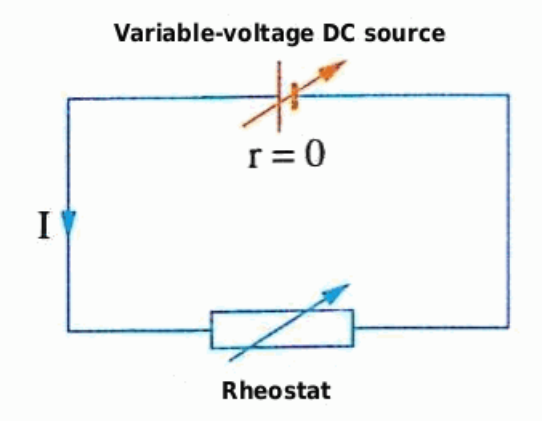
(I) doubling the emf of the source

(II) halving the emf of the source

(III) doubling the value of the rheostat

(IV) halving the value of the rheostat

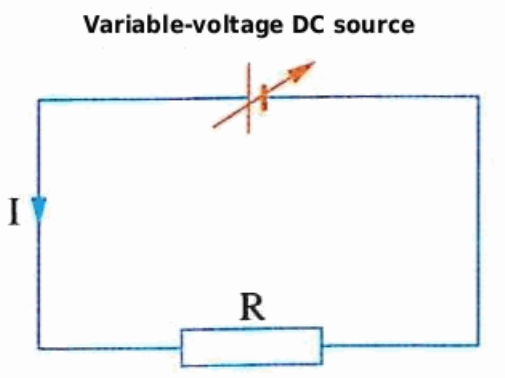
The current in the circuit increases to 2I in the two cases .....



(A) (I), (II) (B) (II), (III) (C) (III), (IV) (D) (I), (IV)

---

35 In the opposite circuit, when the voltage of the source is increased, the physical quantity whose value does not change is .....



(A) the rate of flow of electrons through a cross-section of the circuit

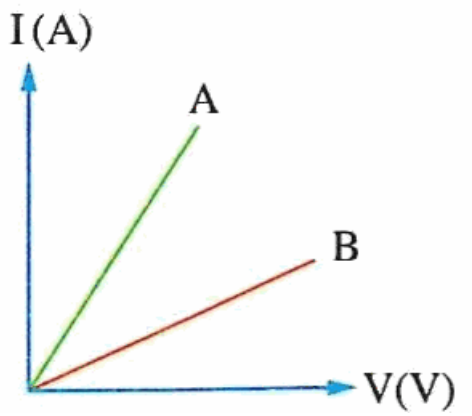
(B) the work done by the source per second

(C) the current (I) in the circuit

(D) the value of the resistance (R)

---

36 The opposite graph shows the relation between the current through each of two wires A, B and the potential difference across each of them. Which wire has the greater electric resistance, and why?



(A) Wire A, because the slope of the line represents the resistance of the wire

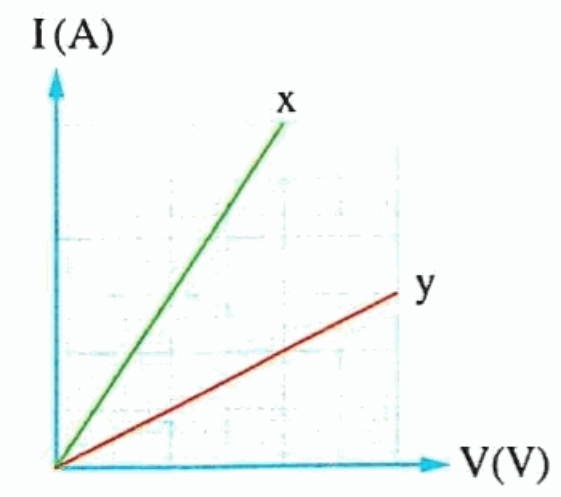
(B) Wire A, because the slope of the line represents the reciprocal of the resistance of the wire

(C) Wire B, because the slope of the line represents the resistance of the wire

(D) Wire B, because the slope of the line represents the reciprocal of the resistance of the wire

---

37 The opposite graph shows the relation between the current (I) in two conductors x, y and the potential difference (V) across each of them. The ratio between the resistances of the two conductors (R_x/R_y) equals .....



(A) *1/2* (B) *3/4* (C) *7/4* (D) *1/3*

---

38 Figure (1) shows the graph of the relation between the work done (W) to move an electric charge through a conductor carrying a current and the quantity of this charge (Q), and figure (2) shows the graph of the relation between the quantity of charge (Q) passing through a certain cross-section of the same conductor and time (t). The electric resistance of the conductor equals .....

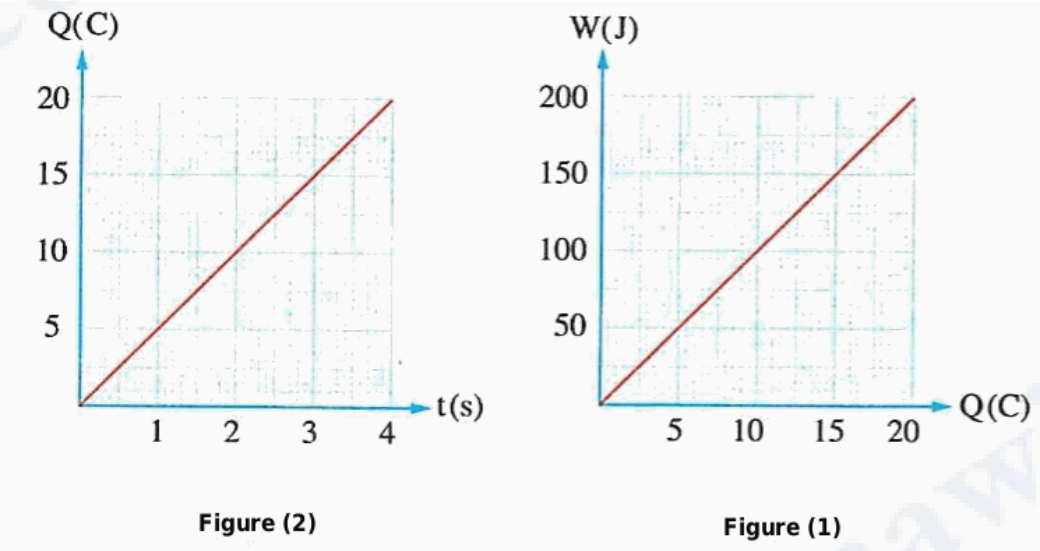
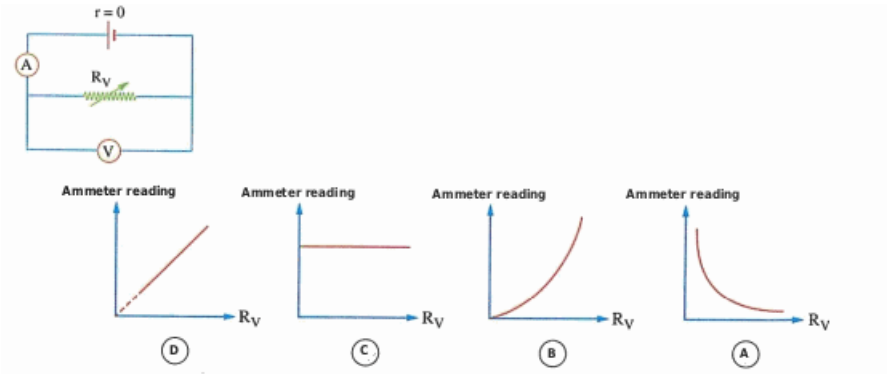


Figure (2) Figure (1)

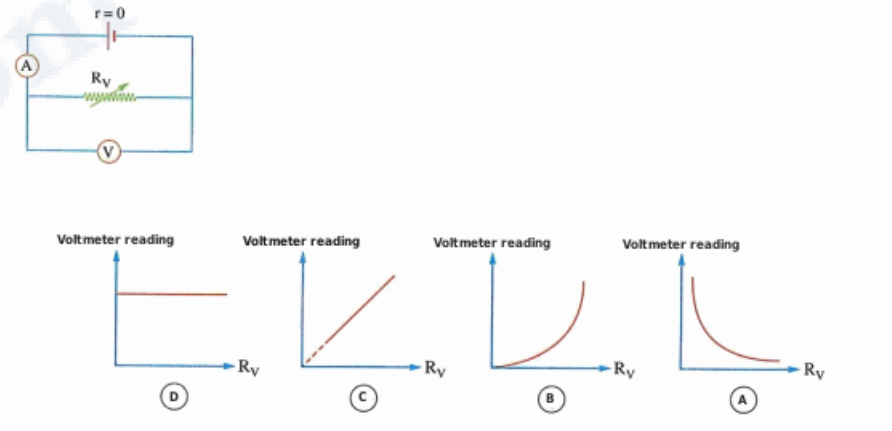
(A) 0.5 Ω (B) 2 Ω (C) 5 Ω (D) 15 Ω

39 In the opposite circuit:
which of the following graphs represents the relation between the ammeter reading and the resistance taken from R_V?



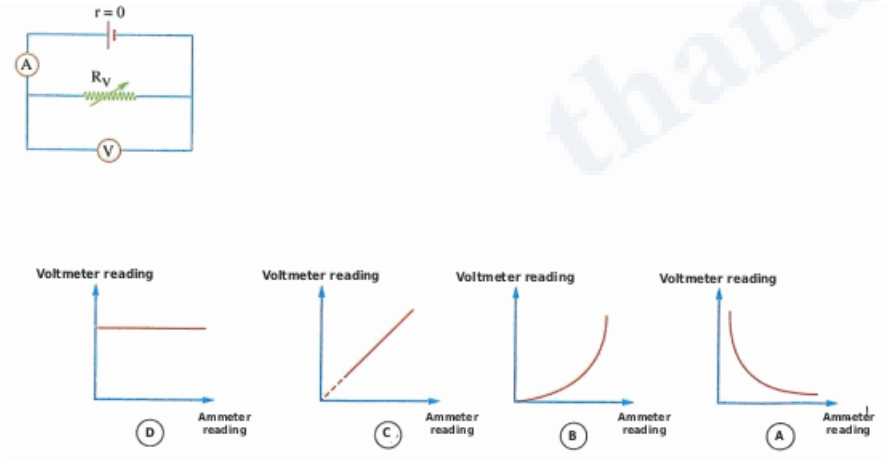
40 In the opposite circuit:

which of the following graphs represents the relation between the voltmeter reading and the resistance taken from R_V?



41 In the opposite circuit:

which of the following graphs represents the relation between the voltmeter reading and the ammeter reading when the resistance taken from R_V is changed?

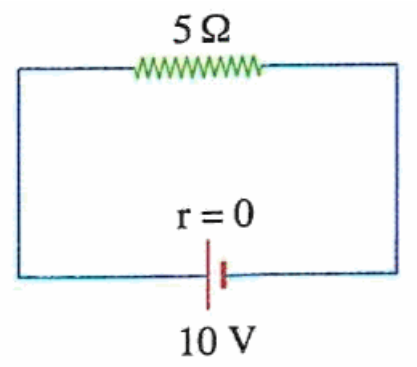


42 Which of the following units is not equivalent to the watt?

(A) J/s (B) A.V (C) $A^2.\Omega$ (D) $\Omega^2.V$

43 In the opposite circuit:

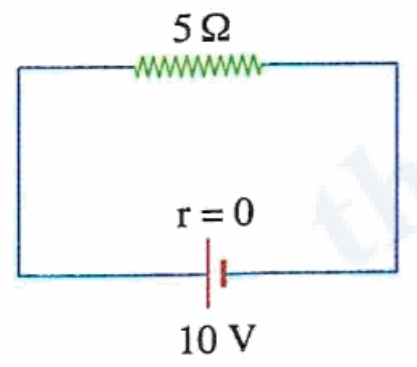
the power consumed in the circuit is .....



(A) 10 W (B) 20 W (C) 50 W (D) 100 W

44 In the opposite circuit:

the energy consumed in the circuit in 20 s is .....

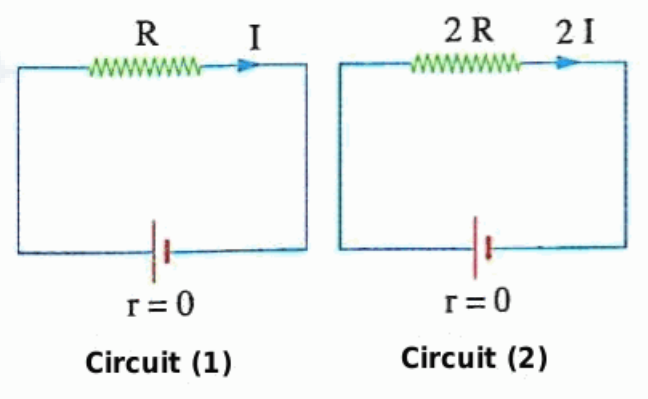


(A) 100 J (B) 200 J (C) 400 J (D) 1000 J

45 In which of the following figures is the power consumed in the resistor the greatest?

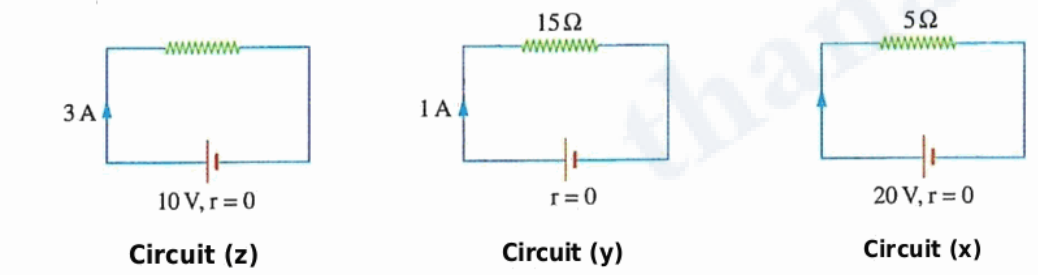


46 In the two opposite circuits, the ratio between the powers consumed in the two circuits $(((P_w)_2)/((P_w)_1))$ is .....



(A) 2/1 (B) 4/1 (C) 8/1 (D) 16/1

47 The following figures show three electric circuits x, y, z.
The correct order of the three circuits according to the power drawn from the source is .....

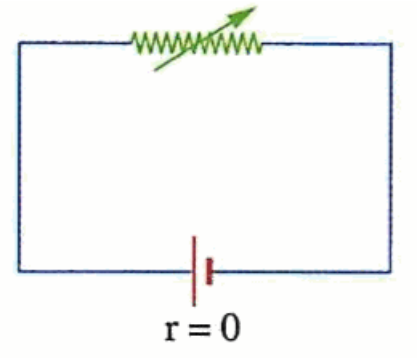


(A) z > y > x (B) x > y > z (C) y > z > x (D) x > z > y

48 An electric fan is labelled (220 V, 100 W) and an electric heater is labelled (220 V, 1000 W).
The resistance of the heater compared with the resistance of the fan is .....

(A) equal to it (B) less than it
(C) greater than it (D) The answer cannot be determined

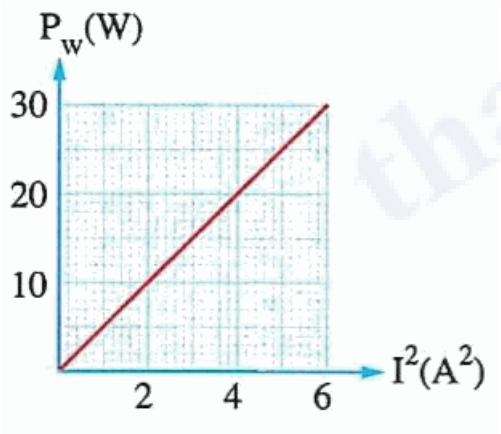
49 In the opposite circuit, when the value of the rheostat is doubled, the rate of consumption of electrical energy in the circuit .....



(A) doubles
(B) decreases to half
(C) decreases to a quarter
(D) stays constant

---

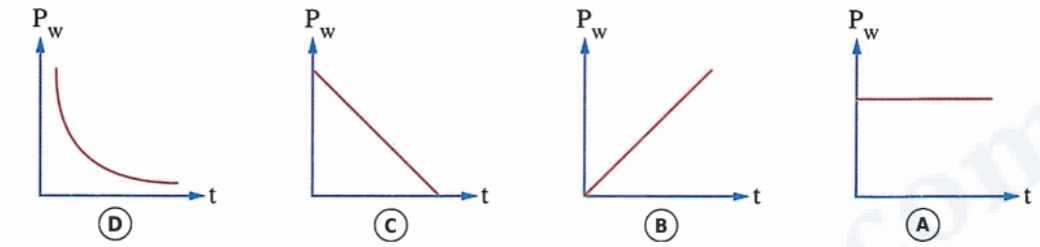
50 The opposite graph shows the relation between the power consumed in a conductor and the square of the current in it. The resistance of the conductor is .....



(A) 2 Ω
(B) 5 Ω
(C) 50 Ω
(D) 0.5 Ω

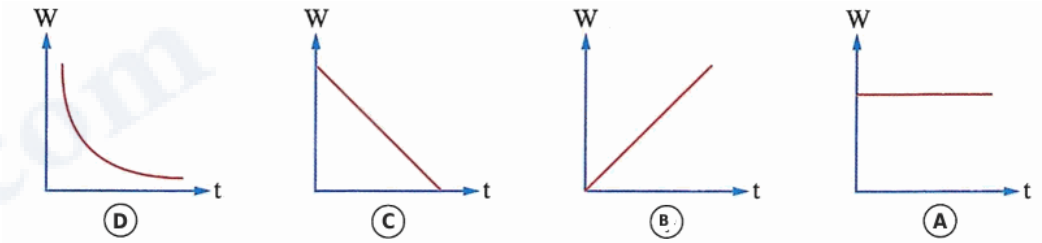
---

51 Which of the following graphs represents the relation between the power consumed (P_w) in a conductor carrying a direct current and time (t)?

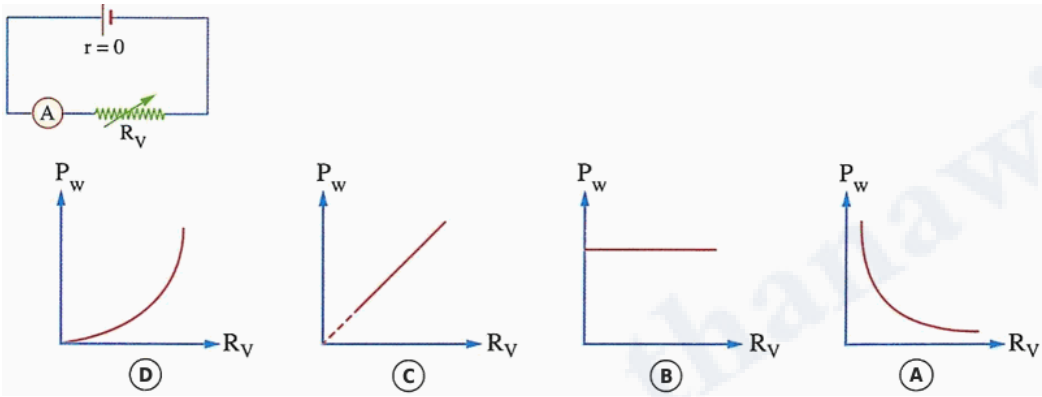


---

52 Which of the following graphs represents the relation between the energy consumed (W) in a conductor carrying a direct current and time (t)?



53 The opposite figure shows an electric circuit. Which of the following graphs represents the relation between the power consumed in the resistance R_V and the value of the resistance taken from it?



54 A metal wire is 20 m long, its cross-sectional area is 0.5 cm² and the resistivity of its metal is 10^{-7} Ω.m. The electric resistance of the wire equals .....

(A) 0.02 Ω (B) 0.04 Ω (C) 0.06 Ω (D) 0.08 Ω

55 An iron wire 3.14 m long with a cross-section radius of 0.5 mm is connected to a battery, so the potential difference across its ends is 5 V. If the resistivity of iron is 10^{-7} Ω.m, then the current in the wire equals .....

(Given: π = 3.14)

(A) 6.2 A (B) 8.2 A (C) 9.6 A (D) 12.5 A

56 A wire 200 m long whose material has a resistivity of 3.14×10^{-7} Ω.m carries 2×10^{19} electrons per second through its cross-section when it is connected to a source with a potential difference of 64 V across its terminals. The radius of the cross-section of the wire equals .....

(Given: π = 3.14)

(A) 10^{-1} m (B) 10^{-2} m (C) 10^{-3} m (D) 10^{-4} m

57 If the length of a copper wire is doubled and its cross-sectional area is halved, its resistance .....

(A) doubles
(B) decreases to half
(C) increases to four times
(D) decreases to a quarter

58 When the length of a conductor is doubled and its cross-sectional area is halved, the resistivity of its material .....

(A) increases four times
(B) increases three times
(C) decreases to half
(D) does not change

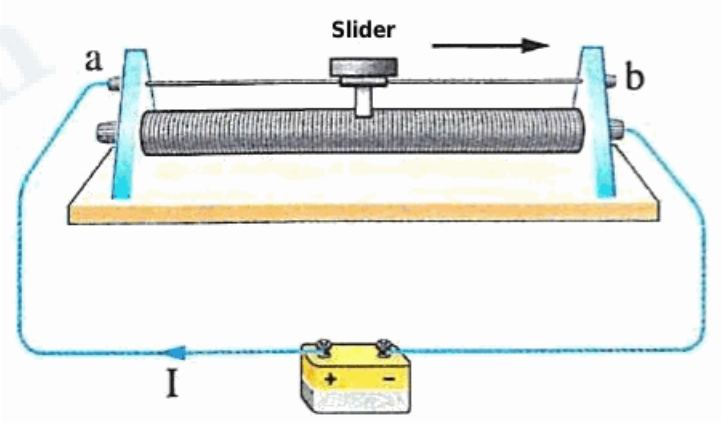
59 Three identical wires x, y, z, each connected to a potential difference (V), were kept at temperatures 3t, 2t, t respectively for a period of time. Which of these wires:
has its free electrons colliding with its atoms at a greater rate?

(A) x
(B) y
(C) z
(D) equal for the three wires

60 Three identical wires x, y, z, each connected to a potential difference (V), were kept at temperatures 3t, 2t, t respectively for a period of time. Which of these wires:
carries the greatest current?

(A) x
(B) y
(C) z
(D) equal for the three wires

61 In the opposite circuit, when the slider of the rheostat is moved from its position towards position b, which of the following choices shows what happens in the circuit?



(A) Length of the rheostat wire carrying the current: increases, current in the circuit: increases

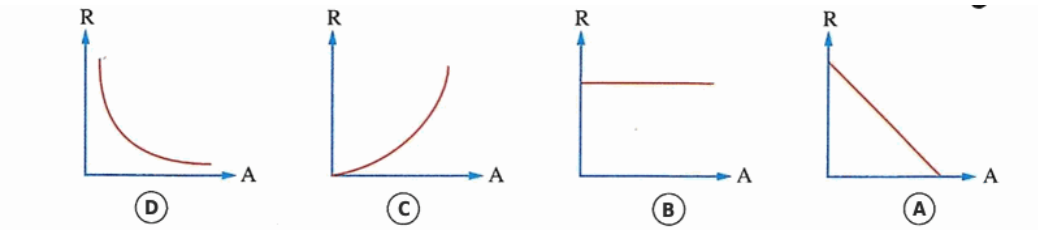
(B) Length of the rheostat wire carrying the current: increases, current in the circuit: decreases

(C) Length of the rheostat wire carrying the current: decreases, current in the circuit: increases

(D) Length of the rheostat wire carrying the current: decreases, current in the circuit: decreases

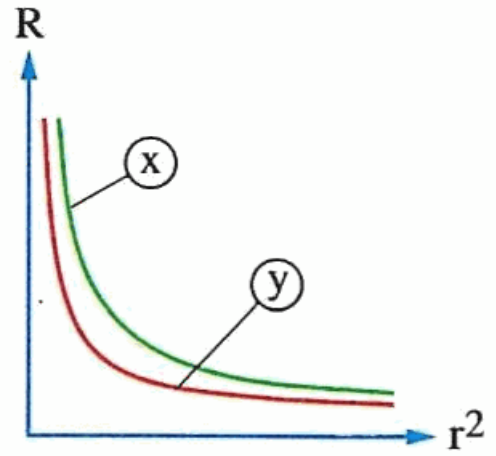
---

62 Which of the following graphs represents the relation between the resistance (R) of several copper wires of the same length and the cross-sectional area (A) of each?



---

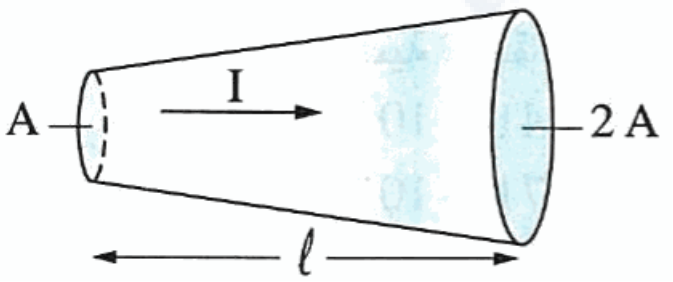
63 A group of wires have the same length; some are made of metal (x) and the others of metal (y). The opposite graph shows the relation between the electric resistance (R) and the square of the radius (r^2) of the cross-section of each at the same temperature. Which of the following relations is correct when comparing the electrical conductivity (σ) of the two metals?



(A) $\sigma_x > \sigma_y$
(B) $\sigma_x < \sigma_y$
(C) $\sigma_x = \sigma_y$
(D) The answer cannot be determined

---

64 The opposite figure shows a conductor whose material has a resistivity ρ_e, and the cross-sectional areas of its two ends are A, 2A. The value of its resistance is .....



(A) equal to $(\rho_e\ \ell)/A$
(B) greater than $(\rho_e\ \ell)/A$
(C) less than $(\rho_e\ \ell)/A$
(D) equal to $(\rho_e\ \ell)/2A$

---

65 If the resistivity of copper = 1.8×10^{-8} Ω.m, then .....

(A) the resistance of a copper conductor 1 m long with a cross-section diameter of 1 m = 1.8×10^{-8} Ω
(B) the resistance of a copper conductor 1 m long with a cross-sectional area of 1 m^2 = 1.8×10^{-8} Ω
(C) the resistance of a unit length of copper = 1.8×10^{-8} Ω/m
(D) the resistance of a unit volume of copper = 1.8×10^{-8} Ω/m^3

66 If the resistivity of copper is 1.8×10^{-8} Ω.m, which of the following represents the length and resistance of a copper wire with a cross-sectional area of 10 mm²?

(A) length 10 m and resistance 1.8×10^{-8} Ω

(B) length 10 m and resistance 0.018 Ω

(C) length 1 m and resistance 1.8×10^{-4} Ω

(D) length 1 m and resistance 1.8 Ω

---

67 Two wires, one of copper (Cu) and the other of iron (Fe), have the same resistance and length. The ratio between the radii of the two wires $((r_{Fe})/(r_{Cu}))$ equals .....

(A) $((\rho_e)_{Fe})/((\rho_e)_{Cu})$

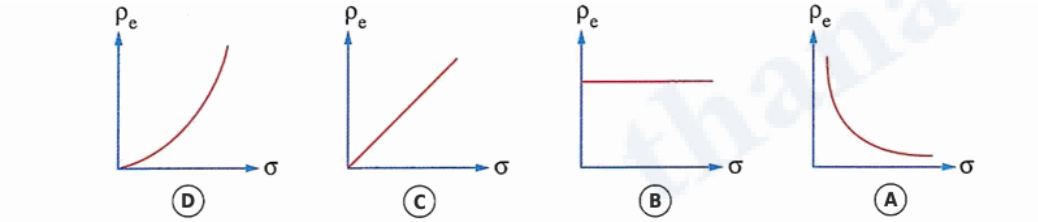
(B) $((\rho_e)_{Fe})/(\sqrt{((\rho_e)_{Cu})})$

(C) $(\sqrt{((\rho_e)_{Fe})})/((\rho_e)_{Cu})$

(D) $\sqrt{(((\rho_e)_{Fe})/((\rho_e)_{Cu}))}$

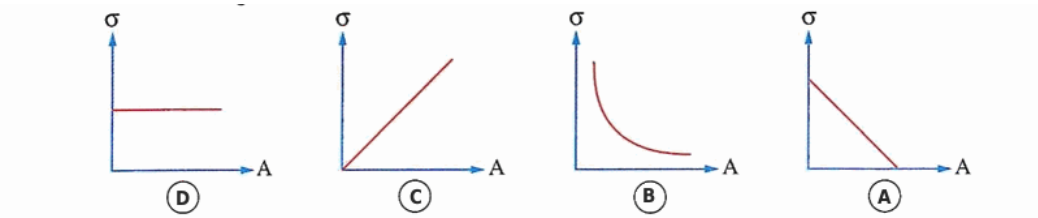
---

68 Which of the following graphs represents the relation between the resistivity (ρ_e) of a group of wires of different materials and the electrical conductivity (σ) of each?



---

69 Which of the following graphs expresses the relation between the electrical conductivity (σ) of a material and the cross-sectional area (A) of several conductors made of it?



---

70 A conductor is 106.3 cm long, its cross-sectional area is 1 mm² and its electric resistance is 1 Ω, then:

the resistivity of the conductor's material equals .....

(A) 9.41×10^{-7} Ω.m

(B) 8.53×10^{-7} Ω.m

(C) 5.71×10^{-6} Ω.m

(D) 6.25×10^{-6} Ω.m

---

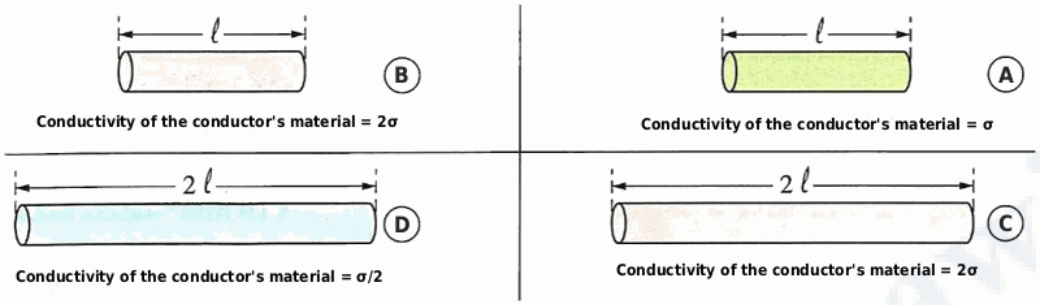
71 A conductor is 106.3 cm long, its cross-sectional area is 1 mm² and its electric resistance is 1 Ω, then:

the electrical conductivity of the conductor's material equals .....

(A) $1.89 \times 10^{6}\ \Omega^{-1}.m^{-1}$ (B) $2.35 \times 10^{9}\ \Omega^{-1}.m^{-1}$

(C) $7.35 \times 10^{8}\ \Omega^{-1}.m^{-1}$ (D) $1.06 \times 10^{6}\ \Omega^{-1}.m^{-1}$

72 The following figures show four metal conductors with the same cross-sectional area, and the electrical conductivity of each conductor's material is written under its figure. Which of these conductors has the greatest resistance?



73 A power station is connected to a factory 2.5 km away by two wires. The potential difference between the ends of the two wires at the station is 240 V, the potential difference between their other ends at the factory is 220 V, and the factory uses a current of 80 A, then: (Given: π = 3.14)

the resistance of one metre of the wire equals .....

(A) $5 \times 10^{-5}\ \Omega/m$ (B) $6 \times 10^{-5}\ \Omega/m$ (C) $12 \times 10^{-5}\ \Omega/m$ (D) $1 \times 10^{-4}\ \Omega/m$

74 A power station is connected to a factory 2.5 km away by two wires. The potential difference between the ends of the two wires at the station is 240 V, the potential difference between their other ends at the factory is 220 V, and the factory uses a current of 80 A, then: (Given: π = 3.14)

the radius of the wire, if the resistivity of its material is $1.57 \times 10^{-8}\ \Omega.m$, equals .....

(A) 0.004 m (B) 0.007 m (C) 0.01 m (D) 0.05 m

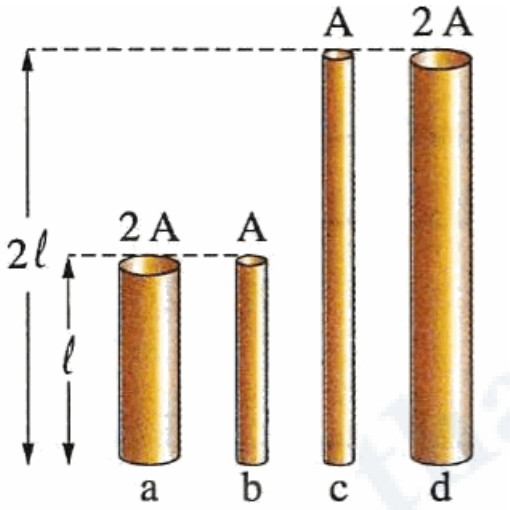
75 You have four wires of the same material, different in length and thickness. Each one was connected separately with the same battery and an ammeter. The ammeter has its greatest reading with the wire that is .....

(A) long and thick (B) long and thin (C) short and thick (D) short and thin

76 A metal wire of uniform cross-section and length (ℓ) carries a current (I) when the potential difference across its ends is (V). If a part (X) is cut from the wire and the ends of the remaining part are connected to the same potential difference (V), the current in it becomes $(4/3\ I)$. The length of the cut part (X) equals .....

(A) $1/4\ \ell$ (B) $1/3\ \ell$ (C) $1/2\ \ell$ (D) $2/3\ \ell$

77 The opposite figure shows the lengths and cross-sectional areas of four wires made of the same material. If each one is connected to the same potential difference at the same temperature, the correct order of the wires according to the current in each is .....



(A) c > b = d > a (B) a > b = d > c (C) b > a = c > d (D) d > a = c > b

78 The following table shows the specifications and temperature of four conductors x, y, z, k of uniform cross-section made of the same metal. Which of these conductors has the greatest electric resistance?

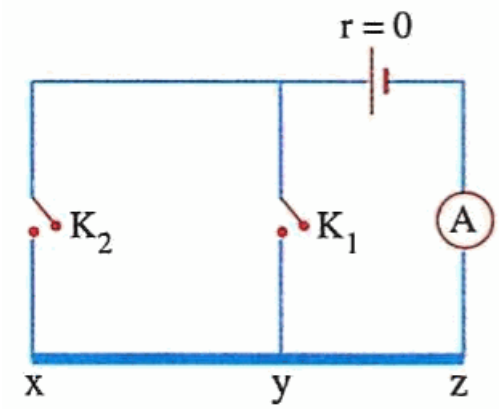
(A) x: length 2 m, cross-sectional area 4 mm², temperature 20°C

(B) y: length 2 m, cross-sectional area 4 mm², temperature 50°C

(C) z: length 4 m, cross-sectional area 2 mm², temperature 20°C

(D) k: length 4 m, cross-sectional area 2 mm², temperature 50°C

79 A wire xyz of uniform cross-section and electric resistance (R) is connected in an electric circuit as in the opposite figure. When only switch (K_1) is closed, the ammeter reading is 4 A, and when only switch (K_2) is closed, the ammeter reading is 1 A. The ratio between the lengths of the two parts of the wire $((\ell_{xy})/(\ell_{yz}))$ equals .....



(A) 2 (B) 3 (C) 4 (D) 5

80 Three copper wires x, y, z have the same cross-sectional area. The length of x = 1 m, the length of y = 4 m and the length of z = 2 m. The ratio of the resistances of the three wires $R_x : R_y : R_z$ is .....

(A) *1 : 4 : 2* (B) *4 : 1 : 2* (C) *2 : 4 : 1* (D) *2 : 1 : 4*

81 Two wires (x), (y) of the same metal have the same length, and the radii of their cross-sections are r_x, r_y. Each wire is wound into a circular coil of radius r_1, r_2 respectively. The ratio between the electric resistances of the two wires (R_x/R_y) equals .....

(A) r_y/r_x (B) r_1/r_2 (C) $(r_y/r_x)^2$ (D) $(r_1/r_2)^2$

82 Two wires of the same material: the length of the second wire is double the length of the first, and its diameter is half the diameter of the first wire. The ratio of the resistance of the second wire to the resistance of the first wire equals .....

(A) *1/8* (B) *8/1* (C) *1/2* (D) *2/1*

83 A conductor of uniform cross-section is 20 m long and its resistance is 108 Ω. Another conductor of the same material is 5 m long and its cross-sectional area is three times that of the first conductor. The resistance of the second conductor equals .....

(A) 81 Ω (B) 27 Ω (C) 9 Ω (D) 6 Ω

84 A cylindrical metal rod has a cross-sectional area of 2 cm^2 and a resistance of 22.5 Ω. If the rod is stretched uniformly until its cross-sectional area becomes 1.5 cm^2, its resistance becomes .....

(A) 37 Ω (B) 40 Ω (C) 52 Ω (D) 56 Ω

85 A metal wire is stretched uniformly until its length becomes double its original length, so its resistance becomes ..... its original value.

(A) double (B) half (C) four times (D) a quarter of

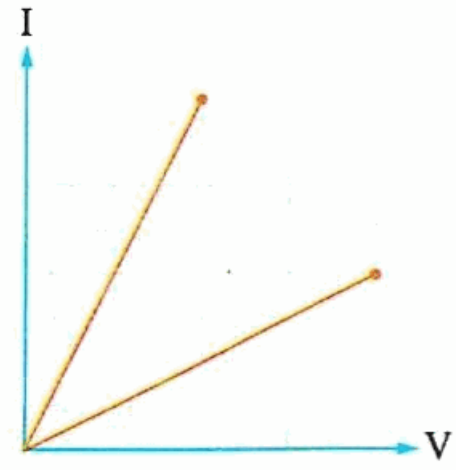
86 A metal wire of uniform cross-section is stretched uniformly so its radius decreases by 20%. The electric resistance of the wire increases by about .....

(A) 44% (B) 56% (C) 144% (D) 244%

87 A cylindrical metal conductor has a cross-section diameter d and an electric resistance R. It is stretched uniformly to become a cylindrical conductor with a cross-section diameter d/x. The electric resistance of the conductor becomes .....

(A) $x^2 R$ (B) $x^4 R$ (C) $R/(x^2)$ (D) $R/(x^4)$

88 A metal wire of uniform cross-section is stretched uniformly, and the relation between the current (I) in the wire and the potential difference (V) across its ends before and after stretching is shown in the opposite graph. The wire was stretched so that .....



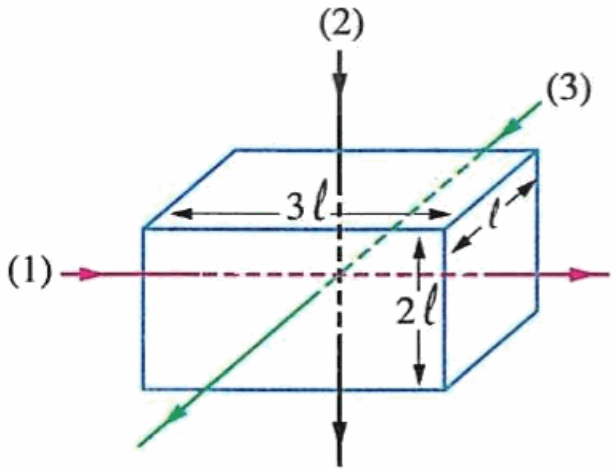
(A) its length doubled

(B) its length became nine times

(C) its cross-sectional area decreased to a third

(D) its cross-sectional area decreased to a ninth

89 In the opposite figure, an electric conductor is a solid cuboid. Any pair of its opposite faces can be connected to an electric source, and paths (1), (2), (3) represent the possible ways for a current to pass through the conductor. In which of these paths does the conductor have the greatest resistance to the current?



(A) Path (1)

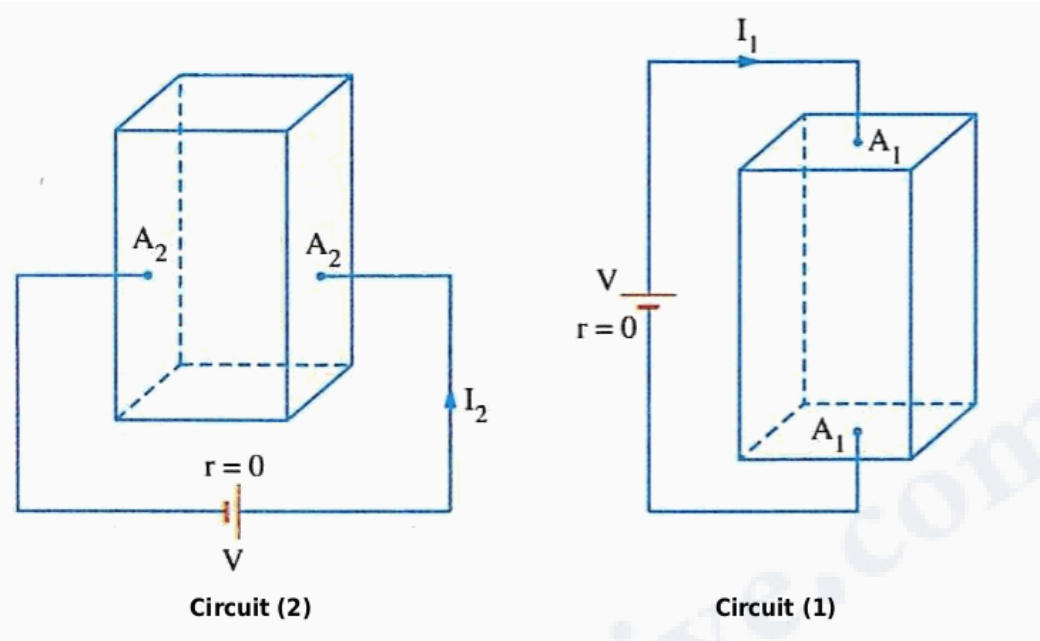
(B) Path (2)

(C) Path (3)

(D) All paths have the same electric resistance

---

90 An electric conductor in the shape of a solid cuboid is connected in two different ways to a battery of negligible internal resistance, as in circuits (1), (2). The ratio between the currents in the two circuits (I_1/I_2) equals .....



(A) A_1/A_2 (B) $(A_1/A_2)^2$ (C) A_2/A_1 (D) $(A_2/A_1)^2$

91 A metal wire has a volume of 2×10^{-4} m³, a cross-sectional area of 4×10^{-5} m² and a resistance of 1.25 Ω. The electrical conductivity of the metal equals .....

(A) $10^{3}\ \Omega^{-1}.m^{-1}$ (B) $10^{5}\ \Omega^{-1}.m^{-1}$ (C) $10^{7}\ \Omega^{-1}.m^{-1}$ (D) $10^{8}\ \Omega^{-1}.m^{-1}$

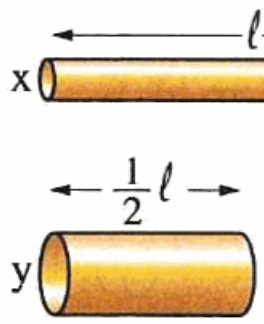
92 A metal cube has a side length ℓ. When two opposite faces are connected to the ends of an electric circuit, its electric resistance is R. The electrical conductivity (σ) of this metal can be found from the relation .....

(A) $\sigma = R\ell$ (B) $\sigma = (\pi)/(R\ell)$ (C) $\sigma = 1/(2R\ell)$ (D) $\sigma = 1/(R\ell)$

93 Two copper wires: the first is 10 m long with a mass of 0.1 kg, and the second is 40 m long with a mass of 0.2 kg. The ratio between their resistances (R_1/R_2) equals .....

(A) 1/4 (B) 1/5 (C) 1/7 (D) 1/8

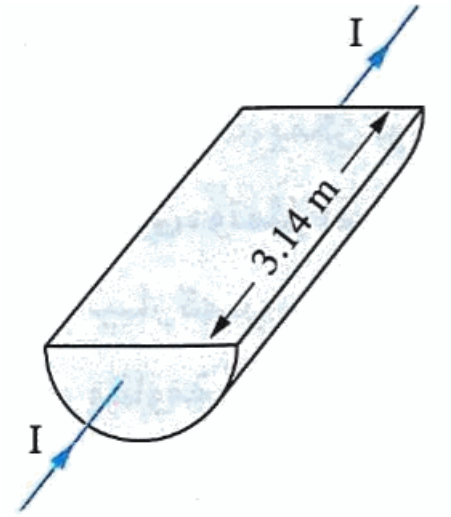
94 In the figure shown, two wires x, y are made of the same material. If the mass of wire x is 5 g and the mass of wire y is 10 g, then the ratio between the resistances of the two wires (R_x/R_y) equals .....



(A) 2/1 (B) 4/1 (C) 8/1 (D) 16/1

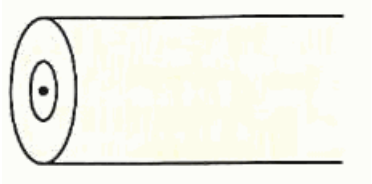
95 In the opposite figure, a conductor 3.14 m long, whose cross-section is a semicircle of diameter 2 mm, carries an electric current. If the resistivity of the conductor's material is 10^{-6} Ω.m, its electric resistance equals .....

(Given: π = 3.14)



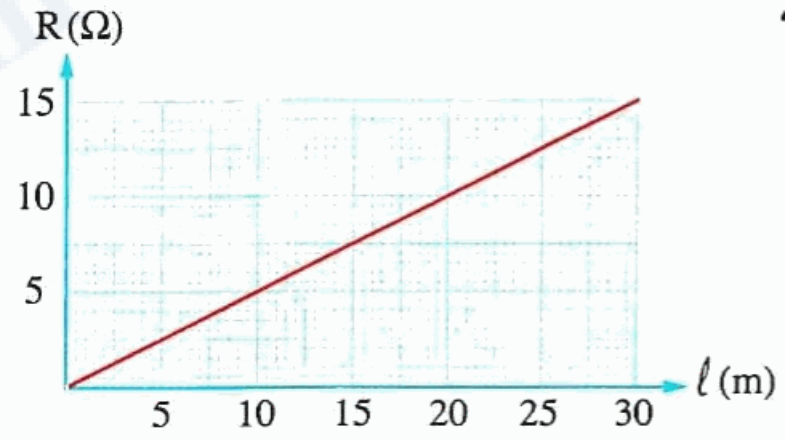
(A) 0.25 Ω (B) 0.5 Ω (C) 1 Ω (D) 2 Ω

96 A hollow cylinder made of a metal of resistivity 2×10^{-8} Ω.m is 1 m long, its inner radius is 1 mm and its outer radius is 2 mm, as in the opposite figure. The electric resistance between the two ends of the cylinder equals .....



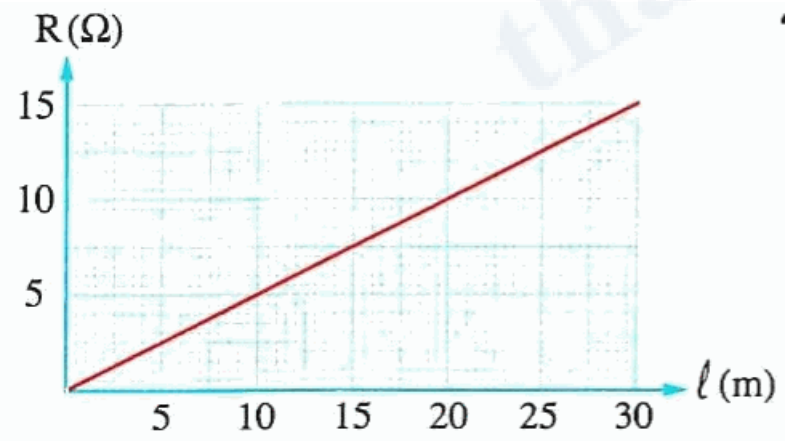
(A) 1.6×10^{-3} Ω (B) 2.1×10^{-3} Ω (C) 4.8×10^{-3} Ω (D) 8×10^{-3} Ω

97 The opposite graph shows the relation between the resistance of a wire (R) and its length (ℓ).
If the cross-sectional area of the wire is 0.1 cm², then:
the resistivity of the material of this wire (ρ_e) equals .....



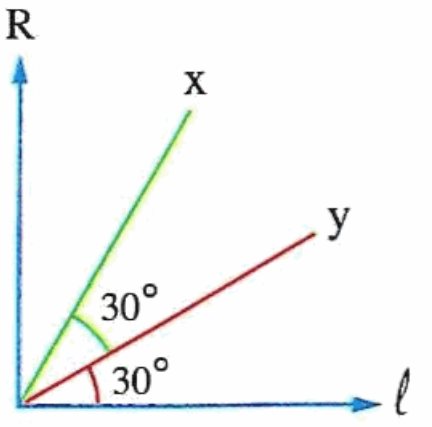
(A) 3×10^{-7} Ω.m (B) 5×10^{-6} Ω.m (C) 4×10^{-5} Ω.m (D) 9×10^{-8} Ω.m

98 The opposite graph shows the relation between the resistance of a wire (R) and its length (ℓ).
If the cross-sectional area of the wire is 0.1 cm², then:
the resistance of a 25 m long piece of the wire equals .....



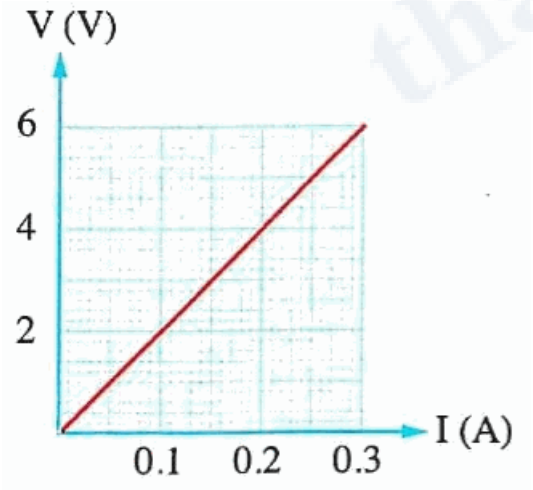
(A) 9.25 Ω (B) 11.3 Ω (C) 12.5 Ω (D) 15.9 Ω

99 The opposite graph shows the relation between the resistance (R) and the length (ℓ) for two groups of wires x, y made of copper. The ratio between the cross-sectional areas of the two groups of wires (A_x/A_y) is .....



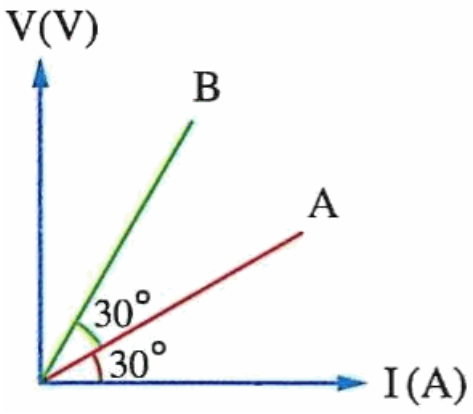
(A) 1/3 (B) 1/2 (C) 3/1 (D) (√(3))/1

100 The opposite graph shows the relation between the potential difference (V) across a wire 5 m long with a cross-sectional area of 0.1 mm² and the current (I) in it. The electrical conductivity of the material of this wire equals .....



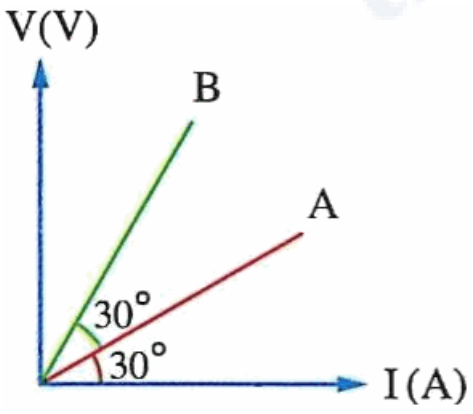
(A) $4.1 \times 10^6\ \Omega^{-1}.m^{-1}$ (B) $3.2 \times 10^5\ \Omega^{-1}.m^{-1}$
(C) $2.5 \times 10^6\ \Omega^{-1}.m^{-1}$ (D) $1.6 \times 10^5\ \Omega^{-1}.m^{-1}$

101 The opposite graph shows the relation between the potential difference (V) and the current (I) in two wires A, B of the same material:
if the two wires have the same length and the cross-sectional area of wire B is 3×10^{-6} m², then the cross-sectional area of wire A equals .....



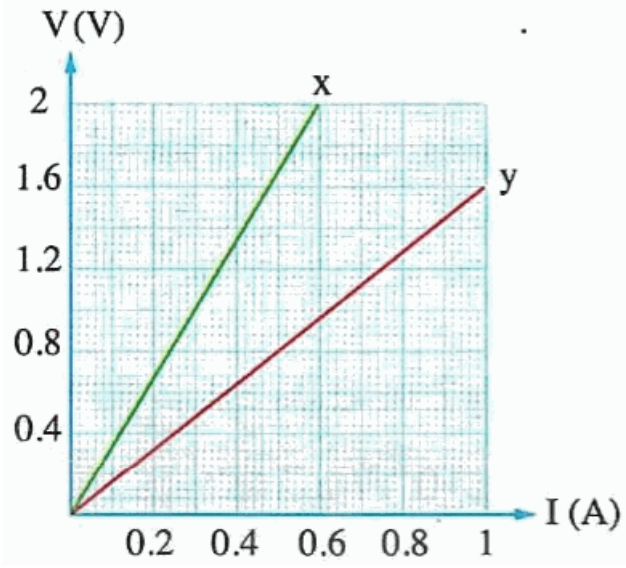
(A) 10^{-6} m² (B) 9×10^{-6} m² (C) 3×10^{-6} m² (D) 12×10^{-8} m²

102 The opposite graph shows the relation between the potential difference (V) and the current (I) in two wires A, B of the same material:
if the two wires have the same cross-sectional area and the length of wire B is 3 m, then the length of wire A equals .....



(A) 1 m (B) 2 m (C) 3 m (D) 9 m

103 The graph shown represents the relation between the potential difference (V) across two wires x, y of the same length and the current (I) in each of them at constant temperature. If the ratio between the cross-sectional areas of the two wires (A_x/A_y) is *12/25*, then the ratio between the resistivities of their materials $((\rho_e)_x/(\rho_e)_y)$ equals .....



(A) *2/1* (B) *1/1* (C) *1/4* (D) *1/7*

104 The opposite table shows different values of lengths, cross-sectional areas and resistivities of wires made of different materials:
which of these wires carries a current of 2 A when the potential difference across its ends is 10 V?

Resistivity $\rho_e \times 10^{-4}(\Omega.m)$	Cross-sectional area $A\ (cm^2)$	Wire length ℓ (m)	Wire
0.05	0.1	10	**(1)**
0.25	0.5	5	**(2)**
0.5	0.1	5	**(3)**
0.005	0.5	0.5	**(4)**

(A) Wire (1) (B) Wire (2) (C) Wire (3) (D) Wire (4)

105 The opposite table shows different values of lengths, cross-sectional areas and resistivities of wires made of different materials:
which of these wires gives a greater quantity of heat than the other wires when the same current passes through them for the same time?

Resistivity $\rho_e \times 10^{-4}(\Omega.m)$	Cross-sectional area $A\ (cm^2)$	Wire length $\ell\ (m)$	Wire
0.05	0.1	10	**(1)**
0.25	0.5	5	**(2)**
0.5	0.1	5	**(3)**
0.005	0.5	0.5	**(4)**

(A) Wire (1) (B) Wire (2) (C) Wire (3) (D) Wire (4)

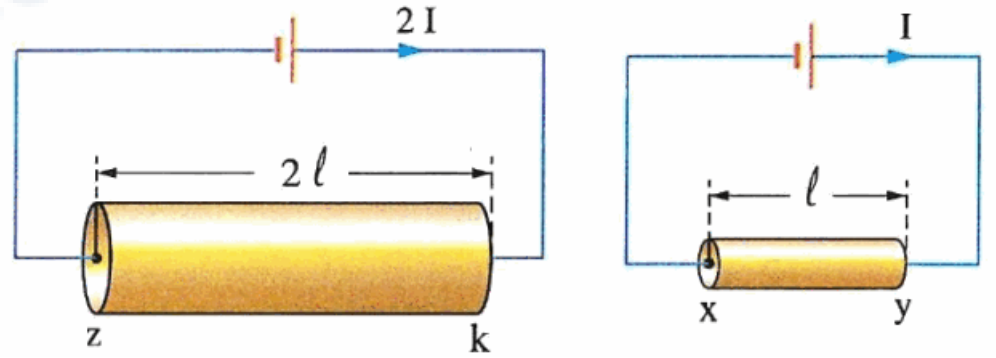
106 The opposite table shows different values of lengths, cross-sectional areas and resistivities of wires made of different materials:
which of these wires gives a smaller heat power than the other wires when each is connected to the same potential difference?

Resistivity $\rho_e \times 10^{-4}(\Omega.m)$	Cross-sectional area $A\ (cm^2)$	Wire length $\ell\ (m)$	Wire
0.05	0.1	10	**(1)**
0.25	0.5	5	**(2)**
0.5	0.1	5	**(3)**
0.005	0.5	0.5	**(4)**

(A) Wire (1) (B) Wire (2) (C) Wire (3) (D) Wire (4)

107 Two conductors xy, zk of uniform cross-section are made of the same metal. The length of xy = ℓ and the length of zk = 2ℓ, and each is connected in an electric circuit as in the two following figures.

If the electric power consumed in the two conductors is equal, then the ratio between their cross-sectional areas $((A_{xy})/(A_{zk}))$ equals .....



(A) $1/2$ (B) $1/4$ (C) $1/6$ (D) $1/8$

108 A wire of resistance R consumes an electric power P_w when the potential difference across its ends is V. If the wire is stretched uniformly so that its length doubles, and its ends are connected to the same potential difference V, the wire consumes an electric power of .....

(A) $2\ P_w$ (B) $4\ P_w$ (C) $P_w/2$ (D) $P_w/4$

109 A wire is 2 m long and its cross-sectional area is 4×10^{-6} m². If the potential difference across its ends is 20 V, the power consumed in it is 10 W, then:

the resistivity of its material equals .....

(A) 2×10^{-7} Ω.m (B) 10^{-5} Ω.m (C) 8×10^{-5} Ω.m (D) 4×10^{-6} Ω.m

110 A wire is 2 m long and its cross-sectional area is 4×10^{-6} m². If the potential difference across its ends is 20 V, the power consumed in it is 10 W, then:

the number of electrons passing through its cross-section in one minute equals ..... electrons.

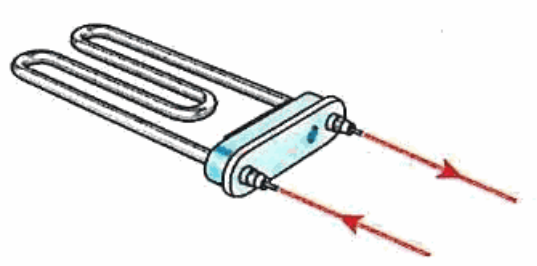
(A) 9.741×10^{17} (B) 6.435×10^{18} (C) 2.314×10^{19} (D) 1.875×10^{20}

Essay questions — 22 questions

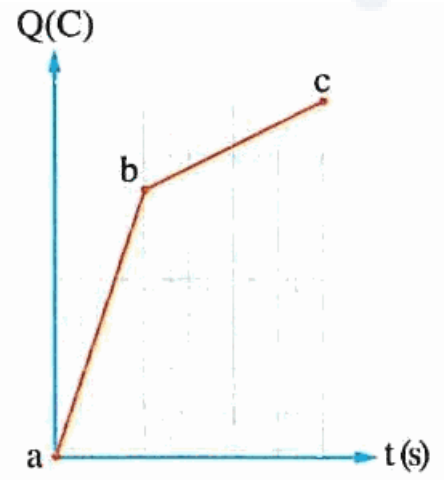
1 Explain why some solids conduct electric current, while others are electrical insulators.

2 An electric current of 3.2 mA passes through a wire. Calculate the rate of flow of electrons through a cross-section of the wire.

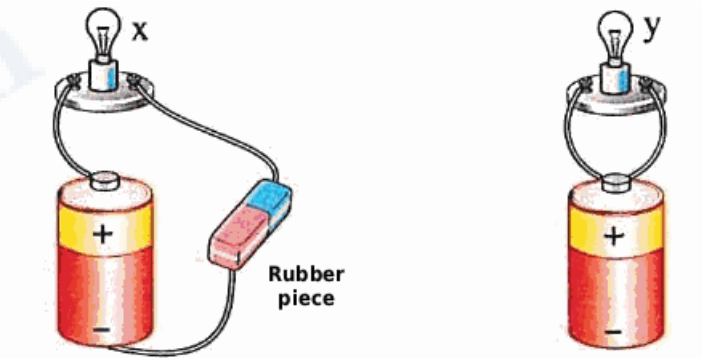
3 The opposite figure shows a heater wire carrying a direct current. Explain why the current at the two ends of the wire is equal, even though electrical energy is consumed in it.



4 The opposite graph shows the relation between the quantity of charge (Q) passing through a certain cross-section of a conductor and time (t). Find the ratio between the currents in the conductor during the two stages ab, bc respectively.



5 Explain why neither of the two lamps x, y lights up, even though each is connected to a dry cell as in the opposite figure.

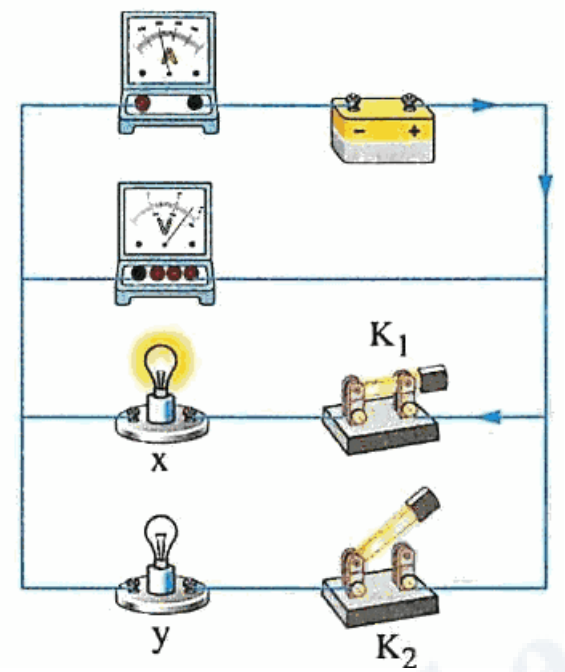


6 In the opposite figure, if the work done to move 10^{20} free electrons from point y to point x is 80 J, calculate the electric potential at point y.



7 An electric lamp whose filament has a resistance of $1.6\ \Omega$ is connected to a potential difference of 9 V. Calculate the number of electrons passing per minute through a cross-section of the lamp filament.

8 In the opposite circuit, a battery of negligible internal resistance is connected to two lamps x, y through two switches K_1, K_2 respectively, an ammeter and a voltmeter. If the resistance of lamp y is greater than the resistance of lamp x, explain what happens to the reading of each of the ammeter and the voltmeter when switch K_1 is opened and switch K_2 is closed.



9 Two metal wires: the first has a resistance R and 10^{20} electrons pass through its cross-section per second, and the second has a resistance 2R and 2×10^{20} electrons pass through its cross-section per second. Calculate the ratio between the power consumed in the first wire and the power consumed in the second wire.

10 The coil of an electric heater used to heat water is connected to a 220 V source of negligible internal resistance. What is the effect of removing the heater coil and using another coil of higher electric resistance on the rate of heating the water? Why?

11 In figures (1), (2), if the power consumed in the two resistors R_1, R_2 is equal, and the ratio between the readings of the two ammeters A_1/A_2 is $1/2$:

(1) Find the ratio between the readings of the two voltmeters V_1/V_2

(2) Explain why the readings of the two voltmeters V_1, V_2 and of the two ammeters A_1, A_2 cannot be used to verify Ohm's law.

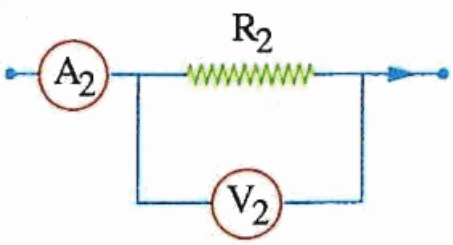


Figure (2)

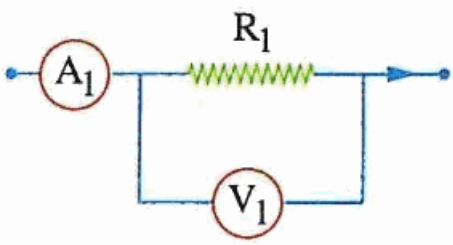
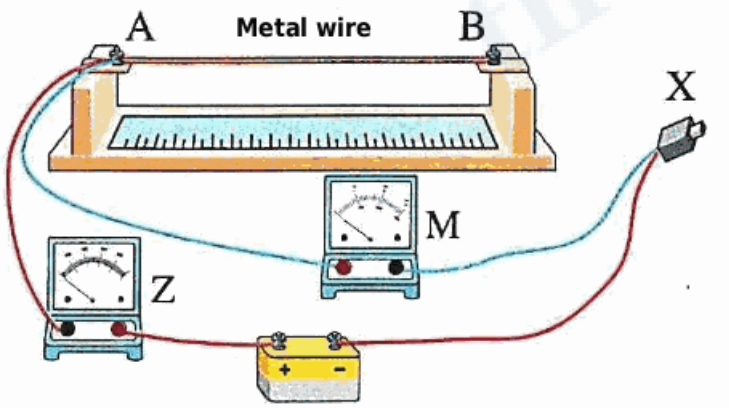


Figure (1)

12 A student used the tools shown in the figure to study how the resistance of a wire (AB) of uniform cross-section changes with its length:

(1) What is the role of end (X) in achieving the aim of the experiment?

(2) What is the purpose of using the two devices Z, M?



Battery of negligible internal resistance

13 How can you increase the electric resistance of a certain copper wire at a certain temperature?

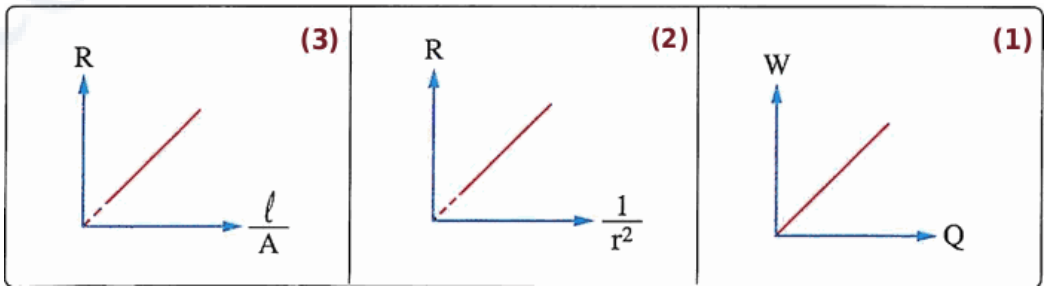
14 What physical quantity is measured by each of the following units:

(1) ampere.second? (2) volt.coulomb? (3) volt.ampere^{-1}?

(4) joule / ohm.coulomb? (5) volt.second.ohm^{-1}?

15 Write the mathematical relation represented by each graph and what the slope of the straight line represents in each of the following:

where: (Q) is the quantity of electric charge, (W) the work, (R) the resistance of the conductor, (ℓ) the length of the conductor, (A) the cross-sectional area of the conductor, (r) the radius of the conductor.



16 The opposite table gives the specifications of three metal conductors with the same cross-sectional area made of different materials (x, y, z). If σ stands for the electrical conductivity of the material:

x: length 2 m, resistance $1\ \Omega$

y: length 3 m, resistance $4\ \Omega$

z: length 3 m, resistance $6\ \Omega$

(1) Find the ratio $\sigma_x : \sigma_y : \sigma_z$

(2) Which of these materials is preferred for making electrical connecting wires? Explain your answer.

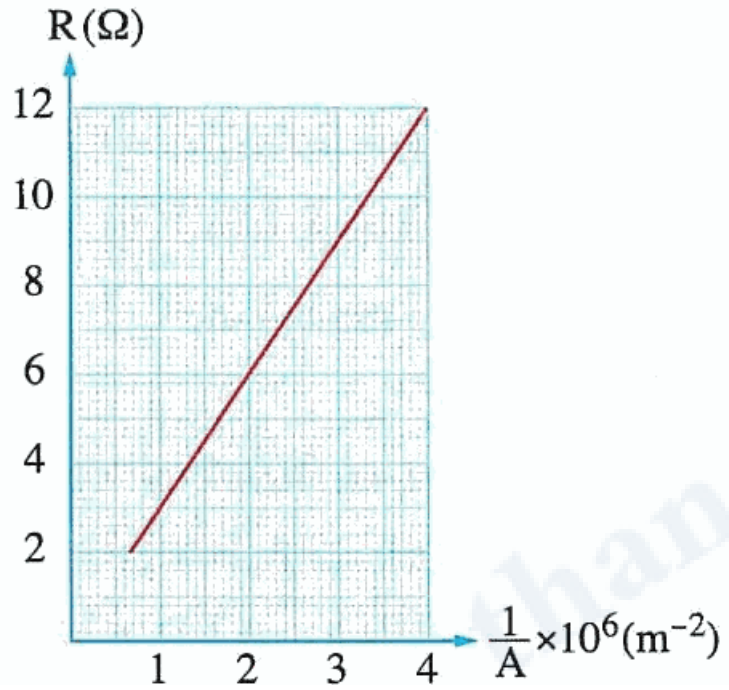
17 A solid cube of side 10 cm made of a conducting material of resistivity $10^{-7}\ \Omega\ m$ is reshaped into a cylindrical wire of resistance $20\ \Omega$. Calculate the length of the wire.

18 A wire is 2 m long and its resistance is $2\ \Omega$. If the density of the wire's material is $7000\ kg/m^3$ and its resistivity is $10^{-6}\ \Omega\ m$, calculate the mass of the wire.

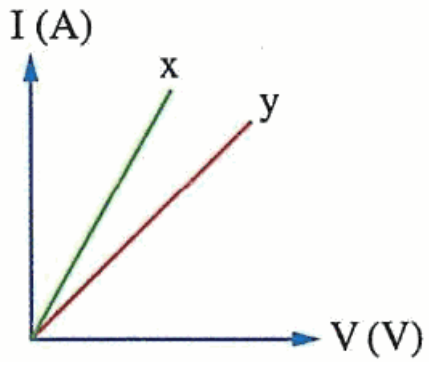
19 A group of wires made of the same material, each 12 m long. The opposite graph shows the relation between the resistance (R) of each wire and the reciprocal of its cross-sectional area $1/A$. Find:

(1) the electric resistance of a wire of the same material and the same length with a cross-sectional area of $0.0025\ cm^2$

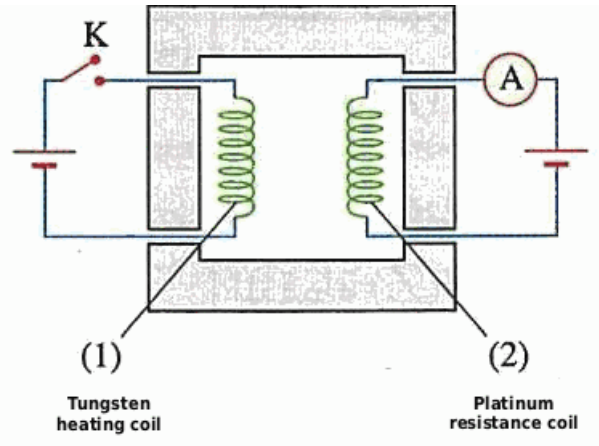
(2) the electrical conductivity of the material of the wires.



20 The opposite graph shows the relation between the current (I) in two wires x, y of uniform cross-section, made of the same material and of the same length, and the potential difference (V) across each of them. Which wire is thicker? Why?



21 The opposite figure shows a closed insulated space containing two coils. After closing switch K connected to coil (1) for a while, the reading of ammeter (A) connected to coil (2) was seen to decrease. How do you explain that?



22 Electric lamp A has a power of 80 W and works on a potential difference of 220 V, and electric lamp B has a power of 20 W and works on a potential difference of 24 V. If the filaments of the two lamps are made of the same material and have the same length, calculate the ratio between the radii of the two filaments r_A/r_B

Past exam questions — 25 questions

1 The electric current through a metal conductor connected to the terminals of a voltage source results from the flow of ..... (2nd session 2025)

(A) free electrons from the end of lower electric potential to the end of higher potential

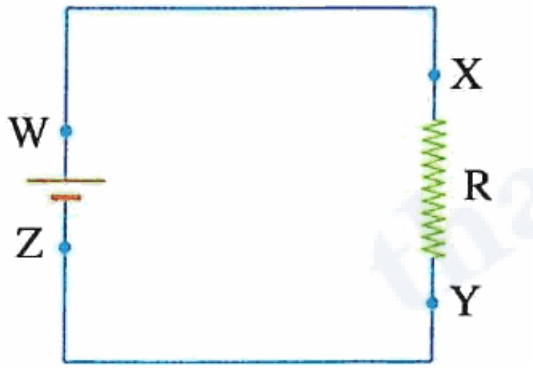
(B) free electrons from the end of higher electric potential to the end of lower potential

(C) positive ions from the end of lower electric potential to the end of higher potential

(D) positive ions from the end of higher electric potential to the end of lower potential

---

2 A simple electric circuit consists of a battery and an ohmic resistor as shown in the figure. Which of the following choices correctly describes the relation between the electric potentials of the points shown (W), (X), (Y), (Z)? (Sample exam 2026)



(A) The potential of W is greater than that of Z, and the potential of X is less than that of Y

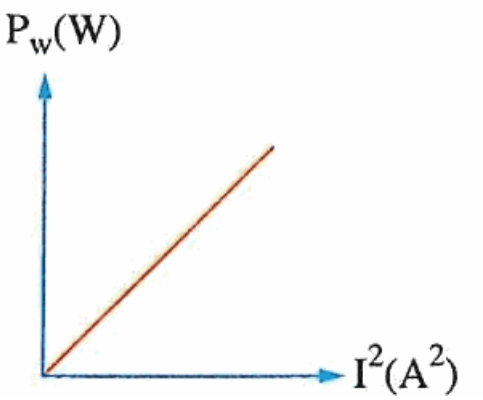
(B) The potential of W is less than that of Z, and the potential of X is greater than that of Y

(C) The potential of W is greater than that of Z, and the potential of X is greater than that of Y

(D) The potential of W is less than that of Z, and the potential of X is less than that of Y

---

3 The opposite graph shows the relation between the power consumed (P_w) in a conductor and the square of the current (I^2) in this conductor. The slope of the line representing the relation equals ..... (Sample exam 2025)



(A) the resistance of the conductor

(B) the reciprocal of the resistance of the conductor

(C) the potential difference across the conductor

(D) the square of the potential difference across the conductor

---

4 An electric lamp labelled (80 W, 100 V) means that ..... (Sample exam 2025)

(A) the electric resistance of the lamp is $0.8\ \Omega$

(B) the electric resistance of the lamp is $1.25\ \Omega$

(C) when the potential difference across the lamp is 100 V, a current of 0.8 A passes through it

(D) when the potential difference across the lamp is 100 V, a current of 1.25 A passes through it

---

5 If the work done to move a charge of 2 C inside and outside the source is 12 J, this means that ..... (1st session 2025)

(A) the opposition of the source to the current is $6\ \Omega$

(B) the current through the source is 6 A

(C) the electric power produced by the source is 6 W

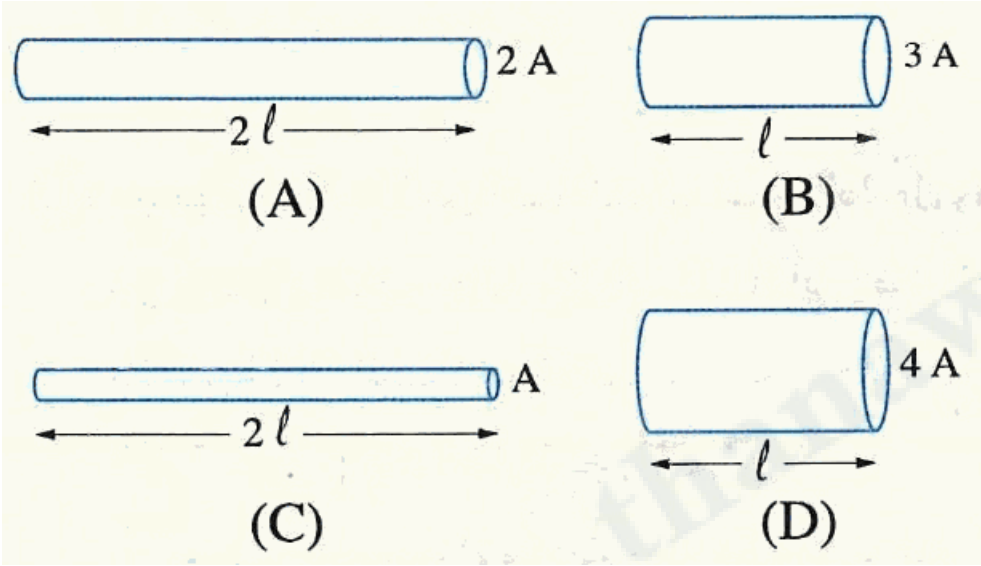
(D) the emf of the source is 6 V

---

6 You have two copper wires of the same length. If the cross-sectional area of the second wire is three times that of the first, then the ratio between the resistance of the first wire and the resistance of the second wire R_1/R_2 equals ..... (Trial exam / May 2021)

(A) *3/1* (B) *1/3* (C) *1/6* (D) *6/1*

7 In front of you are four conductors of uniform cross-section made of the same material with different dimensions. The order of these conductors in ascending order of their electric resistances is ..... (Trial exam / May 2021)



(A) B then C then A then D
(B) D then A then C then B
(C) C then A then B then D
(D) D then B then A then C

8 A conductor of length ℓ and cross-sectional area 3A has a potential difference V applied across its ends, so a current I passes through it. If another conductor of the same material is connected to the same potential difference V, the current in it becomes 3I. The length and cross-sectional area of the second conductor are ..... (Trial exam / June 2021)

(A) length 2ℓ, area 18A
(B) length 3ℓ, area 3A
(C) length 18ℓ, area 2A
(D) length *1/3*ℓ, area *1/3*A

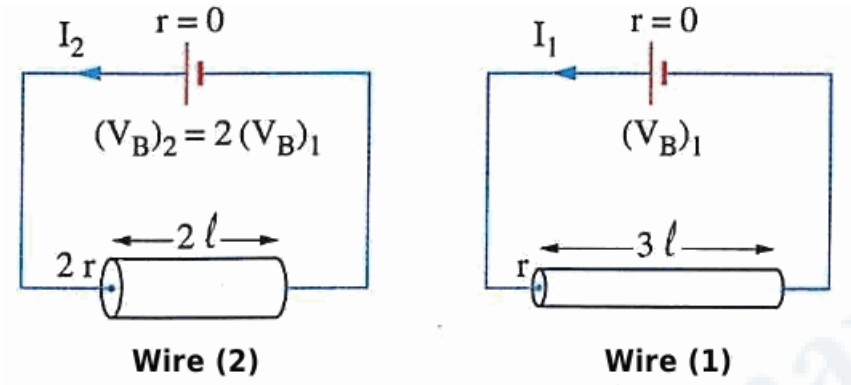
9 Two wires of the same material: the diameter of the first wire is three times the diameter of the second, and the resistance of the second wire is four times the resistance of the first. The length of the second wire is ..... the length of the first wire. (1st session 2021)

(A) *4/3* (B) *4/9* (C) *36/1* (D) *12/1*

10 A current I passes through a conductor of length ℓ and cross-sectional area A. When the battery used is changed, the current in the same conductor becomes 3I. The cross-sectional area of the conductor in this case is ..... (2nd session 2021)

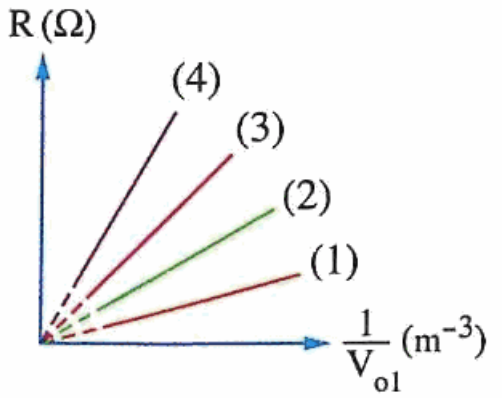
(A) A (B) 3A (C) *1/3* A (D) 6A

11 Two wires (1) and (2) are made of the same material. Wire (1) has a length 3ℓ and a radius (r), while wire (2) has a length 2ℓ and a radius (2r), as shown in the figure. The ratio I_1/I_2 = ... (1st session 2022)



(A) *12/1* (B) *1/12* (C) *3/2* (D) *1/6*

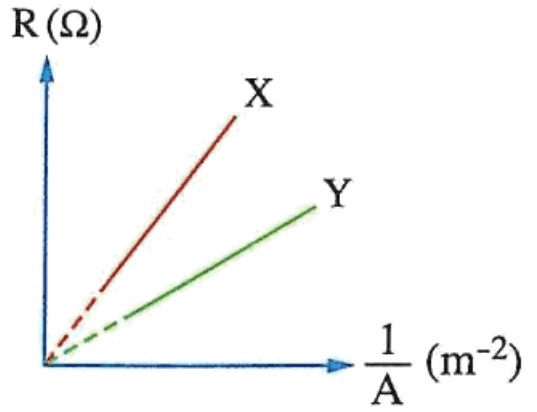
12 The opposite graph shows the relation between the electric resistance (R) of several groups of wires of equal length, each group made of a different material, and the reciprocal of the wire's volume $1/(V_{ol})$ in each group. The order of the electrical conductivity (σ) of the materials of the groups of wires is ..... (2nd session 2022)



(A) $\sigma_4 > \sigma_1 > \sigma_3 > \sigma_2$ (B) $\sigma_1 > \sigma_3 > \sigma_2 > \sigma_4$

(C) $\sigma_1 > \sigma_2 > \sigma_3 > \sigma_4$ (D) $\sigma_4 > \sigma_3 > \sigma_2 > \sigma_1$

13 Two groups X, Y of wires have the same length, and each group is made of a different metal. The opposite graph shows the relation between the electric resistance (R) of the wire and the reciprocal of its cross-sectional area $1/A$. Which of the following choices is correct when comparing the two metals? (Trial exam 2023)



(A) The metal of group X has a greater resistivity

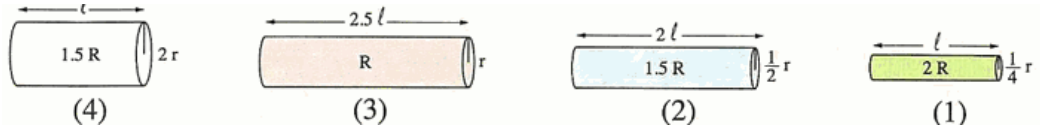
(B) The metal of group Y has a greater resistivity

(C) The metal of group X has a greater electrical conductivity

(D) The electrical conductivities of the two metals are equal

---

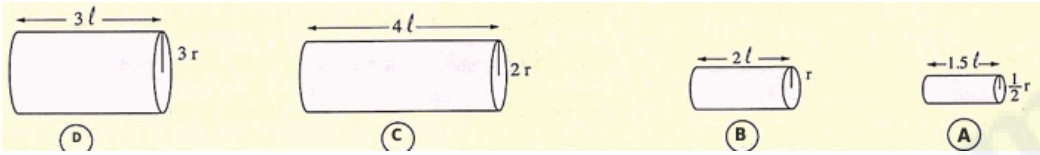
14 You have four wires (1), (2), (3), (4) made of different materials as shown in the following figures. Which of these wires has the material with the highest electrical conductivity at the same temperature? (1st session 2023)



(A) Wire (1) (B) Wire (2) (C) Wire (3) (D) Wire (4)

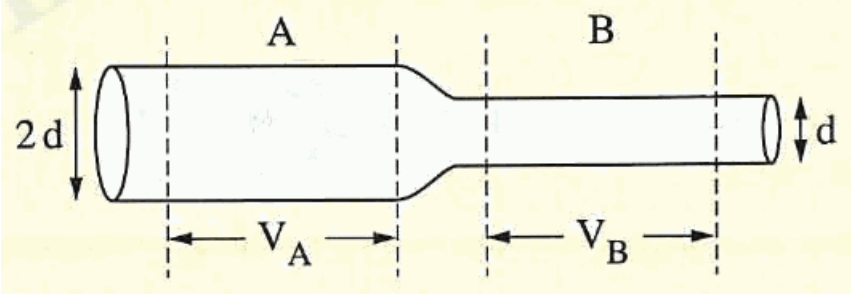
---

15 You have four aluminium wires as in the following figures. Which of these wires has the smallest electric resistance? (2nd session 2023)



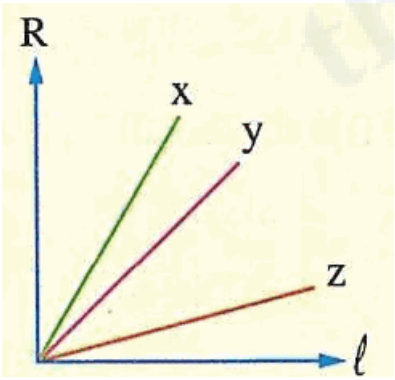
---

16 The figure shows a metal conductor with two parts A, B of uniform cross-section, equal in length and different in cross-sectional area, with electric resistances R_A, R_B respectively. If the conductor is connected across a battery in a closed circuit, the ratio V_A/V_B = ... (1st session 2024)



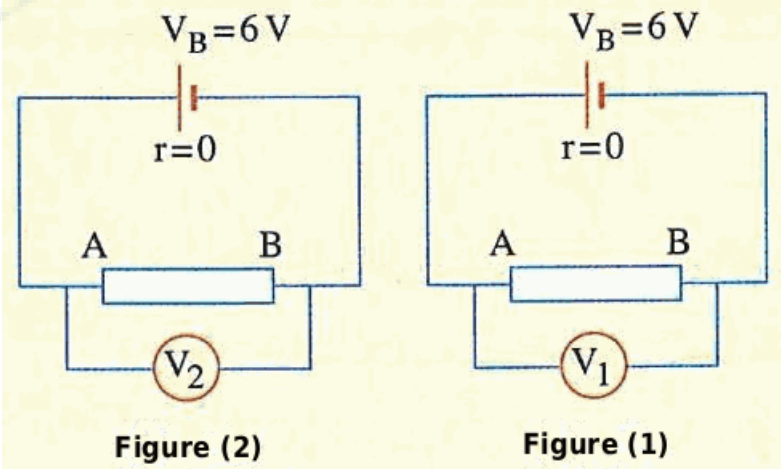
(A) R_B/R_A (B) R_A/R_B (C) $2R_A/R_B$ (D) $4R_A/R_B$

17 Wires of different lengths made of three different materials x, y, z have the same cross-sectional area and are at the same temperature. The opposite graph shows the relation between the electric resistance (R) of the wires and the length (ℓ) of each. If σ_x, σ_y, σ_z represent the electrical conductivities of the wires' materials, which of the following choices is correct? (1st session 2024)



(A) $\sigma_z = \sigma_y = \sigma_x$ (B) $\sigma_z < \sigma_y < \sigma_x$ (C) $\sigma_z > \sigma_y > \sigma_x$ (D) $\sigma_z > \sigma_x > \sigma_y$

18 Figure (1) shows an electric circuit containing a conductor AB at temperature T_1, and the voltmeter reading was V_1. If the temperature of conductor AB is raised to T_2 and then kept constant, the voltmeter reading becomes V_2 as in figure (2). Which of the following choices is correct? (2nd session 2024)



(A) The voltmeter reading V_2 = zero

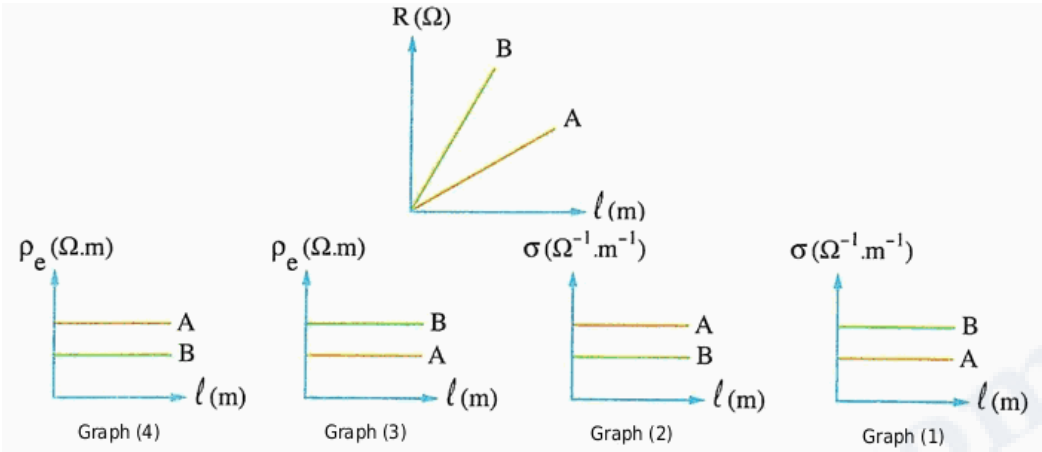
(B) The voltmeter reading V_1 = the voltmeter reading V_2

(C) The voltmeter reading V_1 is less than the voltmeter reading V_2

(D) The voltmeter reading V_1 is greater than the voltmeter reading V_2

---

19 Two groups (A), (B) of wires have the same cross-sectional area, are at the same temperature and are made of two different materials. The opposite graph shows the relation between the electric resistance (R) of each of these wires and its length (ℓ). Which of the following graphs are correct? (2nd session 2024)



(A) Graph (1) and graph (3)

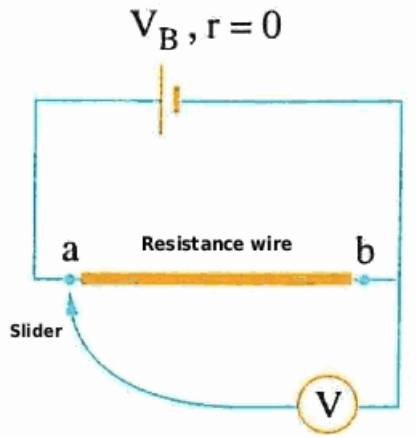
(B) Graph (2) and graph (4)

(C) Graph (1) and graph (4)

(D) Graph (2) and graph (3)

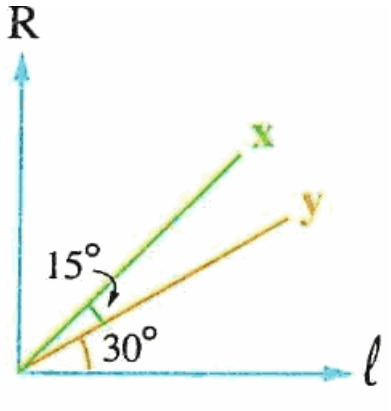
---

20 A battery of emf V_B and negligible internal resistance is connected to a resistance wire ab of uniform cross-section that is not insulated, a voltmeter and a slider as in the opposite figure. While the slider is moved from point a to point b, the voltmeter reading ..... (Sample exam 2025)



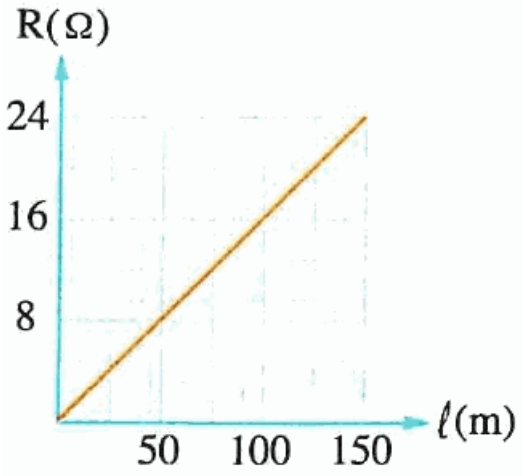
(A) increases
(B) decreases but does not reach zero
(C) does not change
(D) decreases until it becomes zero

21 Two long copper wires x, y differ in thickness, and the length taken from each can be changed. The opposite graph shows the relation between the resistance (R) and the length (ℓ) taken from each wire. The ratio between the cross-sectional areas of the two wires A_x/A_y is ..... (Sample exam 2025)



(A) *1/3*
(B) *3/1*
(C) *1/(√(3))*
(D) *(√(3))/1*

22 The opposite graph shows the relation between the electric resistance (R) of a group of wires of the same material, each with a cross-sectional area of $0.1\ cm^2$, and the length (ℓ) of each of these wires. The resistivity of the material of these wires (ρ_e) equals ..... (Sample exam 2025)



(A) $2.4 \times 10^{-7}\ \Omega\ m$ (B) $3.6 \times 10^{-7}\ \Omega\ m$ (C) $1.2 \times 10^{-6}\ \Omega\ m$ (D) $1.6 \times 10^{-6}\ \Omega\ m$

23 Which of the following changes increases the electric resistance of a metal wire? (1st session 2025)

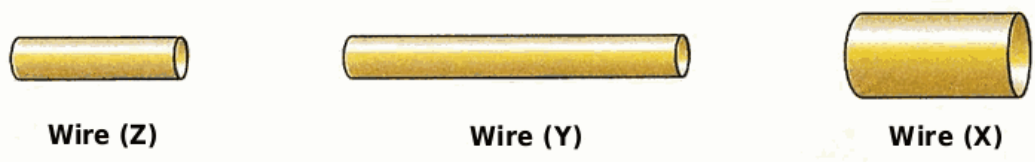
(A) Decreasing the cross-sectional area of the wire

(B) Lowering the temperature of the wire

(C) Decreasing the length of the wire

(D) Covering the wire with an insulating layer

24 In the following figure, three wires (X, Y, Z) of the same metal have lengths $(\ell, 2\ell, \ell)$ and cross-sectional areas (2A, A, A) respectively. If the resistance of wire (X) is R, then the resistances of wires (Y), (Z) are ..... (2nd session 2025)



(A) resistance of Y = 2R, resistance of Z = 4R

(B) resistance of Y = 8R, resistance of Z = 4R

(C) resistance of Y = R, resistance of Z = 2R

(D) resistance of Y = 4R, resistance of Z = 2R

25 An electric conductor 1 m long with a cross-sectional area of $2\ mm^2$ carries a current of 2 A when the potential difference across its ends is 6 V. This means that ..... (Sample exam 2026)

(A) the electric power consumed by the conductor is 3 W

(B) the resistivity of the conductor's material is $6 \times 10^6\ \Omega\ m$

(C) the electrical conductivity of the conductor's material is $1.667 \times 10^5\ \Omega^{-1}\ m^{-1}$

(D) the electric resistance of the conductor is $12\ \Omega$

Answer key and solutions

Multiple choice questions

1 A	2 C	3 D	4 A	5 D	6 C	7 B	8 A	9 A	10 D
11 B	12 B	13 D	14 D	15 D	16 D	17 C	18 D	19 B	20 D
21 B	22 C	23 D	24 B	25 A	26 C	27 C	28 B	29 A	30 A
31 C	32 C	33 C	34 D	35 D	36 D	37 D	38 B	39 A	40 D
41 D	42 D	43 B	44 C	45 C	46 C	47 D	48 B	49 B	50 B
51 A	52 B	53 A	54 B	55 D	56 C	57 C	58 D	59 A	60 C
61 C	62 D	63 B	64 C	65 B	66 B	67 D	68 A	69 D	70 A
71 D	72 D	73 A	74 C	75 C	76 A	77 B	78 D	79 B	80 A
81 C	82 B	83 C	84 B	85 C	86 C	87 B	88 A	89 A	90 B
91 B	92 D	93 D	94 C	95 D	96 B	97 B	98 C	99 A	100 C
101 B	102 A	103 B	104 A	105 C	106 C	107 D	108 D	109 C	110 D

1 **Answer (A)**

The conventional current leaves the positive terminal of the battery, enters the device at its positive end and leaves at its negative end.

2 **Answer (C)**

The two ammeters are in series, so the current is the same at all points of the circuit.

3 **Answer (D)**

$Q = It = 2 \times 10 = 20\ C$

4 **Answer (A)**

$t = Q/I = (4 \times 10^{-3})/2$

$= 2 \times 10^{-3}\ s = 2\ ms$

5 **Answer (D)**

$I = Q/t = (2 \times 10^{-6})/(4 \times 10^{-3}) = 0.5\ mA$

The charge is negative (electrons) moving from x to y, so the conventional current is from y to x.

6 **Answer (C)**

$I_x/I_y = (10^{20})/(2 \times 10^{20}) = 1/2$

7 **Answer (B)**

The slope of the line equals the current:

$I = 30/3 = 10\ A$

8 **Answer (A)**

The slope of (Q–t) equals the current, and the slope of x is greater than the slope of y.

9 **Answer (A)**

The number of electrons increases uniformly with time, so the current is constant (a horizontal line).

10 **Answer (D)**

$Q = It = 5 \times 10 = 50\ C$

11 **Answer (B)**

$I = Qf = 2 \times 10^{-6} \times 1000$

$= 2\ mA$

12 **Answer (B)**

The frequency is the same, x carries Q and y carries 2Q:

$I_x/I_y = Qf/2Qf = 1/2$

13 **Answer (D)**

The linear speed is the same:

$I = Qv/(2\pi r)$

$I_x/I_y = (Q/2r)/(2Q/r) = 1/4$

14 **Answer (D)**

$I = ev/(2\pi r)$

$= (1.6 \times 10^{-19} \times 2.2 \times 10^{6})/(2\pi \times 0.53 \times 10^{-10})$

$\approx 1.057\ mA$

15 **Answer (D)**

The battery is a source of electrical energy.

16 **Answer (D)**

Outside the source, free electrons move towards the terminal of higher (positive) potential.

17 **Answer (C)**

Electrons move from the lower potential to the higher potential, so the correct arrow points towards the higher potential.

18 **Answer (D)**

$W = Q\,\Delta V = 4 \times (15-(-5))$

$= 80\ J$

19 **Answer (B)**

$V = W/Q = 30/10 = 3\ V$

20 **Answer (D)**

$V = W/Q = 100/5 = 20\ V$

21 **Answer (B)**

$I = Q/t = 5/1 = 5\ A$

22 **Answer (C)**

$Q = It = 5 \times 2 = 10\ C$

$n = Q/e = 10/(1.6 \times 10^{-19})$

$= 6.25 \times 10^{19}$

23 **Answer (D)**

Calculate the charge in each choice: (A) 250 C, (B) 25 C, (C) 10 C, (D) 1 C.

24 **Answer (B)**

$V_A/V_B = W_A/W_B times n_B/n_A = 10/20 \times 4/1$

$= 2$

25 **Answer (A)**

The current and the resistance are constant, so the voltage is constant (a horizontal line).

26 **Answer (C)**

$W = VQ$

The voltage is constant, so the relation is direct (a straight line through the origin).

27 **Answer (C)**

Calculate the current in the four cases (A, B, C, D) respectively:

$I = V/R$

$1\ ,\ 0.67\ ,\ 1.5\ ,\ 1.33\ (times V/R)$

The greatest is (C).

28 **Answer (B)**

The ammeter is in series with the resistor (x), and the voltmeter is in parallel with it (y).

29 **Answer (A)**

x is an ammeter: the unit of current is coulomb/second, and y is a voltmeter: its unit is the volt.

30 **Answer (A)**

$I = ne/t$

$= (6.25 \times 10^{18} \times 1.6 \times 10^{-19})/2$

$= 0.5\ A$

$R = V/I = 12/0.5 = 24\ \Omega$

31 **Answer (C)**

$I_1 = 20/5 = 4\ A$

$I_2 = (5-(-20))/10 = 2.5\ A$

$I_1/I_2 = 8/5$

32 **Answer (C)**

The resistance does not change with the current at constant temperature, so it is 10 Ω.

33 **Answer (C)**

$I_1 = (5-(-7))/1.5R = 8/R$

$I_2 = 3I_1 = 24/R = (22-V_X)/R$

$V_X = -2\ V$

34 **Answer (D)**

The current doubles by doubling the emf (I) or by halving the resistance (IV).

35 **Answer (D)**

Resistance is a property of the conductor; it does not change with the voltage at constant temperature.

36 **Answer (D)**

The slope of (I–V) equals the reciprocal of the resistance, so the steeper one (A) has a smaller resistance, and B has the greater resistance.

37 **Answer (D)**

The slope of x is three times the slope of y, and at the same voltage:

$R_x/R_y = I_y/I_x = 1/3$

38 **Answer (B)**

The slope of figure (1) is the potential difference:

$V = W/Q = 200/20 = 10\ V$

and the slope of figure (2) is the current:

$I = Q/t = 20/4 = 5\ A$

$R = V/I = 10/5 = 2\ \Omega$

39 **Answer (A)**

The voltage is constant, so the relation is inverse:

$I = V/R_V$

40 **Answer (D)**

The source has no internal resistance, so the voltmeter reading is constant and is not affected by changing the resistance.

41 **Answer (D)**

The voltmeter reading is constant whatever the ammeter reading.

42 **Answer (D)**

Three units express power:

J/s , $A\cdot V$, $A^2\cdot\Omega$

but $\Omega^2\cdot V$ is not a unit of power.

43 **Answer (B)**

$P=(V^2)/R=(10^2)/5=20\ W$

44 **Answer (C)**

$P=(V^2)/R=20\ W$

$E=Pt=20\times 20=400\ J$

45 **Answer (C)**

Calculate the power in the four cases (A, B, C, D) respectively:

$P=(V^2)/R$

1 , 0.5 , 4 , 2 $(\times(V^2)/R)$

The greatest is (C).

46 **Answer (C)**

$P_2/P_1=((2I)^2\times 2R)/(I^2R)=8$

47 **Answer (D)**

$P_z=10\times 3=30\ W$

$V_y=IR=15\ V$

$\Rightarrow P_y=15\times 1=15\ W$

$I_x=20/5=4\ A$

$\Rightarrow P_x=20\times 4=80\ W$

48 **Answer (B)**

At the same voltage:

$R=(V^2)/P$

A greater power means a smaller resistance, so the heater has the smaller resistance.

49 **Answer (B)**

$P=(V^2)/R$

Doubling the resistance halves the power.

50 **Answer (B)**

The resistance equals the slope of the line:

$R = 30/6 = 5\ \Omega$

51 **Answer (A)**

The current and the voltage are constant, so the power is constant (a horizontal line).

52 **Answer (B)**

$W = Pt$

A direct relation (a straight line through the origin).

53 **Answer (A)**

The voltage is constant, so the relation is inverse:

$P = (V^2)/R_V$

54 **Answer (B)**

$R = rhoL/A = (10^{-7} \times 20)/(0.5 \times 10^{-4})$

$= 0.04\ \Omega$

55 **Answer (D)**

$R = rhoL/(\pi\ r^2)$

$= (10^{-7} \times 3.14)/(3.14 \times (0.5 \times 10^{-3})^2)$

$= 0.4\ \Omega$

$I = V/R = 5/0.4 = 12.5\ A$

56 **Answer (C)**

$I = ne/t$

$= 2 \times 10^{19} \times 1.6 \times 10^{-19}$

$= 3.2\ A$

$R = 64/3.2 = 20\ \Omega$

$A = (\rho\ L)/R = (3.14 \times 10^{-7} \times 200)/20$

$= 3.14 \times 10^{-6}\ m^2$

$r = \sqrt{(A/(\pi))} = 10^{-3}\ m$

57 **Answer (C)**

$(R')/R = 2/(1/2) = 4$

58 **Answer (D)**

Resistivity is a property of the material and does not change with the dimensions.

59 **Answer (A)**

A higher temperature increases the vibration of the atoms, so collisions increase, and the hottest wire is x (3t).

60 **Answer (C)**

The hottest wire has the greatest resistance and the smallest current, so the greatest current is in the coolest wire z (t).

61 **Answer (C)**

Moving the slider towards b decreases the length of the part carrying the current, so the resistance decreases and the current increases.

62 **Answer (D)**

$R \propto 1/A$

An inverse relation.

63 **Answer (B)**

The higher curve has the greater resistivity, and conductivity is its reciprocal:

$\rho_x > \rho_y \Rightarrow \sigma_x < \sigma_y$

64 **Answer (C)**

The area is between A and 2A, so the resistance is between the two limits:

$(\rho\ l)/2A < R < (\rho\ l)/A$

65 **Answer (B)**

Resistivity is the resistance of a conductor 1 m long with a cross-sectional area of 1 m^2.

66 **Answer (B)**

$R = rhoL/A = (1.8 \times 10^{-8} \times 10)/(10 \times 10^{-6})$

$= 0.018\ \Omega$

67 **Answer (D)**

The resistance and the length are equal:

$(\rho_{Fe})/(A_{Fe}) = (\rho_{Cu})/(A_{Cu})$

$(r_{Fe})/(r_{Cu}) = \sqrt{((\rho_{Fe})/(\rho_{Cu}))}$

68 **Answer (A)**

$\rho = 1/(\sigma)$

An inverse relation.

69 **Answer (D)**

Conductivity is a property of the material; it does not change with the area (a horizontal line).

70 **Answer (A)**

$\rho = RA/L = (1 \times 10^{-6})/1.063$

$= 9.41 \times 10^{-7}\ \Omega cdotm$

71 **Answer (D)**

$\sigma = 1/(\rho) = 1.06 \times 10^{6}\ \Omega^{-1}m^{-1}$

72 **Answer (D)**

$R = L/(\sigma A)$

Its values in cases (A, B, C, D) respectively:

$1\ ,\ 0.5\ ,\ 1\ ,\ 4\ (\times (\ell)/(\sigma A))$

73 **Answer (A)**

The voltage drop across the two wires:

$\Delta V = 240\text{-}220 = 20\ V$

$\Rightarrow R = 20/80 = 0.25\ \Omega$

Each wire has 0.125 Ω over a length of 2500 m:

$0.125/2500 = 5 \times 10^{-5}\ \Omega/m$

74 **Answer (C)**

$A = (\rho\ L)/R$

$= (1.57 \times 10^{-8} \times 2500)/0.125$

$= 3.14 \times 10^{-4}\ m^2$

$r = \sqrt{(A/(\pi))} = 0.01\ m$

75 **Answer (C)**

The greatest ammeter reading means the smallest resistance: the short thick wire.

76 **Answer (A)**

$R' = 3/4R \Rightarrow L' = 3/4\ell$

$x = \ell\text{-}3/4\ell = 1/4\ell$

77 **Answer (B)**

$R_a = 0.5$, $R_b = 1$, $R_c = 2$,

$R_d = 1\ (\times (\rho \ell)/A)$

The current is the reciprocal of the resistance: a > b = d > c

78 **Answer (D)**

L/A: x, $y = 0.5\ z$, $k = 2$

and k is the hottest, so its resistance is the greatest.

79 **Answer (B)**

With K1 only (part yz):

$R_{yz} = V/4$

and with K2 only (the whole wire):

$R_{xz} = V/1$

$R_{xy} = V\text{-}V/4 = 3V/4$

$\Rightarrow (\ell_{xy})/(\ell_{yz}) = 3$

80 **Answer (A)**

The area and the material are the same, so the resistance is proportional to the length:

$R_x{:}R_y{:}R_z = 2{:}4{:}1$

81 **Answer (C)**

The length and the material are the same (the radius of the coil has no effect):

$R_x/R_y = (r_y/r_x)^2$

82 **Answer (B)**

$R_2/R_1 = L_2/L_1 \times (r_1^2)/(r_2^2) = 2 \times 4 = 8$

83 **Answer (C)**

$R_2 = 108 \times 5/20 \times 1/3 = 9\ \Omega$

84 **Answer (B)**

The volume is constant:

$L' = 4/3L$

$R' = 22.5 \times 4/3 \times 2/1.5 = 40\ \Omega$

85 **Answer (C)**

The volume is constant:

$R \propto L^2 = 2^2 = 4$

so it becomes 4 times.

86 **Answer (C)**

$A' = 0.64A$, $L' = L/0.64$

$R' = R/(0.64^2) = 2.44R$

that is, an increase of 144%.

87 **Answer (B)**

The volume is constant:

$R \propto 1/(d^4) \Rightarrow R' = x^4 R$

88 **Answer (A)**

The slope decreased, so the resistance increased, and the volume is constant:

$R \propto L^2$

so doubling the length makes the resistance 4 times.

89 **Answer (A)**

Calculate length ÷ area for each path:

$(1): (3\ell)/(2\ell \times \ell) = 1.5/(\ell)$

$(2): (2\ell)/(3\ell \times \ell) = 0.67/(\ell)$

$(3): (\ell)/(3\ell \times 2\ell) = 0.17/(\ell)$

90 **Answer (B)**

The volume is the same, so the length = volume ÷ area:

$R \propto 1/(A^2)$

$I_1/I_2 = R_2/R_1 = (A_1/A_2)^2$

91 **Answer (B)**

$L = Vol/A = (2 \times 10^{-4})/(4 \times 10^{-5}) = 5\ m$

$\sigma = L/RA = 5/(1.25 \times 4 \times 10^{-5})$

$= 10^5\ \Omega^{-1} m^{-1}$

92 **Answer (D)**

$R = (\ell)/(\sigma \ell^2) \Rightarrow \sigma = 1/(R\ell)$

93 **Answer (D)**

The material is the same, so the resistance is proportional to the square of the length ÷ the mass:

$R \propto (L^2)/m$

$R_1/R_2 = (10^2/0.1)/(40^2/0.2) = 1/8$

94 **Answer (C)**

$R \propto (L^2)/m$

$\Rightarrow R_x/R_y = (\ell^2/5)/((\ell/2)^2/10) = 8$

95 **Answer (D)**

$A = (\pi r^2)/2 = (3.14 \times (10^{-3})^2)/2$

$= 1.57 \times 10^{-6}\ m^2$

$R = rhoL/A = (10^{-6} \times 3.14)/(1.57 \times 10^{-6})$

$= 2\ \Omega$

96 **Answer (B)**

$A = \pi(r_2^2 - r_1^2)$

$= 3\pi \times 10^{-6}\ m^2$

$R = (\rho\ L)/A = (2 \times 10^{-8} \times 1)/(3\pi \times 10^{-6})$

$\approx 2.1 \times 10^{-3}\ \Omega$

97 **Answer (B)**

The slope of the line equals ρ ÷ A:

$(\rho)/A = 15/30 = 0.5$

$\rho = 0.5 \times 0.1 \times 10^{-4}$

$= 5 \times 10^{-6}\ \Omega cdotm$

98 **Answer (C)**

$R = 15/30 \times 25 = 12.5\ \Omega$

99 **Answer (A)**

The slope equals the tangent of the angle with the length axis:

$tan60^\circ = \sqrt{(3)}\ (x)$,

$tan30^\circ = 1/(\sqrt{(3)})\ (y)$

$A_x/A_y = (1/\sqrt{(3)})/(\sqrt{(3)}) = 1/3$

100 **Answer (C)**

$R = V/I = 6/0.3 = 20\ \Omega$

$\sigma = L/RA = 5/(20 \times 0.1 \times 10^{-6})$

$= 2.5 \times 10^{6}\ \Omega^{-1}m^{-1}$

101 **Answer (B)**

The slope of (V–I) equals the resistance:

$R_B/R_A = fractan60°tan30° = 3$

$A_A = 3A_B = 9 \times 10^{-6}\ m^2$

102 **Answer (A)**

$R_B/R_A = 3 \Rightarrow L_A = L_B/3 = 1\ m$

103 **Answer (B)**

$R_x = 2/0.6\ ,\ R_y = 1.6/1$

$\Rightarrow R_x/R_y = 25/12$

$(\rho_x)/(\rho_y) = R_x/R_y timesA_x/A_y = 25/12 \times 12/25$

$= 1$

104 **Answer (A)**

$R = V/I = 10/2 = 5\ \Omega$

Wire (1):

$R = rhoL/A = (0.05 \times 10^{-4} \times 10)/(0.1 \times 10^{-4})$

$= 5\ \Omega$

105 **Answer (C)**

At the same current and time, the most heat is in the greatest resistance:

$R = rhoL/A$

$5\ ,\ 2.5\ ,\ 25\ ,\ 0.005\ (\Omega)$

106 **Answer (C)**

At the same voltage, the smallest power is in the greatest resistance:

$P = (V^2)/R\ ,\ R_3 = 25\ \Omega$

107 **Answer (D)**

$(2I)^2R_{zk} = I^2R_{xy}$

$\Rightarrow R_{xy} = 4R_{zk}$

$(\rho\ell)/(A_{xy}) = 4 \times (2\rho\ell)/(A_{zk}) \Rightarrow (A_{xy})/(A_{zk}) = 1/8$

108 **Answer (D)**

The length doubles with the volume constant:

$R' = 4R \Rightarrow P' = (V^2)/4R = P_w/4$

109 **Answer (C)**

$R = (V^2)/P = 400/10 = 40\ \Omega$

$\rho = RA/L = (40 \times 4 \times 10^{-6})/2$

$= 8 \times 10^{-5}\ \Omega cdotm$

110 **Answer (D)**

$I = P/V = 0.5\ A$

$\Rightarrow Q = It = 0.5 \times 60 = 30\ C$

$n = Q/e = 30/(1.6 \times 10^{-19})$

$= 1.875 \times 10^{20}$

Essay questions

1 **Model answer**

Because some solids contain plenty of free electrons, so they allow the electric current to pass (conductors), while others do not contain plenty of free electrons, so they do not allow the electric current to pass (insulators).

2 **Model answer**

The rate of flow of electrons = the number of electrons passing per second.

$Q = It = Ne$

$N/t = I/e = (3.2 \times 10^{-3})/(1.6 \times 10^{-19}) = 2 \times 10^{16}$ electron/s

3 **Model answer**

Because the rate of flow of electrons is constant at any cross-section of the wire, according to the law of conservation of charge, even though part of their energy changes into heat energy.

4 **Model answer**

Slope = $(\Delta Q)/(\Delta t) = I$

$I_{ab} = 3/1$, $I_{bc} = 1/2$

$(I_{ab})/(I_{bc}) = 6/1$

5 **Model answer**

Lamp (x) does not light up because there is an insulating material (rubber) in its circuit that prevents the current from passing.

Lamp (y) does not light up because its two ends are connected to the same potential; when there is no potential difference across the lamp, no current passes through its filament.

6 **Model answer**

$V_{xy} = W/Ne = 80/(10^{20} \times 1.6 \times 10^{-19}) = 5\ V$

The free electrons flow from y to x, so the conventional current is from x to y.

$V_{xy} = V_x - V_y$, $5 = 5 - V_y$

$V_y = 0$

7 **Model answer**

$I = V/R = 9/1.6 = 5.625\ A$

$N = It/e = (5.625 \times 60)/(1.6 \times 10^{-19}) = 2.1 \times 10^{21}$ electrons

8 **Model answer**

The ammeter reading decreases because the resistance connected to the battery increases (the resistance of lamp y is greater), and the voltmeter reading stays constant because it is connected across the battery, which has negligible internal resistance.

9 **Model answer**

$P_w = I^2R$, $I = Ne/t$

$((P_w)_1)/((P_w)_2) = (N_1^2\ R_1)/(N_2^2\ R_2) = ((10^{20})^2 \times R)/((2 \times 10^{20})^2 \times 2R) = 1/8$

10 **Model answer**

The rate of heating the water decreases, because the rate of heating increases as the heat power produced in the coil increases.

According to the relation $P_w = (V^2)/R$, increasing the resistance of the coil at a constant potential difference decreases the power, so the rate of heating decreases.

11 **Model answer**

(1) $P_w = IV$ and $(P_w)_1 = (P_w)_2$

$I_1V_1 = I_2V_2$, $V_1/V_2 = I_2/I_1 = 2/1$

(2) The ratio V_1/I_1 is not equal to the ratio V_2/I_2 because the electric resistance is not constant, and Ohm's law requires a constant resistance.

12 **Model answer**

(1) End X is used as a slider to change the length of the wire included in the circuit, so its resistance changes according to the relation $R = \rho_e\ (\ell)/A$

(2) Device Z (the ammeter) measures the current in part AX, and device M (the voltmeter) measures the potential difference across part AX. Dividing the voltmeter reading by the ammeter reading gives the resistance of part AX.

13 **Model answer**

By increasing the length of the wire, or decreasing the cross-sectional area of the wire.

14 **Model answer**

(1) Quantity of electric charge. (2) Work. (3) Electric resistance.

(4) Electric current. (5) Quantity of electric charge.

15 **Model answer**

(1) Relation: $V = W/Q$, slope = $(\Delta W)/(\Delta Q) = V$ the potential difference.

(2) Relation: $R = \rho_e\ (\ell)/(\pi r^2)$, slope = $(\rho_e\ \ell)/(\pi)$

(3) Relation: $R = \rho_e\ (\ell)/A$, slope = ρ_e the resistivity.

16 **Model answer**

(1) $\sigma = (\ell)/AR$

$\sigma_x : \sigma_y : \sigma_z = 2/A : 3/4A : 3/6A = 2 : 0.75 : 0.5 = 8 : 3 : 2$

(2) Material x, because it has the greatest electrical conductivity, so wires made of it have a smaller resistance for the same dimensions.

17 **Model answer**

The volume of the wire after reshaping = the volume of the cube.

$R = \rho_e\ (\ell^2)/(V_{ol})$

$\ell = \sqrt{((R\ V_{ol})/(\rho_e))} = \sqrt{((20 \times (10 \times 10^{-2})^3)/(10^{-7}))} = 447.21\ m$

18 **Model answer**

$R = \rho_e (\ell^2)/(V_{ol}) = \rho_e (\ell^2 \rho)/m$

$m = (\rho_e \ell^2 \rho)/R = (10^{-6} \times 2^2 \times 7000)/2 = 0.014\ kg$

19 **Model answer**

(1) When the cross-sectional area is $0.0025\ cm^2$: $1/A = 4 \times 10^6\ m^{-2}$

and from the graph: $R = 12\ \Omega$

(2) Slope = $(12 - 6)/((4 - 2) \times 10^6) = 3 \times 10^{-6}\ \Omega\ m^2$

$\sigma = (\ell)/slope = 12/(3 \times 10^{-6}) = 4 \times 10^6\ \Omega^{-1}\ m^{-1}$

20 **Model answer**

Wire (x) is thicker, because its resistance is smaller (the slope = $(\Delta I)/(\Delta V) = 1/R$ is greater). The two wires are of the same material and length, so the resistance is inversely proportional to the cross-sectional area.

21 **Model answer**

When switch K is closed, heating coil (1) raises the temperature of resistance coil (2), so the resistivity of its material increases and its resistance increases. The current in its circuit decreases, so the ammeter reading decreases.

22 **Model answer**

$R = (V^2)/P_w$, $R_B/R_A = (V_B^2\ (P_w)_A)/(V_A^2\ (P_w)_B)$

The two filaments are of the same material and length: $R_B/R_A = (r_A^2)/(r_B^2)$

$(r_A^2)/(r_B^2) = (24^2 \times 80)/(220^2 \times 20) = 144/3025$

$r_A/r_B = 12/55$

Past exam questions

1	2	3	4	5	6	7	8	9	10
A	C	A	C	D	A	D	A	B	A
11	12	13	14	15	16	17	18	19	20
B	C	A	A	D	B	C	B	D	D
21	22	23	24	25					
C	D	A	D	C					

1 **Answer (A)**

Free electrons are negative, so they move from the end of lower potential to the end of higher potential.

2 **Answer (C)**

The long line in the battery symbol is the positive terminal, so the potential of W is greater than that of Z.

Point X is connected to the positive terminal, and the current flows in the resistor from X to Y, so the potential of X is greater.

3 **Answer (A)**

$P_w = I^2 R$

Slope = $P_w/(I^2) = R$

4 **Answer (C)**

$I = P_w/V = 80/100 = 0.8\ A$

5 **Answer (D)**

$V_B = W/Q = 12/2 = 6\ V$

The total work to move the charge inside and outside the source is the emf.

6 **Answer (A)**

$R \propto 1/A$ for the same material and length

$R_1/R_2 = A_2/A_1 = 3/1$

7 **Answer (D)**

$R \propto (\ell)/A$

A : $(2\ell)/2A = 1$, B : $(\ell)/3A = 1/3$, C : $(2\ell)/A = 2$, D : $(\ell)/4A = 1/4$

In ascending order: D then B then A then C

8 **Answer (A)**

The current increased 3 times at the same potential difference, so the resistance decreases to a third.

$R_1 = \rho\ (\ell)/3A$, $R_2 = \rho\ (2\ell)/18A = \rho\ (\ell)/9A = R_1/3$

9 **Answer (B)**

$A_1 = 9A_2$ and $R_2 = 4R_1$

$(\ell_2)/(\ell_1) = (R_2\ A_2)/(R_1\ A_1) = 4/9$

10 **Answer (A)**

The cross-sectional area does not change when the battery is changed, so the resistance is constant and the current increased because the potential difference increased.

11 **Answer (B)**

$R_1 = \rho\,(3\ell)/(\pi r^2)$, $R_2 = \rho\,(2\ell)/(4\pi r^2)$, $R_1/R_2 = 6$

$I_1/I_2 = V_1/V_2 \times R_2/R_1 = 1/2 \times 1/6 = 1/12$

12 **Answer (C)**

$R = \rho_e\,(\ell^2)/(V_{ol})$, slope = $\rho_e\,\ell^2$

The wires have equal lengths, so the greater slope has the greater resistivity and the smaller conductivity.

$\sigma_1 > \sigma_2 > \sigma_3 > \sigma_4$

13 **Answer (A)**

Slope = $\rho_e\,\ell$ with the same length, and the slope of X is greater,

so the metal of X has the greater resistivity.

14 **Answer (A)**

$\sigma = (\ell)/(R\,A)$

$(1) : (\ell)/(2R \times (\pi r^2)/16) = (8\ell)/(\pi r^2 R)$, $(2) : (16\ell)/(3\pi r^2 R)$, $(3) : (2.5\ell)/(\pi r^2 R)$, $(4) : (\ell)/(6\pi r^2 R)$

So wire (1) has the highest conductivity.

15 **Answer (D)**

$R \propto (\ell)/(r^2)$

A : $1.5/0.25 = 6$, B : 2 , C : $4/4 = 1$, D : $3/9 = 1/3$

So wire (D) has the smallest resistance.

16 **Answer (B)**

The two parts are in series, so the same current passes through them.

$V_A/V_B = (I\,R_A)/(I\,R_B) = R_A/R_B$

17 **Answer (C)**

Slope = $(\rho_e)/A$ with the same cross-sectional area, and the slope of x is greatest, so its resistivity is greatest and its conductivity is smallest.

$\sigma_z > \sigma_y > \sigma_x$

18 **Answer (B)**

The voltmeter is connected across the battery of negligible internal resistance, so its reading equals $V_B = 6\ V$ however the resistance of AB changes.

$V_1 = V_2$

19 **Answer (D)**

The slope of B is greater, so the resistivity of material B is greater and its conductivity is smaller.
Resistivity and conductivity do not change with length (horizontal lines).
Graph (2): σ of material A is greater, graph (3): ρ_e of material B is greater.

20 **Answer (D)**

The voltmeter measures the potential difference between the slider and end b.
Moving the slider towards b decreases the length of the part between them, so its resistance and the potential difference decrease until it becomes zero at b.

21 **Answer (C)**

Slope = $(\rho_e)/A$, so the cross-sectional area is inversely proportional to the slope.
$A_x/A_y = (\tan 30)/(\tan 45) = 1/(\sqrt{3})$

22 **Answer (D)**

Slope = $R/(\ell) = 24/150 = 0.16\ \Omega/m$
$\rho_e = slope \times A = 0.16 \times 0.1 \times 10^{-4} = 1.6 \times 10^{-6}\ \Omega\ m$

23 **Answer (A)**

$R = \rho_e\ (\ell)/A$, so decreasing the cross-sectional area increases the resistance.

24 **Answer (D)**

$R_X = \rho\ (\ell)/2A = R$, so $\rho\ (\ell)/A = 2R$
$R_Y = \rho\ (2\ell)/A = 4R$, $R_Z = \rho\ (\ell)/A = 2R$

25 **Answer (C)**

$R = V/I = 6/2 = 3\ \Omega$
$\sigma = (\ell)/RA = 1/(3 \times 2 \times 10^{-6}) = 1.667 \times 10^5\ \Omega^{-1}\ m^{-1}$