leaves will be positively charged. **D.** The cap and the leaves will be negatively charged. *[1992/41]*

20. **When the pointed end of an uncharged optical pin is brought near the cap of a positively charged electroscope, it is observed that the gold leaves**
A. collapse slowly. **B.** vibrate. **C.** are not affected.
D. diverge rapidly. *[2011/37]*

21. **Which of the following devices is used to compare the relative magnitudes of charges on two given bodies? A**. Electrophorus. **B**. Ebonite rod. **C**. Proof plane. **D**. Gold leaf electroscope *[2023/25]*

CHAPTER 12 [Current Electricity]

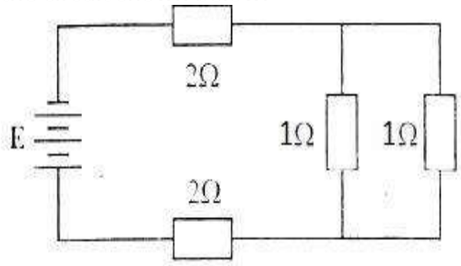
Electric Circuit & Ohm's Law

Introduction

Current electricity deals with electric charges in motion. The ohm's law explains the relationship between the current flowing through a conductor and the potential difference across it. Download Prep50 app today from Google PlayStore to study current electricity.

Examiner's Corner

1. Some candidates rather than defining terms were showing mathematical relationship between parameters. For example, when asked to define coulomb, candidates will write **Q = It** (which is the correct mathematical expression) instead of coulomb is defined as **the quantity of electric charge passing through a point in a conductor when steady current of one ampere passes for one second.** They also wrongly define **resistance** as a ratio of voltage to current instead of resistance is the **opposition to the flow of electric current**.
2. In determining the quantity of current **I** across circuit with an internal resistance **r** and external resistance/load **R**, candidates often use **I =** $\frac{V}{R}$ (as given by Ohm's Law) whereas the **proper formula** to use is **I =** $\frac{E}{R+r}$ (where E is emf of the cell)
3. Candidates often have poor knowledge of resistors arranged in parallel and in series often leading to poor interpretations of circuit diagrams. The correct method of determining effective resistance when given a circuit with resistors **in parallel and in series** is to first determine the combined resistance of the ones in parallel and then solve for the serial ones.
For example, solve for the effective resistance of the circuit shown below.



We have four resistors; 2 in parallel and 2 in series.

The 1Ω are in parallel while the 2Ω are in series.
To resolve the parallel, recall that for resistors in parallel $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ (where R_T = combined resistance and R_1 and R_2 are the individual resistors in parallel.

$\therefore \frac{1}{R_T} = \frac{1}{1} + \frac{1}{1} = \frac{1+1}{1} = \frac{2}{1}$

$\frac{1}{R_T} = \frac{2}{1}$; $2R_T = 1$. $\therefore R_T = \frac{1}{2}\Omega$

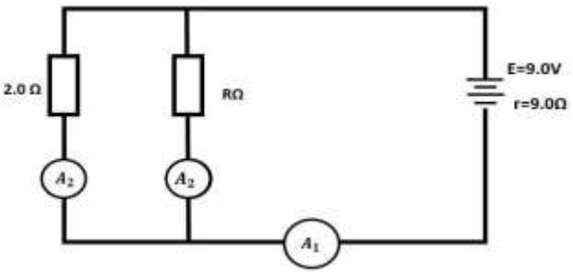
Recall that for resistors in series $R_T = R_1 + R_2$

Here the 2Ω resistors are now in series with $\frac{1}{2}\Omega$

$\therefore R_T = 2 + 2 + \frac{1}{2} = \mathbf{4\frac{1}{2}\ \Omega}$

Example

1. **The diagram below illustrates a 9.0 *V* battery of internal resistance 0.5 Ω connected to two resistors of values 2.0 Ω and R Ω A_1A_2 and A_3 are ammeters of negligible internal resistances. If A_1 reads 4.0 A,**AA



calculate the: (i) equivalent resistance of the combined resistors 2.0 Ω and R Ω; (ii) currents through A_2 and A_3; (iii) value of R *[2010/14]*

Solution

(i) Recall that once there is internal resistance **I =** $\frac{E}{R_c+r}$**.** Here I = A_1 = 4A, E = 9.0V, r = 0.5Ω and we are asked to find R. Here R_c will be the combined resistance of 2.0Ω and the RΩ from the diagram.

$\therefore E = I(R_c + r)$; $9 = 4(R_c + 0.5)$

$\therefore R_c = 1.75\Omega$

(ii) To calculate the currents through A_2 and A_3 wehave to first determine the lost voltage.

Lost voltage = Ir = 4.0 x 0.5 = 2.0V. Voltage across 2Ω and RΩ = 9.0 - 2.0 = 7.0V

Current in $A_2 = I_2 = \frac{v}{R_2} = \frac{7}{2} = 3.5A$

Current $A_3 = I_3 = \frac{v}{R} = \frac{7.0}{14} = 0.5A$

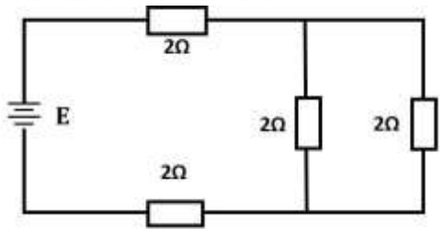
(iii) To determine the value of R. Notice that the 2 Ω resistor and R are in parallel.

Recall that for resistors in parallel $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$. $\therefore \frac{1}{1.75} = \frac{1}{R} + \frac{1}{2}$

$\therefore R = 14\ \Omega$

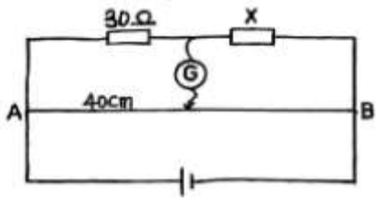
THEORY

1. **Define Electromotive Force** *[2014/11]*
2. **(a) Explain electromotive force (b) List two sources of electromotive force other than a chemical cell** *[2004/14]*
3. **Define (a) the coulomb (b) resistance (c) State the three effects of an electric current (** *[2015/11]*
4. **Explain: (i) electric potential; (ii) electric potential energy; (iii) State the Si unit of each of the terms in (i) and (ii).** *[2005/14]*
5. **An electric bell takes a current of 0.2A from a battery of two dry cells connected in series. Each cell has an e.m.f. of 1.5V and an internal resistance of 1.0Ω. (i) Calculate the effective resistance of the bell; (ii) What current would the bells take if the cells were arranged in parallel?** *[1997/3]*
6. **Two cells, one having an emf of 2.0 V and an internal resistance of 0.4Ω and the other having an emf of 2.0 V and an internal resistance of 0.1Ω, are connected in parallel. The combination is then connected in series with a 5Ω resistor. (i) Draw a circuit diagram of the arrangement. (ii) Calculate the current through the 5 Ω resistor.** *[2011/14]*
7. **A battery of negligible internal resistance is connected to a set of resistors as illustrated in the circuit diagram below. Determine the equivalent resistance of the circuit.**



[2017/11]

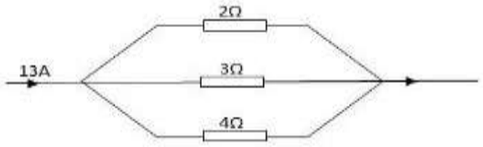
8. **Two cells, each of e.m.f. 2V and internal resistance 0.5Ω, are connected in series. They are made to supply current to a combination of three resistors, one of resistance 2Ω connected in series to a parallel combination of two other resistors each of resistance 3Ω. (a) Draw the circuit diagram and calculate the current in the circuit; (b) potential difference across the parallel combination of the resistors; (c) lost volts of the battery.** *[1998/3]*
9. **Define the volt.** *[2022/9]*
10. **(a) State two characteristics of an electromotive force. (b) Draw the electrical symbol for each of the following components of an electrical circuit. I. inductor; II. rheostat; III. diodes; IV. fuse. (c) The diagram below illustrates a metre bridge with an unknown resistance X and 30 Ω in the arms respectively**



If the balance point is 40 cm from A, calculate the magnitude of X *[2026/11]*

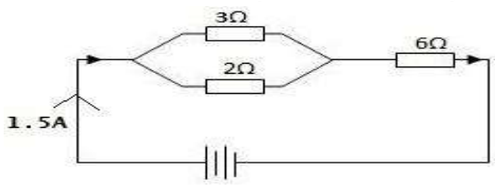
OBJ

1. **Calculate the quantity charge flowing through a conductor if a current of 10A passes through the conductor for 10s A.** 100c. **B.** 20c. **C.** 15c. **D.** 10c. *[1995/46] [2003/37]*
2. **Calculate the current in the 3Ω resistor shown in the diagram below**



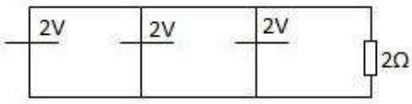
A. 3.0A. **B.** 4.0A. **C.** 4.3A. **D.** 12.0A. *[1990/37]*

3. *Use the diagram below to answer this questions* **Calculate the terminal p.d. of the battery in the**



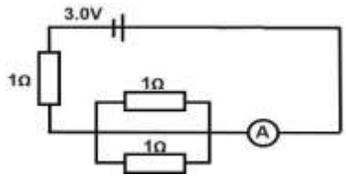
A. 7.50V. **B.** 9.00V. **C.** 10.80V. **D.** 11.25V. *[2000/39]*

4. **Which of the following is a unit of the time rate of flow of electric charges? A.** Coulomb. **B.** Ampere. **C.** Volt. **D.** Watt. *[2008/37]*
5. **Which of the following factors does not affect the e.m.f. of a primary cell? Its A.** size. **B.** internal resistance. **C.** operating temperature. **D.** duration of usage. *[2016/40]*
6. **An electric circuit is connected as illustrated below. Determine the equivalent e.m.f and current flowing through the circuit respectively, neglecting the internal resistance of the cells.**



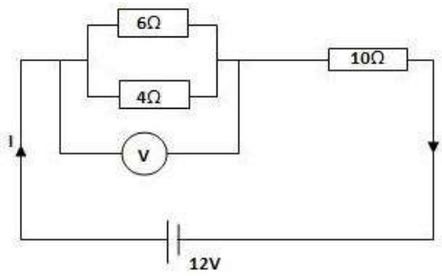
A. 2V, 1.0A. **B.** 2V, 4.0A. **C.** 6V, 0.3A. **D.** 6V, 3.0A. *[2013/36]*

7. **Which of the following instruments is used to determine the accurate value of the electromotive force of a cell? A.** Voltmeter. **B.** Meterbridge. **C.** Voltameter. **D.** Potentiometer. *[2013/39]*
8. **A circuit is set up as shown in the diagram below. When the key is closed, the reading on the ammeter will be**



A. 6 A. **B.** 4 A. **C.** 2 A. **D.** 1 A. *[2017/37]*

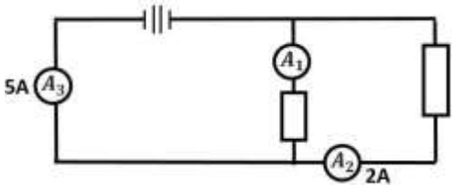
Use the diagram below to answer this question 9 & 10



9. **Calculate the current, I.A.** 0.60A. **B.** 0.97A. **C.** 1.03A. **D.** 5.00A. *[2010/36]*

10. **Determine the potential difference, V across the parallel resistors. A.** 2.0 *V*. **B.** 2.3 *V* C. **C.** 3.0 *V*. **D.** 0.7 *V*. *[2010/37]*

11. **A circuit contains three ammeters A_1, A_2 and A_3 with readings of A_2 and A_3 shown as indicated in the diagram below. Determine the reading of A_1.**



A. 2A. **B.** 3A. **C.** 5A. **D.** 8A. *[2018/41]*

12. **What must be connected between the points P and Q to establish a steady current through the incomplete circuit diagram illustrated below?**

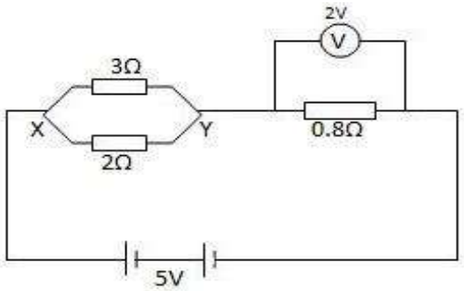
A. Fuse. **B.** Ammeter. **C.** Cell. **D.** Voltmeter.*[2015/44*

13. **A cell can supply currents of 0.80 A and 0.40 A through a 2Ω and a 3Ω resistor respectively. Calculate the internal resistance of the cell.** **A.** 0.2Ω. **B.** 0.4Ω.**C.** -1.0Ω. **D.** 3.0Ω. *[1988/38]*

14. **A battery of e.m.f. 24 V and internal resistance 4Ω is connected to a resistor of 32Ω. What is the terminal p.d. of the battery? A.** 24.0V. **B.** 21.3V. **C.** 16.0V. **D.** 2.7V. *[1988/40]*

15. **A cell of e.m.f. 1.5 V and internal resistance 1.0 Ω is connected to two resistors of resistances 2.0 Ω and 3.0 Ω in series. Calculate the current through the resistors A.** 0.25A. **B.** 0.30A. **C.** 0.35A. **D.** 0.50A. *[2006/42]*

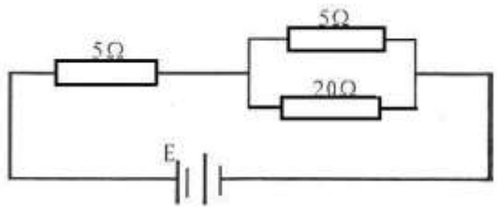
Use the diagram below to answer question 16 & 17.



16. **What is the potential difference between X and Y in the diagram below if the battery is of negligible internal resistance? A.** 12.5V. **B.** 5.8V. **C.** 5.0V. **D.** 3.0V. *[1995/48]*

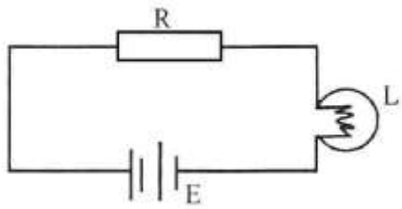
17. **Calculate the current in the 3Ω resistor. A.** 0.3A. **B.** 0.4A. **C.** 1.0A. **D.** 1.5A. *[1995/49]*

18. **In the circuit diagram below, E is a battery of negligible internal resistance. If its e.m.f is 9.0 V, calculate the current in the circuit.**



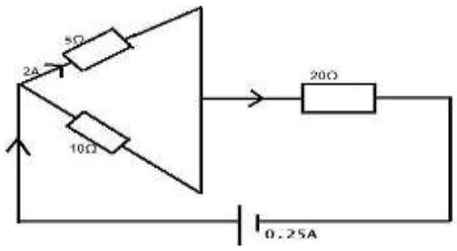
A. 1.8 A. **B.** 1.0 A. **C.** 0.8 A. **D.** 0.3 A. *[2014/43]*

19. **The circuit below illustrates a standard resistor R, voltage source E and a lamp L connected in series. If the temperature of R is increased, the brightness of the lamp will**



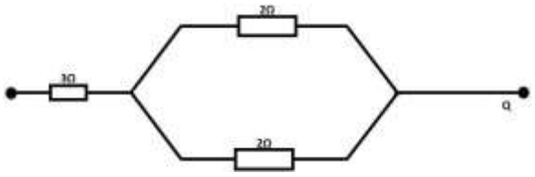
A. increase sharply. **B.** decrease slightly. **C.** remain the same. **D.** increase gradually. *[2014/46]*

20. **Using the data on the diagram below, calculate the potential difference across the 20-Ω resistor. (Neglect the internal resistance of the cell)**



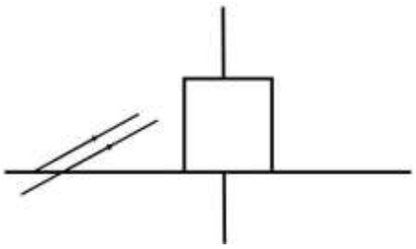
A. 5V. **B.** 10V. **C.** 2.0V. **D.** 60V. *[1999/31]*

21. **Calculate the effective resistance between P and Q in the diagram shown below.**



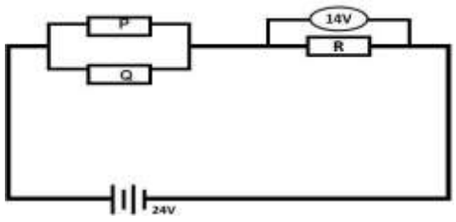
A. 0.75 Ω. **B.** 4.00 Ω. **C.** 5.00 Ω. **D.** 7.00 Ω. *[2007/42]*

22. **The Symbol illustrated below is that of a resistor**



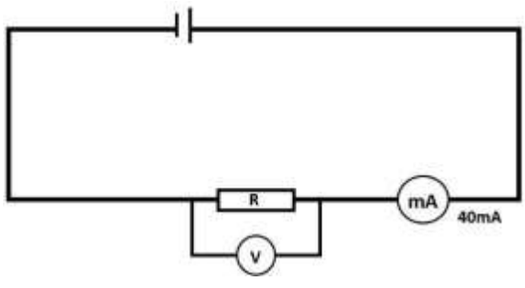
A. which absorbs light. **B.** which emits light. **C.** which absorbs heat to function properly. **D.** whose resistance is light dependent. *[2015/39]*

23. **A battery of e.m.f 24 V is connected to three resistors P, Q and R as illustrated in the diagram below. Determine the voltage across the resistor Q**



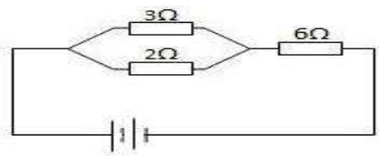
A. 5 V. **B.** 10 V. **C.** 14 V. **D.** 24 V. *[2015/41]*

24. **Using the data in the circuit illustrated below, calculate the value of R.**



A. 0.02Ω. **B.** 0.05Ω. **C.** 5.00Ω. **D.** 50.00Ω. *[1991/46]*

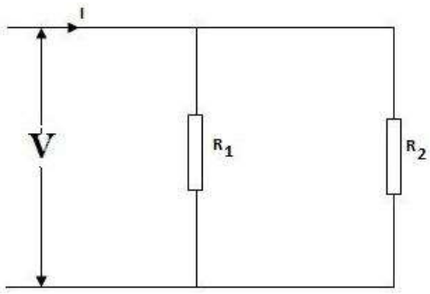
25. *Use the diagram below to answer this question*
In the diagram here, the current passing through the 6Ω resistor is 1.5 A. Calculate the current in the 3Ω resistor



A. 1.20 A. **B.** 0.90 A. **C.** 0.75 A. **D.** 0.60 A. *[2000/38]*

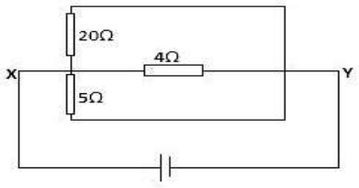
26. A cell of e.m.f. 1.5 V and internal resistance 2.5Ω is connected in series with an ammeter of resistance 0.5Ω and a resistor of resistance 7.0Ω. Calculate the current in the circuit. A. 0.15A. **B.** 0.20A. **C.** 2.10A. **D.** 3.00A. *[1994/35]*

27. A battery of e.m.f. E and negligible internal resistance supplies a current I to the combination of two resistances R_1 and R_2 as shown in the diagram. Calculate the current through R_2



A. $\frac{R_1 I}{R_2}$. **B.** $\frac{R_2 I}{R_1}$. **C.** $\frac{R_2 I}{R_1+R_2}$. **D.** $\frac{R_1 I}{R_1+R_2}$. *[1994/37]*

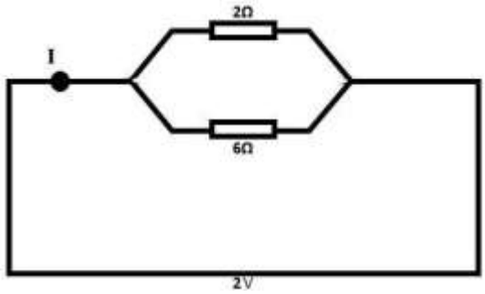
28. Calculate the effective resistance between points X and Y in the diagram



A. 0.5Ω. **B.** 2.0Ω. **C.** 3.0Ω. **D.** 8.0Ω. *[1994/39]*

29. A battery of e.m.f 10v and internal resistance 2Ω is connected to a resistance of 6Ω. Calculate the p.d. across the terminals A. 8.75. **B.** 7.50. **C.** 5.00. **D.** 2.50. *[1994/41]*

30. Calculate the current I in the diagram. (neglect the internal resistance of the cell)

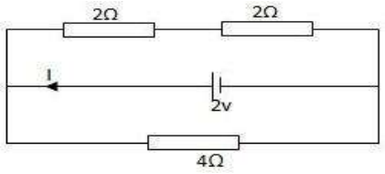


A. 1.0A. **B.** 2.0A. **C.** 2.5A. **D.** 4.0A. *[1994/49]*

31. A resistor of resistance R is connected to a battery of negligible internal resistance. If a similar resistor is connected in series with it the A. effective resistance of the circuit is halved. **B.** total power dissipated is doubled. **C.** total current in the circuit is halved. **D.** terminal voltage is halved. *[2009/38]*

32. A battery of e.m.f. 12.0V and internal resistance 0.5 Ω is connected to 1.5 Ω and 4.0 Ω series resistors. Calculate the terminal voltage of the battery.
A. 13.0 V.**B.** 11.0 V. **C.** 3.0 V. **D.** 1.0 V. *[2009/41]*

33. Calculate the current, I in the diagram shown below. (Neglect the internal resistance of the cell)



A. 4.0A. **B.** 2.0A. **C.** 1. 0A. **D.** 3.0A. *[1993/45]*

34. Which of the following factors does not affect the electric resistance of a wire? A. Length. **B.** Mass. **C.** Temperature. **D.** Cross-sectional area. *[2010/40]*

35. When a resistor of resistance R is connected across a cell, the terminal p.d of the cell is reduced to three quarters of its e.m.f. The internal resistance of the cell is expressed as A. R/4. **B.** R/3. **C.** R/2. **D.** 3R/4. *[1997/43]*

36. Calculate the terminal potential difference across a 20Ω resistor connected to a battery of e.m.f. 15V and internal resistance 5Ω A. 60.0V. **B.** 15.0V. **C.** 12.0V. **D.** 6.3V. *[1997/45]*

37. In a domestic circuit, electrical appliances and lamps are arranged in parallel across the mains so as to enable the A. same current to flow through the electric appliances and the lamps. **B.** maximum energy to be consumed at least cost. **C.** same fuse to be used for the electrical appliances and the lamps. **D.** voltage across the appliances not to be affected when the lamps are switched on and off. *[1992/45]*

38. Two identical cells each of emf 2V and internal resistance 1.0Ω are connected in parallel. The combination is connected to an external load of 1.5Ω. Calculate the current in the circuit.
A. 0.57A. **B.** 1.00A. **C.** 1.14A. **D.** 2.00A. *[2003/35]*

39. Which of the following factors does not affect the electric resistance of a wire? A. Length. **B.** Mass. **C.** Temperature. **D.** Cross sectional area. *[2003/36]*

40. Six dry cells each of emf 2.0 and internal resistance of 1.0 Ω are connected in parallel across a load of 3.0Ω. Calculate the effective current in the circuit.
A. 0.63A. **B.** 0.50A. **C.** 0.31A. **D.** 0.22A. *[2012/37]*

41. A chemical cell of internal resistance 1Ω supplies electric current to an external resistor of resistance 3Ω. Calculate the efficiency of the cell. A. 75%. **B.** 50%. **C.** 33%. **D.** 25%. *[2005/36]*

42. A resistor with fixed resistance value is called a
A. resistance box. **B.** standard resistor. **C.** shunt. **D.** multiplier. *[2018/37]*

43.When two cells of negligible internal resistances and equal e.m.f denoted by E_1 and E_2 are connected in parallel, the combined e.m.f. E is given by A. E = E_1 + E_2 **B.** $\frac{1}{E} = \frac{1}{E_1} + \frac{1}{E_2}$ **C.** E = E_1 = E_2. **D.** $E = \frac{E_1}{E_2}$.
[2020/50]

44. Which of the following units is equivalent to the unit of electric current? A. C s^{-1} **B.** W **C.** J s^{-1} **D.** C
[2021/19]

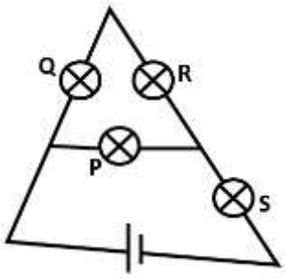
45. An electric circuit consists of a resistor, a battery and a key. If the voltage of the battery is increased, there would be an increase in the
A. current and resistance only. **B.** current, resistance and temperature. **C.** current and temperature only. **D.** resistance and temperature only. *[2021/37]*

46. Three cells each of *emf,* 1.1 *V,* and internal resistance, 2 *Ω,* are connected in parallel across a 3 *Ω* resistor. Determine the current in the resistor. A. *0.*90 *A* **B.** 0.39 *A* **C.** 0.30 *A* **D.** 0.01 *A [2022/23]*

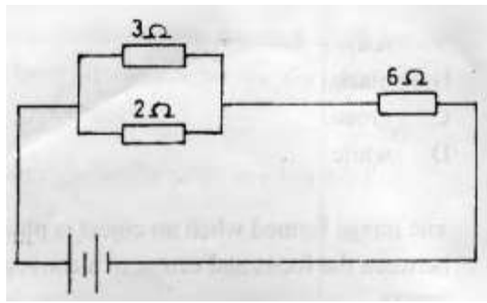
47. A cell of emf 2 *V* has an internal resistance of 0.5 *Ω*. A current of 0.4 *A* passes through an external resistor, P. Determine the resistance of P. A. 5.0 *Ω* **B**. 4.5 *Ω*. **C**. 4.0 *Ω*. **D**. 1.0 *Ω [2023/30]*

48. The function of a fuse in an electric circuit is to A. break the circuit when the current exceeds a certain value. **B.** save energy by reducing the voltage. **C.** ensure that the current in the circuit exceeds a certain value. **D.** save energy by reducing the current. *[2024/8]*

49. In the circuit diagram below, which lamp causes the other to go off? A. P **B**. Q **C**. R **D**. S *[2024/19]*



Use the circuit diagram below to answer question 50 and 51.



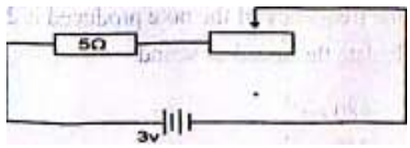
50. The current passing through the 6 Ω resistor is 1.5 A. Calculate the current in the 3 Ω resistor. **A.** 1.20 A **B.** 0.90 A **C.** 0.75 A **D.** 0.60 A *[2025/17]*

51. Calculate the terminal p.d of the battery in the diagram. A. 7.20 V **B.** 7.50 V **C.** 10.80 V **D.** 11.25 V *[2025/18]*

52. Two identical cells each of emf 2 V and internal resistance 0.5 Ω are connected in series with a 4.0 Ω resistor. Calculate the current in the circuit. A. 1.0 A **B.** 0.9 A **C.** 0.8 A **D.** 0.5 A. *[2026/15]*

53. A cell has an opened circuit voltage V_O. When the cell delivers current I, the closed-circuit voltage is V_C. What is the internal resistance of the cell? A. $\frac{V_C}{I}$ **B.** $\frac{V_O}{I}$ **C.** $\frac{V_O - V_C}{I}$ **D.** $\frac{V_C - V_O}{I}$. *[2026/29]*

54. The circuit diagram below consists of a 3.0 *V* battery of negligible internal resistance, a 5 Ω resistor and a rheostat.



To what value must the resistance of the rheostat be adjusted to produce a current of 0.25 *A* through the resistor? A. 4 Ω **B.** 7 Ω **C.** 15 Ω **D.** 20 Ω. *[2026/30]*

Resistivity & Conductivity

Introduction

The resistance of a conductor **R**, the length **l** and the cross sectional area **A** are related by the expression **R =** $\frac{\rho l}{A}$ where ρ is the constant of proportionalilty called resistivity of the conductor.

Examiner's Corner.

1. Candidates often forget or are unable to convert values of length, resistivity and cross-sectional area in centimetres and millimetres to metres before solving when the **units are not same**. Recall that **100cm = 1m and 1000mm = 1m.**
2. When given diameter of conductor, candidates often forget or are unable to determine the cross-sectional area before using the formular **R =** $\frac{\rho l}{A}$**. Recall that area A =** $\frac{\pi d^2}{2}$**.**

Example

1. **A resistance wire of length 2m and of uniform cross-sectional area 5.0 x 10^{-7}m^2 has a resistance of 2.2Ω. Calculate its resistivity A.** 1.8 x 10^{-7}Ωm. **B.** 5.5 x 10^{-7}Ωm. **C.** 1.8 x 10^{-7}Ωm. **D.** 5.5 x 10^{-7}Ωm. *[1999/34]*
   Solution
   Here l = 2m, A = 5.0 x 10^{-7}m^2**,** R = 2.2Ω and we asked to find ρ.
   Recall that **R =** $\frac{\rho l}{A}$ (make ρ the subject of the formular)
   $\rho = \frac{RA}{l} = \frac{2.2\ x\ 5.0\ x\ 10^{-7}}{2}$ **=** 5.5 x 10^{-7}Ωm.

OBJ

1. **Calculate the resistivity of a wire of length 2m and cross-sectional area 0.004 cm^2 if resistance is 3.0 ohm. A.** 0.0000267 ohm cm. **B.** 0.00006 ohm cm. **C.** 0.26700 ohm cm. **D.** 0.37500 ohm cm. *[1988/51]*
2. **An Aluminum cable of diameter 4 x 10^{-3}m and resistivity 3.0 x 10^{-8}Ωm has a resistance of 21 Ω. Calculate the length of the cable (π = 3.14)**
   A. 8.0 x l0^{2}m. **B.** 8.8 x 10^3 m. **C.** 8.0 x 10^4 m. **D.** 8.8 x 10^4 m. *[2016/34]*
3. **A given wire of resistance 10Ω has a length of 5m and a cross-sectional area of 4.0 x 10^{-3}m^2. Calculate the conductivity of the wire A.** 0.80 X 10^7M^{-1}. **B.** 1.25 x 10^7M^{-1}. **C.** 2.02 x 10^7M^{-1}. **D.** 2.50 x 10^7M^{-1}. *[1995/50]*
4. **A wire of resistivity 4.40 x 10^{-5} Ω cm has a cross-sectional area of 7.50 x 10^{-4} cm^2. Calculate the**