ANSWERS to CIRCUITS

1. The speed with which electrons move through a copper wire is typically 10^{-4} m s^{-1}.
   a. Explain why is it that the electrons cannot travel faster in the conductor?
   b. Explain why the electron drift produces heat?

*1. **a) collisons with the crystal lattice atoms b) collisions with lattice atoms transfers energy.***

2. Explain in terms of atomic and electron movement, why resistance increases with temperature.

*2. **Electrons drift through the lattice, as temperature increases the lattice atoms vibrate more and this increases the probability of collision and hence resistance to electrons has increased.***

3. Calculate the resistance of an aluminum ($\rho = 2.8 \times 10^{-8}$ Ωm) wire that is 2.0 m long and of circular cross section with a diameter of 1.5 mm.

3. 32 mΩ

4. Determine the length of tungsten ($\rho = 5.6 \times 10^{-8}$ Ωm) wire with a diameter of 1.0 mm that is used to make a 20.0 Ω resistor.

*4. **280 m***

5. A nichrome ($\rho = 100 \times 10^{-8}$ Ωm) wire has a diameter of 0.40 mm. Calculate the length of this wire needed to carry a current of 30 mA when there is a potential difference of 12 V across it.

*5. **50 m***

6. A thin copper ($\rho = 1.68 \times 10^{-8}$ Ωm, but you don't need it) wire 200 cm in length has a 9 V dry cell connected between its ends. Determine the voltage drop that occurs along 30 cm of this wire.

*6. **1.35 V***

7. If the potential difference across the bulb in a camping lantern is 9.0 V, what is the potential difference across the battery used to power it?
battery gives the voltage of 9.0 V to the lantern to use it.

8. How much current, in amperes, is in a lightning stroke that lasts 0.05 second and transfers 100 coulombs?

I = q/t = (100 C)/(0.05 s) =2000 A

9. Calculate the resistance of the filament in a light bulb that carries 0.4 A when 3.0 V is impressed across it.

V = IR R = V/I = 7.5 Ω

10. Electric socks, popular in cold weather, have a 90-ohm heating element that is powered by a 9-volt battery. How much current warms your feet?

V = I/R = 0.1 A

11. Calculate the current of a lightning bolt that delivers a charge of 35 coulombs to the ground in a time of 1/1000 second.

11. I = q/t = 35 000 A.

12. Calculate the current where 10 coulombs of charge pass a point in 5 seconds.

12. I = V/R = 2 A

13. Two light bulbs designed for 120-V use are rated at 40W and 60W. Which light bulb has the greater filament resistance? Why?

13. More current flows in the 60-W bulb, which means the resistance of the filament is less.
P = IV = V2/R, R = V2/P = (120 V)2/(60 W) = 240 Ω; for the 40-W lamp, R = (120 V)2/(40 W) = 360 Ω

14. A battery does 18 joules of work on 3 coulombs of charge. What voltage does it supply?

14. V= E/q= (18 J)/(3 C) = 6V

15. A power line with a resistance of 2 ohms has a current of 80 A in it. The power dissipated in the line is

15. 12800 W.

16. A toaster oven is plugged into an outlet that provides a voltage difference of 120 V.
What power does the oven use if the current is 10A?

16. P = IV = 1200 W

17. A VCR that is not playing still uses 10.0 W of power. What is the current if the VCR is plugged into a 120 V electric outlet? ***17.***
17. P = IV I = P/V = 0.083 A

18. A flashlight bulb uses 2.4 W of power when the current in the bulb is 0.8 A. What is the voltage difference?

18. P = IV V = P/I = 3V

19. A refrigerator operates on average for 10.0 h a day. If the power rating of the refrigerator is 700 W, how much electrical energy does the refrigerator use in 1 day? (make sure to convert to kW)

19. E = Pt = (0.7 kW)(10.0 h) = 7 kWhours

20. A TV with a power rating of 200 W uses 0.8 kWh in one day. For how many hours was the TV on during this day?

20. E = Pt t = E/P= 0.8 kWh/0.2 kW = 4 h

21. Calculate the voltage difference in a circuit with a resistance of 25 Ω if the current in the circuit is 0.5 A.

21. V = IR = 12.5 V

22. A current of 0.5 A flows in a 60 W light bulb when the voltage difference between the ends of the filament is 120 V.
What is the resistance of the filament?

22. R = V/I = 240 Ω

23. A toy car with a resistance of 20 Ω is connected to a 3 V battery. How much current flows in the car?

23. I = V/R = 0.15 A

24. The current flowing in an appliance connected to a 120 V source is 2 A. How many kilowatt-hours of electrical energy does the appliance use in 4 h? (2 equations used & convert watts to kW)

24. E = Pt P = IV = 0.24 kW E = 0.96 kWh

25. A calculator uses 9 V battery & draws 0.1 A of current. How much power does it use?

25. P = IV = 0.9 W

26. A battery causes 250 mA to flow when it is applied to a light bulb with a resistance of 50 ohms. How much current would flow if the same source were applied to a 12 ohm resistor?

26. voltage of the source: V = IR = 12.5 V I = V/R = 1.04 A

27. A 160 ohm load is connected to a 325 volt source. If the source voltage increases to 425 volts, what value must the load resistance be changed to keep the current flow the same?

27. I = V/R = 2.03 A R = V/I = 209 Ω

28. A 100 W light bulb draws 833 mA when the rated voltage is applied. What is the rated voltage?

28. P = IV V = P/I = 120 V

29. A 1.5 kΩ resistor rated at 250 mW will be damaged if 18 V is applied across it. T/F

29. F ***$P = IV = (V/R)V = V^2/R = 0.216\ W = 216\ mW < 250\ mW$***

30. A 30 kΩ resistor rated at ½ Watt will be damaged if a current flow of 4.5 mA is flowing through it. T/F

30. T ***$P = IV = I(IR) = I^2R = 0.608\ W > ½\ W$***

31. A 1 Watt, 220 Ω resistor has 14 V applied. The resistor will exceed the power rating and be damaged. T/F

31. F ***$P = IV = (V/R)V = V^2/R = 0.89\ W < 1\ W$***

32. A 1/8 Watt 50 kΩ resistor has 70 V applied. The resistor will exceed the power rating and be damaged. T/F

32. F ***$P = IV = (V/R)V = V^2/R = 0.098\ W < 1/8\ W = 0.125\ W$***

33. Calculate the resistance of a wire if 0.5 V across it causes a current of 2.5 A to flow.

33. $R = V/I = 0.2\ \Omega$

34. Calculate current flow through a 20 MΩ resistor connected across a 100 kV power supply.

34. $I = V/R = 5.0 \times 10^{-3}\ A = 5.0\ mA$

35. An iron draws 6.0 A of current when operating in a country with a mains supply of 120 V. Calculate the resistance of the iron?

35. $R = V/I = 20\ \Omega$

36. An electrical appliance is rated as 2.5 kW, 240 V.
(a) Determine the current needed for it to operate.
(b) Calculate the energy it would consume in 2.0 hours.

36. (a) $I = P/V = 2500W/240V = 10.4 = 1.0 \times 10^1\ A$
(b) energy = VIt = (240V)(10.4A)(7200s) = $1.8 \times 10^7\ J$

37. Calculate the current in a 48-V battery that powers a pair of 30 Ω resistors connected in series.

37. $R_{eq} = 60\ \Omega$ ***$I = V/R = 0.8\ A$***

38. Calculate the current in a 48-V battery that powers a pair of 30 Ω resistors connected in parallel.

38. $1/30 + 1/30 = 1/R_{eq}$ ***$R_{eq} = 15\ \Omega$*** ***$I = V/R = 3.2\ A$***

39. The following three appliances are connected in series to a 120 V house circuit: a toaster, 1200 W; a coffee pot, 750 W; and a microwave, 6.0×10^2 W. If all were operated at the same time, what total current would they draw?

39. 21 A

40. Three resistors with values of 3.0 Ω, 6.0 Ω, and 12 Ω are connected in parallel. What is the equivalent resistance of this combination?

40. 1.7 Ω

41. Determine the equivalent resistance when 12 Ω, 6 Ω and 4 Ω are placed in
(a) series
(b) parallel

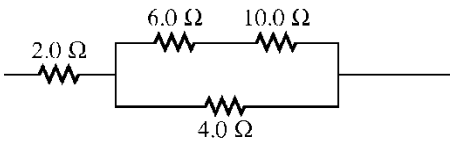
41. a) 22 Ω b) 2 Ω

42. Two resistors with values of 6.0 Ω and 12 Ω are connected in parallel. This combination is connected in series with a 4.0 Ω resistor. What is the overall resistance of this combination?

42. 8.0 Ω

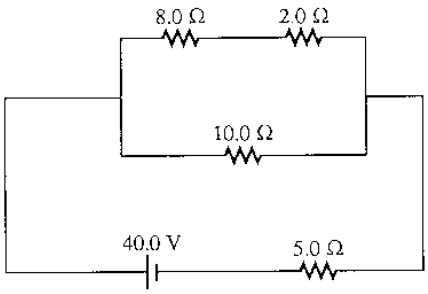
43. What is the equivalent resistance for the resistors in the figure ?

a. 2.3 Ω b. 5.2 Ω c. 13 Ω d. 22 Ω



43. b.

44. What is the equivalent resistance for the resistors in the figure ?



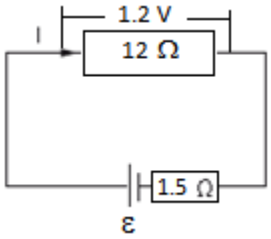
44. $1.0 \times 10^1\ \Omega$

45. A dry cell has an internal resistance of 1.50 Ω. A resistor of 12.0 Ω is connected in series with the dry cell. If the potential difference across the 12.0 Ω resistor is 1.20 V, calculate the emf of the cell.

45. $R_{eq} = 13.5\ \Omega$ $I = \varepsilon/R_{eq} = \varepsilon/13.5$

$V = IR$ $1.2 = 12\ I = 12\ \varepsilon/13.5$

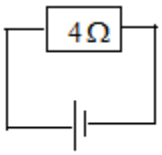
$\varepsilon = 1.35\ V$



46. When a dry cell is connected to a circuit with a load resistor of 4.0 Ω, there is a terminal voltage of 1.3 V. When the load resistor is changed to 12 Ω, the terminal voltage is found to be 1.45 V.
Calculate
(a) the emf of the cell.
(b) the internal resistance of the cell.

46.

$V = \varepsilon - Ir$ $I = \frac{V}{R}$



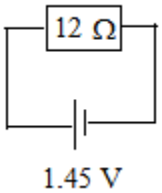
$$I = \frac{1.3}{4} \rightarrow 1.3 = \varepsilon - 0.325 \times r$$

$$1.3 + 0.325 \times r = 1.45 + 0.12 \times r$$

r= ***0.75 Ω***

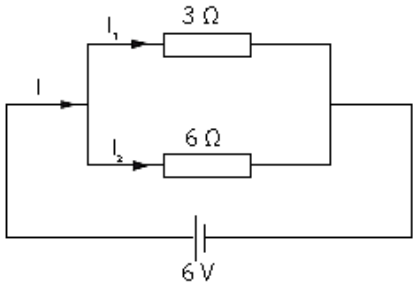
$$1.3 = \varepsilon - 0.325 \times .75$$

$$\varepsilon = 1.54\ V$$



$$I = \frac{1.45}{12} \rightarrow 1.45 = \varepsilon - 0.12 \times r$$

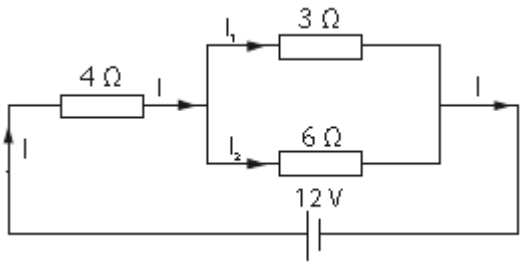
47. From the diagram given in the Figure , calculate
(a) the effective resistance of the circuit,
(a) the current flowing in the main circuit,
(a) the current in each resistor.



47. (a) Using $1 / R_{eff} = 1 / R_1 + 1 / R_2 = 1/3 + 1/6 = 1/2$ $R_{eff} = 2\ \Omega$

(b) $I = V/R_{eff} = 6V/2\Omega = 3\ A$
(c) $I_1 = V_1/R_1 = 6/3 = 2\ A$ or $3 = I_1 + I_2$ and $I_1 = 2\ I_2$ $3 = 3\ I_2$ $I_2 = 1\ A$ $I_1 = 2\ A$
$I_2 = V_2/R_2 = 6/6 = 1\ A$

48. From the diagram given in the figure , calculate



(a) the total resistance of the circuit
(b) the current flowing in the main circuit
(c) the current in each resistor

48.
(a) parallel circuit:
$1/R_{eff} = 1/R_1 + 1/R_2 = 1/3 + 1/6 = 1/2$ $R_{eff} = 2\ \Omega$

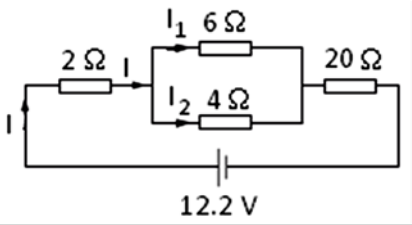
total resistance: $R_{eff} = 4\ \Omega + 2\ \Omega = 6\ \Omega$

(b) $I = V/R = 12/6 = 2\ A$

(c) $V_1 = V_2 = 12 - IR = 12 - 2x4 = 4\ V$

$I_1 = V_1/R_1 = 4/3 = 1.33\ A$
$I_2 = 2 - 1.33 = 0.67\ A$

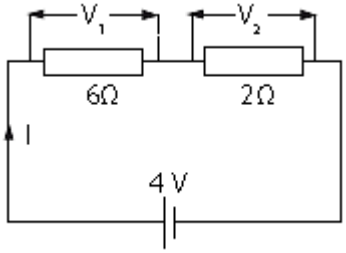
49. The diagram shows resistances joined in a compound circuit.



(a) Determine the total resistance of the circuit.
(b) Calculate current flows through the 2.0 Ω resistor.
(c) Deduce the potential difference across the 20.0 Ω resistor.
(d) Determine is the potential difference across the 6.0 Ω resistor.
(e) Calculate is the current through the 4.0 Ω resistor.

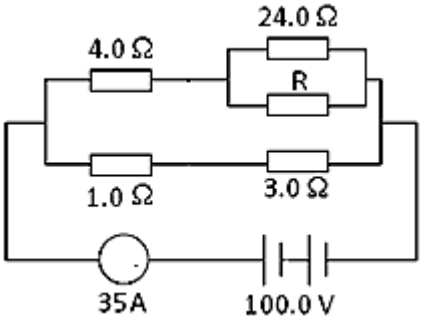
49. a) 24.4 Ω b) 0.5 A c) 10 V d) 1.2 V e) 0.3 A

50. From the diagram given in the Figure below of a potential divider, calculate
(a) the effective resistance of the circuit
(b) the current flowing
(c) the potential difference across each resistor

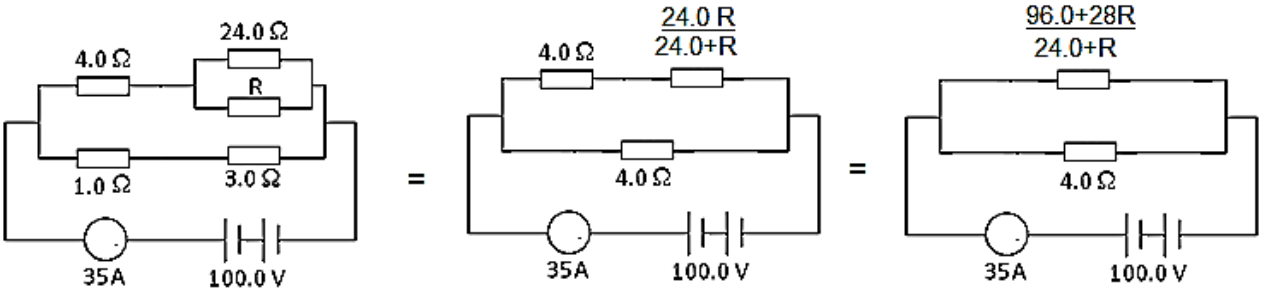


50. (a) $R_{eq} = R_1 + R_2 = 6\ \Omega + 2\ \Omega = 8\ \Omega$
(b) $I = V/R_{eq} = 4V/8\ \Omega = 0.5\ A$
(c) $V_1 = IR_1 = 0.5 \times 6 = 3\ V$. $V_2 = IR_2 = 0.5 \times 2 = 1\ V$

51. The circuit below refers to the following questions:



Determine the value of resistor R, and current through it.

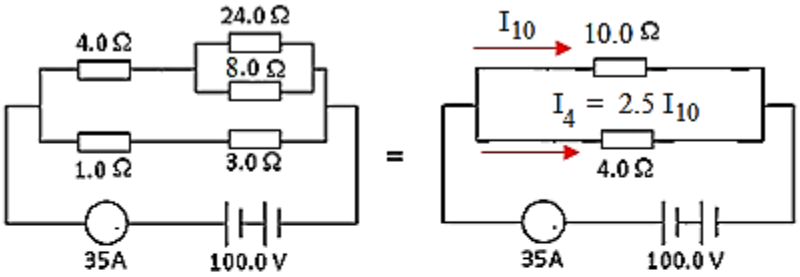


$$R_{eq} = \frac{V}{I} = \frac{100.0}{35} = \frac{20.0}{7}\ \Omega$$

$$\frac{1}{R_{eq}} = \frac{1}{4.0} + \frac{24.0 + R}{96.0 + 28R} = \frac{24.0 + 7R + 24.0 + R}{4.0(24.0 + 7R)} = \frac{12.0 + 2R}{24.0 + 7R}$$

$$\frac{24.0 + 7R}{12.0 + 2R} = \frac{20.0}{7} \quad \rightarrow \quad 168 + 49R = 240 + 40R \quad \rightarrow \quad 9R = 72$$

$$R = 8.0\ \Omega$$



$10 = I_8 + I_{24}$

$I_8 = 3\,I_{24}$

$10 = 4I_{24}$

$I_{24} = 2.5\text{A}$

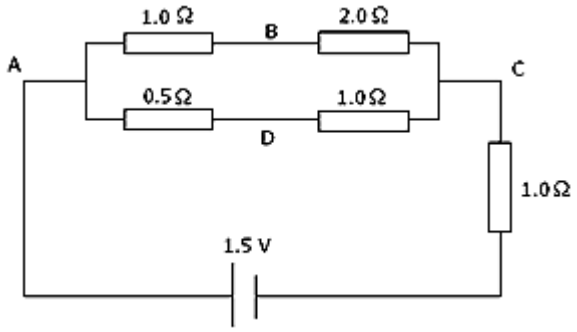
$\boxed{I_8 = 7.5\ \text{A}}$

$35 = I_4 + I_{10}$

$35 = 3.5\,I_{10}$

$I_{10} = 10\ \text{A}$

52. The diagram shows a typical circuit.



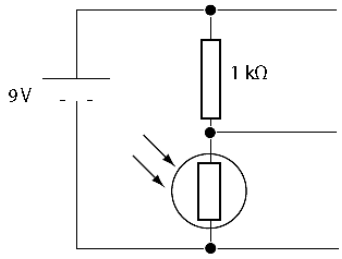
(a) Determine the effective resistance of the whole circuit.
(b) Determine the currents flowing in each network resistor.
(c) Determine the potential differences V_{AB} and V_{AD}.
(d) Determine the potential difference between B and D.

52. ***a) R_{ABC} = 3 Ω R_{ADC} = 1.5 Ω R_{AC} = 1 Ω R_{eff} = 2 Ω***
(b) I = V / R_{eff} = 1.5 / 2 = 0.75 A
Voltage in 1 Ω series resistor = IR = (1)(0.75) = 0.75 V
Voltage in each network = 1.5 – 0.75 = 0.75 V
I_{ABC} = V/R = (0.75) / 3 = 0.25 A
I_{ADC} = V/R = 0.75 / 1.5 = 0.5 A

(c) V_{AB} = IR = (1)(0.25) = 0.25 V
V_{AD} = IR = (0.5)(0.5) = 0.25 V

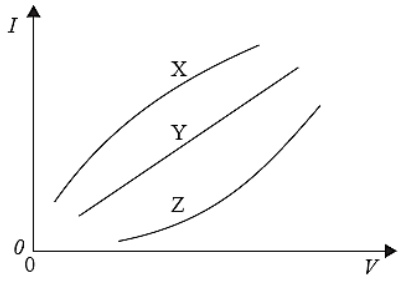
(d) 0 V

53. Determine the resistance of the LDR in the diagram below if a current of 4.5 mA is flowing in the circuit.



53. ***Voltage in the 1 k Ω resistor: V = IR = 1000 x 4.5 x 10^{-3} = 4.5 V***
Voltage in the LDR = 4.5 V.
Resistance in the LDR = V/I = 4.5 / 4.5 x 10^{-3} = 1000 = 1 k Ω

54. The graph below shows the variation with voltage V of the current I in three resistors X, Y and Z.

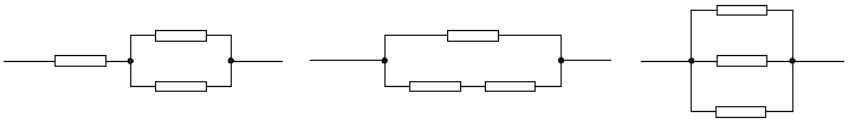


Which of the following corresponds to resistors for which the resistance increases with increasing current?

A. X only
B. Z only
C. X and Z
D. Y and Z

54. A

55. The diagrams below show combinations X, Y and Z of three resistors, each resistor having the same resistance.



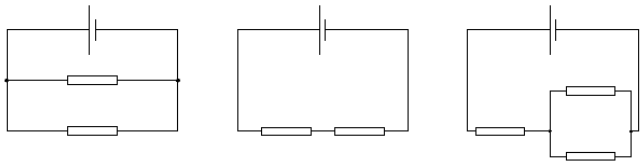
combination X combination Y combination Z

Which one of the following shows the resistances of the combinations in increasing order of magnitude?

	lowest	→	highest
A.	Y	X	Z
B.	Z	X	Y
C.	X	Y	Z
D.	Z	Y	X

55. D

56. In the circuits below, the batteries each have the same voltage. All the resistors have the same resistance.



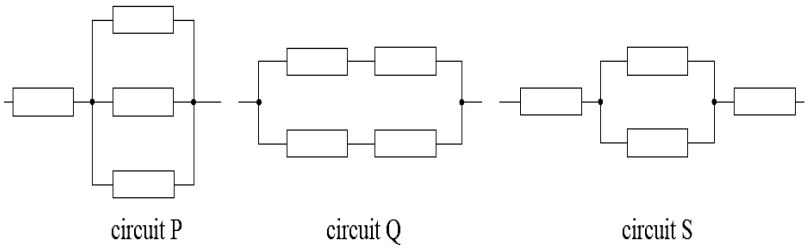
Circuit X Circuit Y Circuit Z

Which of the following gives the current through the cells in order of increasing magnitude?

	Lowest current	→	Highest current
A.	X	Y	Z
B.	Z	X	Y
C.	Y	Z	X
D.	Y	X	Z

56. C

57. The resistors in each of the circuits shown below each have the same resistance.



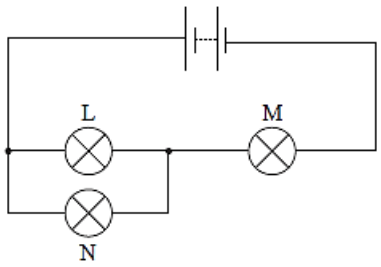
circuit P circuit Q circuit S

Which of the following gives the circuits in order of increasing total resistance?

A. P Q S
B. Q P S
C. S Q P
D. P S Q

57. B

58. In the circuit below, the battery has negligible internal resistance. Lamps L, M and N which have different resistance are connected as shown.



Which **one** of the following is always true?

A. Lamps L and N have the same current through them.
B. Lamps L and M have the same current through them.
C. Lamps L and N have the same potential difference across them.
D. Lamps L and M have the same potential difference across them.

58. C

59. A DC electric motor converts 75 % of the input electrical energy to mechanical energy. The remaining 25 % is

A. dissipated as heat energy.
B. returned to the battery.
C. used to maintain the potential difference of the battery.
D. converted to electrical potential energy.

59. A

60. The element of an electric heater has a resistance R when in operation. What is the resistance of a second heater that has a power output three times as large at the same operating voltage?

A. R/9
B. B. R/3
C. C. 3R
D. D. 9R

60. B