11. Electricity - Board Exam Questions

2 Mark Questions

1) *The resistance of a wire of 0.01 cm radius and 1.0 cm length is 7 Ω. Calculate its resistivity.*

r = 0.01 cm = 1×10^{-4} m, l = 1 cm = 0.01 m, R = 7 Ω

R = ρl/A, so ρ = RA/l = R × πr^2/l

ρ = $7 \times (22/7) \times (10^{-4})^2 / 0.01 = 22 \times 10^{-8} / 0.01 = 2.2 \times 10^{-5}$ Ω m

2) *An electric heater is rated 220 V; 11 A. Calculate the power consumed if the heater is operated at 200 V.*

Resistance of the heater: R = V/I = 220/11 = 20 Ω

At 200 V: P = V^2/R = (200 × 200)/20 = 2000 W = 2 kW

3) *(a) Define volt, the unit of potential difference. (b) Calculate the work done required to move an electron between two points A and B located at a potential difference of 100 V in an electric field.*

(a) The potential difference between two points is 1 volt when 1 joule of work is done to move 1 coulomb of charge from one point to the other.

(b) W = Q × V = $1.6 \times 10^{-19} \times 100 = 1.6 \times 10^{-17}$ J (charge of an electron = 1.6×10^{-19} C)

4) *I. State Joule's Law of heating. II. What happens to the heat produced in a conductor if the resistance is doubled while keeping other variables constant?*

I. The heat produced in a resistor is directly proportional to (i) the square of the current, (ii) the resistance, and (iii) the time for which the current flows. H = I^2Rt

II. H = I^2(2R)t = 2 × I^2Rt. The heat doubles.

5) *I. Define resistivity. II. Justify with an example why resistivity is an intrinsic property of a material.*

I. Resistivity (ρ) is the resistance of a wire of unit length and unit area of cross-section. ($R = \rho l/A$)

II. Resistivity depends only on the material, not on its size. Example: two copper wires of different lengths and thicknesses give the same ρ when we work out $R \times A / l$.

6) *A wire of resistance R is cut into three equal parts. If these three parts are then joined in parallel, calculate the total resistance of the combination so formed.*

Each part has resistance R/3.

$1/R_p = 3/R + 3/R + 3/R = 9/R$

$R_p = R/9$

7) *Define electric power. When do we say that the power consumed in an electric circuit is 1 watt?*

Electric power is the rate at which electrical energy is used up in a circuit.

The power is 1 watt when a current of 1 A flows at a potential difference of 1 V.

8) *An electric kettle is rated 750 W; 220 V. Can this kettle be used in a circuit which has a fuse of current rating 3 A? Give reason for your answer.*

$I = P/V = 750/220 = 3.4$ A

No. The kettle draws more current (3.4 A) than the fuse rating (3 A), so the fuse will melt and break the circuit.

9) *An electric kettle is rated 230 V; 1000 W. Calculate the resistance of its heating element when in operation.*

$P = V^2/R$, so $R = V^2/P = (230 \times 230)/1000 = 52.9\ \Omega$

10) *(A) State two applications of Joule's heating in domestic electric circuit. (B) (a) Establish the relationship between the commercial unit of electric energy and the SI unit of electric energy. OR (B) (b) Determine the*

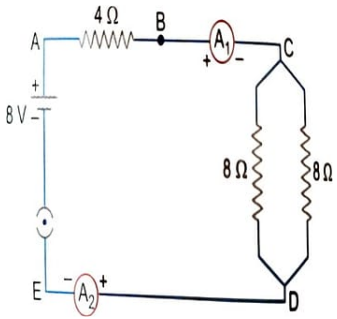
total resistance of the parallel combination of three resistances of 2 Ω, 4 Ω and 6 Ω.

(A) Electric bulb and electric iron

(B) (a) 1 kWh = 1000 W × 3600 s = 3.6×10^6 W s = 3.6×10^6 J

OR (B) (b) $1/R_p = 1/2 + 1/4 + 1/6 = 11/12$, so $R_p = 12/11 = 1.09$ Ω

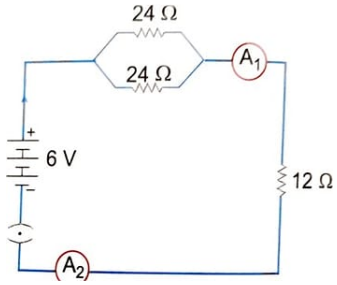
11) *Find out the following in the electric circuit given in the figure- (i) Effective resistance of two 8 ohm resistors in the combination. (ii) Current flowing through the 4-ohm resistor*



(i) The two 8 Ω resistors are in parallel: R = (8 × 8)/(8 + 8) = 4 Ω

(ii) Total R = 4 + 4 = 8 Ω, so I = V/R = 8/8 = 1 A. The same current flows through the 4 Ω resistor.

12) *Study the circuit and find out- (i) Current in 12 ohm resistor (ii) Difference in the readings of ammeter A_1 and A_2 if any*



(i) The two 24 Ω resistors in parallel: $1/R_p = 1/24 + 1/24$, so $R_p = 12$ Ω

Total R = 12 + 12 = 24 Ω, so I = V/R = 6/24 = 0.25 A

(ii) No difference. A_1 and A_2 show the same reading (they are in series).

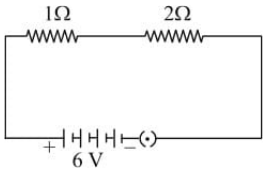
13) *Show how you would connect three resistors each of resistance 6 Ω, so that the combination has a resistance of 9 Ω. Also justify your answer.*

Connect two 6 Ω resistors in parallel, and the third 6 Ω resistor in series with them.

Parallel part: $1/R_p = 1/6 + 1/6$, so $R_p = 3\ \Omega$

Total: $3 + 6 = 9\ \Omega$

14) *In the given circuit calculate the power consumed in watts in the resistor of 2 Ω:*

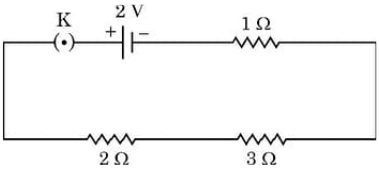


Total resistance = 1 + 2 = 3 Ω

I = V/R = 6/3 = 2 A

Power in the 2 Ω resistor: $P = I^2R = 2^2 \times 2 = 8$ W

15) *Use Ohm's law to determine the potential difference across the 3 Ω resistor in the circuit shown in the following diagram when key is closed:*



Total resistance $R_s = 1 + 2 + 3 = 6\ \Omega$

I = V/R = 2/6 = 1/3 A

Potential difference across 3 Ω: $V = IR = 1/3 \times 3 = 1$ V

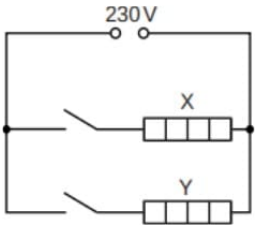
16) *Two wires A and B of same material, having same lengths and diameters 0.2 mm and 0.3 mm respectively, are connected one by one in a circuit. Which one of these two wires will offer more resistance to the flow of current in the circuit? Justify your answer.*

Wire A. $R = \rho l/A$, so a thinner wire (smaller area A) has more resistance. Wire A is thinner.

17) *An electric source can supply a charge of 500 coulomb. If the current drawn by a device is 25 mA, find the time in which the electric source will be discharged completely.*

Q = I × t, so t = Q/I = 500 / (25/1000) = 20000 s

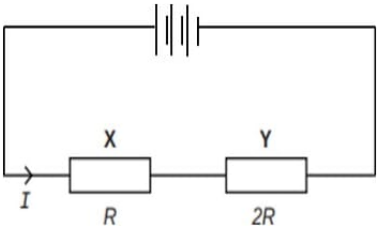
18) *The electric circuit (above figure) in a clothes dryer contains two heaters X and Y in parallel. The above figure shows the circuit connected to a 230 V power supply. When both switches are closed, the current in X is 3.5 A. Analyse the circuit given above and answer the following questions. (i) Calculate the power developed in heater X. (ii) If the resistance of X is double that of Y calculate the current in heater Y.*



(i) P = VI = 230 × 3.5 = 805 W

(ii) Both heaters have the same voltage (parallel). Y has half the resistance of X, so it carries double the current: 7.0 A.

19) *The given figure shows two resistors X and Y connected in series to a battery. The power dissipated for this combination is P_1. When these resistors are connected in parallel to the same battery then the power dissipated is given by P_2. Find out the ratio P_1/P_2.*

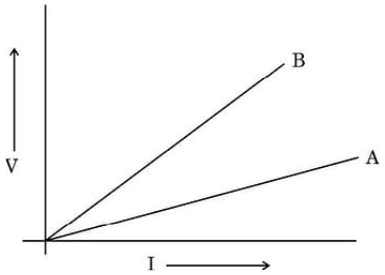


Series: total resistance = R + 2R = 3R, so $P_1 = V^2/3R$

Parallel: total resistance = (R × 2R)/(R + 2R) = 2R/3, so $P_2 = V^2/(2R/3) = 3V^2/2R$

$P_1/P_2 = (V^2/3R) / (3V^2/2R) = 2/9$

20) *V – I graph for two conducting wires A and B are as shown. If both wires are of the same length and same diameter, which of the two is made of a material of high resistivity? Give reasons to justify your answer.*



Wire B. Its graph is steeper, so it has more resistance. For wires of the same size, more resistance means higher resistivity.

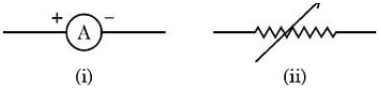
21) *Let the resistance of an electrical device remain constant, while the potential difference across its two ends decreases to one fourth of its initial value. What change will occur in the current through it? State the law which helps us in solving the above stated question.*

The current also becomes one fourth.

Ohm's law: the potential difference across a conductor is directly proportional to the current through it, if the temperature stays the same.

3 Mark Questions

1) *(a) Explain the statement "Potential difference between two points is 1 volt". (b) What do the symbols given below represent in an electric circuit? Write one function of each.*

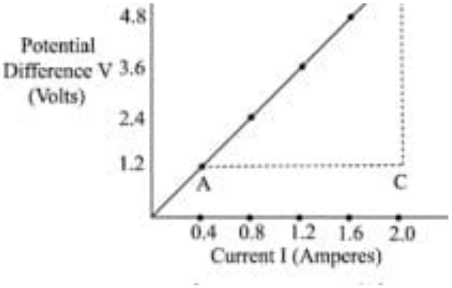


(a) It means 1 joule of work is done to move 1 coulomb of charge from one point to the other.
(b) (i) Ammeter: measures electric current.
(ii) Rheostat: changes the resistance (and so the current) in the circuit.

2) *(a) Name a device which is used to: (i) Maintain a constant potential difference in a circuit. (ii) Change the electric current in an electric circuit. (b) When the potential difference between the terminals of an electric heater is 110 V, a current of 5 A flows through it. What will be the value of current flowing through it when the potential difference is increased to 220 V?*
(a) (i) Battery (cell) (ii) Rheostat
(b) R = V/I = 110/5 = 22 Ω
At 220 V: I = V/R = 220/22 = 10 A

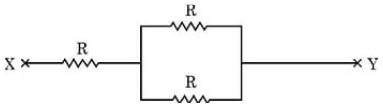
3) *The values of current I flowing in a given resistor for the corresponding values of potential difference V applied across the ends of resistor are given below in the table. Plot a graph between V and I and calculate the resistance of that resistor.*

I (Amperes)	0.4	0.8	1.2	1.6	2.0
V (Volts)	1.2	2.4	3.6	4.8	6.0



Resistance = slope of the V–I graph
R = (6.0 − 1.2)/(2.0 − 0.4) = 4.8/1.6 = 3 Ω

4) *(a) State Ohm's law. Write formula for the equivalent resistance R_p of the parallel combination of three resistors of values R_1, R_2 and R_3. (b) Find the resistance of the following network of resistors.*



(a) Ohm's law: the potential difference V across a metal wire is directly proportional to the current through it, if its temperature stays the same.

$1/R_p = 1/R_1 + 1/R_2 + 1/R_3$

(b) The two R resistors in parallel give R/2, and this is in series with R:

$R + R/2 = 3R/2$

5) *A. State the relationship between the resistance R of a wire to its length l and cross sectional area A. Use the mathematical symbols to arrive at the final formula. B. Using the formula define the resistivity of a material.*

A. $R \propto l$ (longer wire, more resistance) and $R \propto 1/A$ (thicker wire, less resistance).

So $R \propto l/A$, which gives $R = \rho l/A$, where ρ is the resistivity.

B. $\rho = RA/l$. If $l = 1$ m and $A = 1$ m^2, then $\rho = R$.

So resistivity is the resistance of a wire 1 m long with a cross-section of 1 m^2.

6) *(a) Write the relationship between resistivity and resistance of a cylindrical conductor of length l and area of cross-section A. Hence derive the SI unit of resistivity. (b) Why are alloys used in electrical heating devices?*

(a) $R = \rho l/A$, so $\rho = RA/l$

Unit of ρ = ohm × metre^2 / metre = ohm metre (Ω m)

(b) Alloys have higher resistivity than pure metals (and do not burn easily at high temperature).

7) *The electrical resistivity of three materials A, B and C at 20°C is given below. (i) Classify these materials as conductor, alloy and insulator. (ii) Give one example of each of these materials and state one use of each material in the design of an electrical appliance say an electric stove or an electric iron.*

Material	Resistivity (Ω m)
A	10^{17}
B	44×10^{-6}
C	1.62×10^{-8}

(i) A: insulator B: alloy C: conductor

(ii) A: plastic, for the handle of an electric iron.

B: nichrome, for the heating element of an electric iron.

C: copper, for the connecting wires.

8) *The resistance of a wire of 0.01 cm radius is 7 ohms. If the resistivity of the material of the wire is 44×10^{-6} ohm meter, calculate the length of the wire.*

$r = 0.01$ cm $= 1 \times 10^{-4}$ m, $R = 7\ \Omega$, $\rho = 44 \times 10^{-6}\ \Omega$ m

$A = \pi r^2$, and $R = \rho l/A$, so $l = RA/\rho$

$l = 7 \times (22/7) \times (10^{-4})^2 / (44 \times 10^{-6}) = 0.5 \times 10^{-2}$ m $= 0.5$ cm

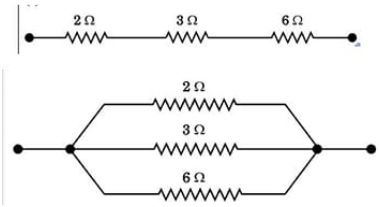
9) *A student needs to make a 0.12 Ω resistor. She has some copper wire of 0.80 mm diameter. Resistivity of copper is 1.8×10^{-8} Ωm (i) Determine the cross-sectional area of the wire. (ii) Calculate the length of wire required for the 0.12 Ω resistor.*

(i) Radius $= 0.40$ mm $= 0.40 \times 10^{-3}$ m

$A = \pi r^2 = 3.14 \times (0.40 \times 10^{-3})^2 = 3.14 \times 0.16 \times 10^{-6} \approx 5 \times 10^{-7}$ m^2

(ii) $l = RA/\rho = (0.12 \times 5 \times 10^{-7}) / (1.8 \times 10^{-8}) = 6/1.8 = 3.33$ m

10) *Three resistors of 2 Ω, 3 Ω and 6 Ω are connected in (i) series, and (ii) parallel. Draw the arrangements of the resistors and find the equivalent resistance of each arrangement.*



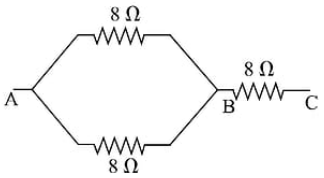
(i) Series: $R_s = 2 + 3 + 6 = 11\ \Omega$

(ii) Parallel: $1/R_p = 1/2 + 1/3 + 1/6 = 6/6 = 1$, so $R_p = 1\ \Omega$

11) *(a) Why does an electric bulb become dim when an electric heater in parallel circuit is switched ON? (b) How to connect three resistors each of resistance 8 Ω, so that the equivalent resistance of the combination is 12 Ω? Draw diagram of the combination and justify your answer.*

(a) The heater draws a large current. So less current reaches the bulb, and it glows dimly.

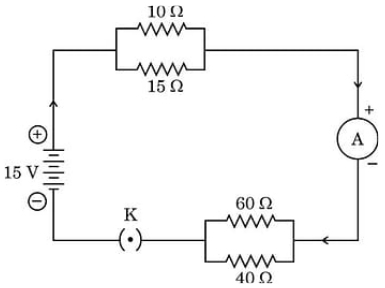
(b) Connect two 8 Ω resistors in parallel, and the third 8 Ω resistor in series with them.



Parallel part: $1/R_1 = 1/8 + 1/8$, so $R_1 = 4\ \Omega$

Total: $R_{eq} = 4 + 8 = 12\ \Omega$

12) *Consider the following electric circuit. Calculate the values of the following: (a) The total resistance of the circuit (b) The total current drawn from the source (c) Potential difference across the parallel combination of 10 Ω and 15 Ω resistors*



(a) 10 Ω and 15 Ω in parallel: $1/R_1 = 1/10 + 1/15 = 1/6$, so $R_1 = 6$ Ω

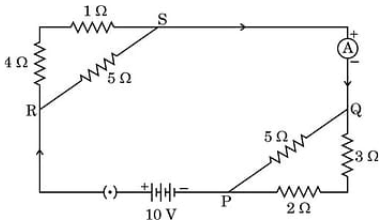
60 Ω and 40 Ω in parallel: $1/R_2 = 1/60 + 1/40 = 1/24$, so $R_2 = 24$ Ω

R_1 and R_2 in series: total = 6 + 24 = 30 Ω

(b) $I = V/R = 15/30 = 0.5$ A

(c) $V = I \times R_1 = 0.5 \times 6 = 3.0$ V

13) *Consider the given electric circuit. Calculate the following: (a) Total resistance of the circuit (b) The electric current drawn from the battery (c) Potential difference between points P and Q*



(a) 4 Ω + 1 Ω = 5 Ω, in parallel with 5 Ω: $1/R_1 = 1/5 + 1/5$, so $R_1 = 5/2$ Ω (between R and S)

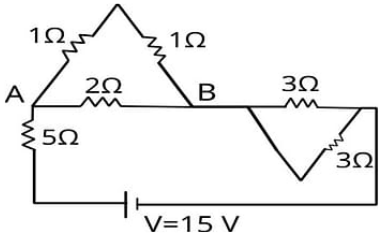
2 Ω + 3 Ω = 5 Ω, in parallel with 5 Ω: $R_2 = 5/2$ Ω (between P and Q)

Total: $R = 5/2 + 5/2 = 5$ Ω

(b) $I = V/R = 10/5 = 2$ A

(c) $V_{PQ} = I \times R_2 = 2 \times 5/2 = 5$ V

14) *The figure shows a circuit with a 15 V battery connected to several resistors. Using the given circuit diagram: A. Find the total current supplied by the battery. B. Calculate the potential difference between points A and B.*



A. The two 1 Ω resistors in series make 2 Ω. This is in parallel with 2 Ω: 1/R = 1/2 + 1/2, so R_{AB} = 1 Ω.

The two 3 Ω resistors in parallel: 1/R = 1/3 + 1/3, so R = 1.5 Ω.

5 Ω, 1 Ω and 1.5 Ω are in series: R_s = 5 + 1 + 1.5 = 7.5 Ω

I = V/R = 15/7.5 = 2 A

B. $V_{AB} = I \times R_{AB} = 2 \times 1 = 2$ V

15) *Explain in brief the function of an electric fuse in a domestic circuit. An electric heater of current rating 3 kW; 220 V is to be operated in an electric circuit of rating 5 A. What is likely to happen when the heater is switched 'ON'? Justify your answer with necessary calculation.*

A fuse protects the appliances and the circuit from damage due to overloading and short-circuiting. It melts and breaks the circuit when too much current flows.

I = P/V = 3000/220 = 13.63 A

This is much more than 5 A, so the fuse wire will melt and break the circuit.

16) *(i) State the law that explains the heating effect of current with respect to the measurable properties in an electrical circuit. (ii) List the factors on which the resistance of a conductor depends.*

(i) Joule's law of heating: the heat produced in a resistor is directly proportional to (a) the square of the current, (b) the resistance, and (c) the time for which the current flows. $H = I^2Rt$

(ii) The length of the conductor, its area of cross-section (and the material it is made of).

4 Mark Questions (Case Study)

1) *Three students Shweta, Ayesha and Samridhi were performing an experiment to understand the factors on which the resistance of a conductor depends. Each one of them completed electric circuit with the help of a cell, an ammeter, a plug key and wire. Shweta put nichrome wire of length 'l' in the circuit and after plugging the key, noted current in the ammeter. Ayesha put nichrome wire of same thickness but twice the length i.e. '2l' in the circuit and after plugging the key, noted current in the ammeter. Samridhi took copper wire of length 'l' and same thickness in the circuit and after plugging the key, noted current in the ammeter.*
(a) If the ammeter reading is X ampere with nichrome wire of length 'l', then what will be the ammeter reading if the length of nichrome wire is doubled with same area of cross-section? (1)

X/2 (half). Doubling the length doubles the resistance.

(b) What happens to the ammeter reading if the area of cross-section of nichrome wire is doubled, keeping the length of wire 'l' the same? (1)

2X (double). Doubling the area halves the resistance.

(c) Define 'resistivity'. Write its SI unit. Compare the resistivity of an alloy with its constituents metals. (2)

Resistivity is the resistance of a conductor of unit length and unit area of cross-section.

SI unit: ohm metre (Ω m)

An alloy has higher resistivity than the metals it is made of.

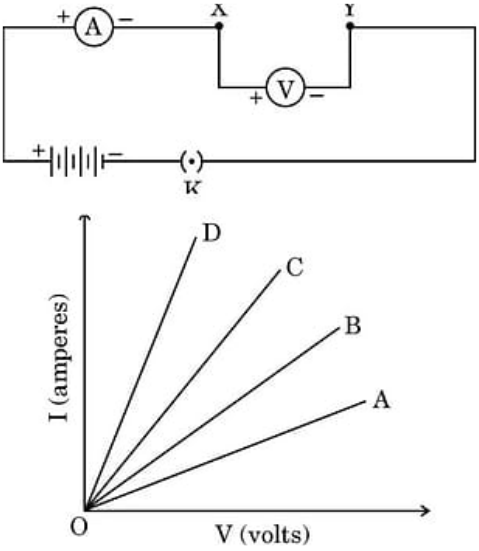
OR (c) Give reason: (i) Tungsten is used almost exclusively for making the filament of electric lamps. (ii) Conductors of bread-toasters are made of an alloy rather than a pure metal.

(i) Tungsten has a very high melting point.

(ii) An alloy has higher resistivity than pure metals (and does not burn easily when hot).

2) *As shown in the diagram, an electric circuit consisting of an ammeter, a voltmeter, 4 cells of 1.5 V each, a plug key with a gap XY was set up.*

Voltmeter and ammeter readings were recorded in the observation table for four arrangements as given below: Arrangement No. 1 – only resistor R_1 in gap XY; Arrangement No. 2 – only resistor R_2 in gap XY; Arrangement No. 3 – Resistors R_1 and R_2 in series in gap XY; Arrangement No. 4 – Resistors R_1 and R_2 in parallel in gap XY. Based on the observations, four V – I graphs A, B, C and D as shown in figure were drawn. Study these graphs.



(a) Which one of the graphs represents the series combination of R_1 and R_2? (1)

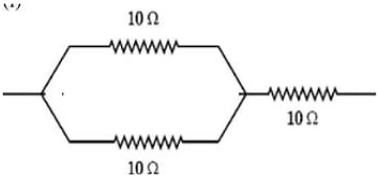
Graph A (steepest, so the most resistance).

(b) Which one of these graphs represents the parallel combination of R_1 and R_2? (1)

Graph D (least steep, so the least resistance).

(c) (i) Show an arrangement of three resistors, each of resistance 10 Ω, so that the combination has a resistance of 15 Ω. Give justification for your answer. (2)

Connect two 10 Ω resistors in parallel, and the third 10 Ω resistor in series with them.



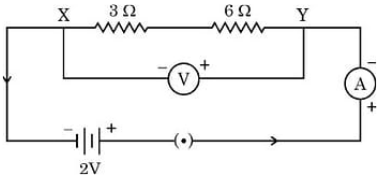
R = (10 × 10)/(10 + 10) + 10 = 5 + 10 = 15 Ω

OR (c) (ii) A battery of 6 V is connected with a series combination of five resistors of 0.1 Ω, 0.2 Ω, 0.3 Ω, 0.4 Ω and 0.5 Ω. How much current would flow through the 0.3 Ω resistor? Justify your answer.

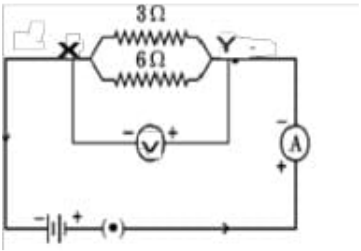
Total R = 0.1 + 0.2 + 0.3 + 0.4 + 0.5 = 1.5 Ω, so I = 6/1.5 = 4.0 A.

In series, the same current flows through every resistor, so 4.0 A flows through the 0.3 Ω resistor.

3) *Study the circuit shown in which two resistors X and Y of resistances 3 Ω and 6 Ω respectively are joined in series with a battery of 2 V.*



(I) Draw a circuit diagram showing the above two resistors X and Y joined in parallel with same battery and same ammeter and voltmeter. (1)



(II) In which combination of resistors will the (i) potential difference across X and Y and (ii) current through X and Y, be the same? (1)

(i) Parallel combination (ii) Series combination

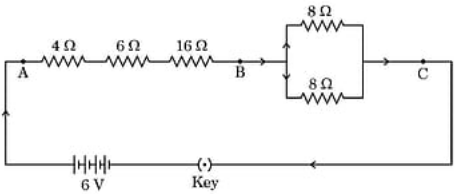
(III) (a) Find the current drawn from the battery by the series combination of the two resistors (X and Y). (2)

R = 3 + 6 = 9 Ω, so I = V/R = 2/9 = 0.22 A

OR (III) (b) Determine the equivalent resistance of the parallel combination of the two resistors (X and Y).

1/R = 1/3 + 1/6 = 9/18, so R = 2 Ω

4) *Study the following circuit. On the basis of this circuit, answer the following questions:*



(a) Find the value of total resistance between the points A and B. (1)

They are in series: R_s = 4 + 6 + 16 = 26 Ω

(b) Find the resistance between the points B and C. (1)

Two 8 Ω in parallel: $1/R_p = 1/8 + 1/8 = 1/4$, so R_p = 4 Ω

(c) (i) Calculate the current drawn from the battery, when the key is closed. (2)

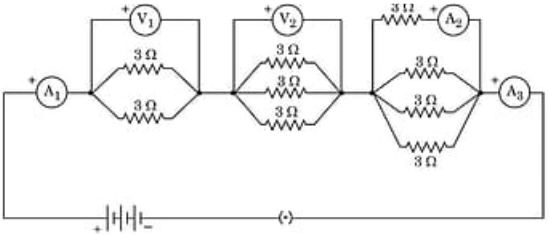
Total resistance = 26 + 4 = 30 Ω, so I = V/R = 6/30 = 0.2 A

OR (c) (ii) In the above circuit, the 16 Ω resistor or the parallel combination of two resistors of 8 Ω, which one of the two will have more potential difference across its two ends? Justify your answer.

The 16 Ω resistor. The same current flows through both, so the bigger resistance has the bigger potential difference.

Across 16 Ω: V = 0.2 × 16 = 3.2 V. Across the 8 Ω pair (4 Ω): V = 0.2 × 4 = 0.8 V.

5) *Consider the following electrical circuit diagram in which nine identical resistors of 3 Ω each are connected as shown. If the reading of the ammeter A_1 is 1 ampere, answer the following questions:*



(a) What is the relationship between the readings of A_1 and A_3? Give reasons for your answer. (1)

$A_1 = A_3$, because they are in series (the same current flows through both).

(b) What is the relationship between the readings of A_2 and A_3? (1)

A_2 = ¼ of A_3 (0.25 A). The current divides equally among the four identical resistors.

(c) Determine the reading of the voltmeter V_1. (2)

Two 3 Ω in parallel: $1/R_p = 1/3 + 1/3$, so $R_p = 3/2$ Ω

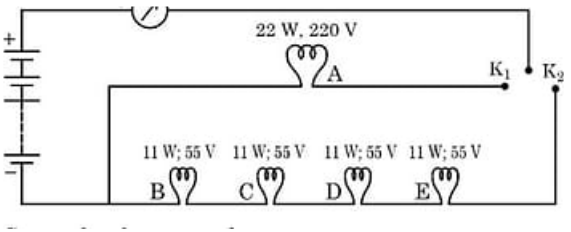
$V_1 = IR = 1 \times 3/2 = 1.5$ V

OR (c) Find the total resistance of the circuit.

Two 3 Ω in parallel: 3/2 Ω. Three in parallel: 1 Ω. Four in parallel: 3/4 Ω.

Total: R = 3/2 + 1 + 3/4 = 3.25 Ω

6) *In a domestic circuit five LED bulbs are arranged as shown. The source voltage is 220 V and the power rating of each bulb is marked in the circuit diagram. Based on the following circuit diagram, answer the following questions:*



(a) State what happens when (i) key K_1 is closed. (ii) key K_2 is closed. (1)

(i) Bulb A glows. (ii) Bulbs B, C, D and E glow.

(b) Find the current drawn by the bulb B when it glows. (1)

P = VI, so I = P/V = 11/55 = 0.2 A

(c) Calculate (i) the resistance of bulb B, and (ii) total resistance of the combination of four bulbs B, C, D and E. (2)

(i) R = V/I = 55/0.2 = 275 Ω

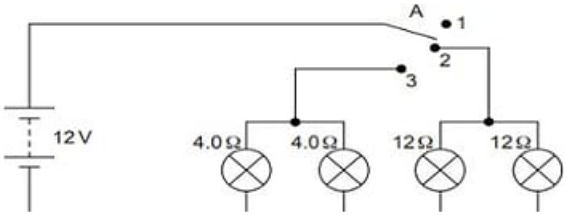
(ii) They are in series: 4 × 275 = 1100 Ω

OR (c) What would happen to the glow of all the bulbs in the circuit when keys K_1 and K_2 both are closed and the bulb C suddenly get fused? Give reason to justify your answer.

Bulb A keeps glowing as before. Bulbs B, D and E stop glowing.

B, D and E are in series with C, so when C fuses, no current flows through them. A is in a separate parallel branch, so it is not affected.

7) *Vinita and Ahmed demonstrated a circuit that operates the two headlights and the two sidelights of a car, in their school exhibition. Based on their demonstrated circuit, answer the following questions.*



(i) State what happens when switch A is connected to a) Position 2 b) Position 3 (1)

a) Only the 12 Ω lamps are on. b) Only the 4 Ω lamps are on.

(ii) Find the potential difference across each lamp when lit. (1)

12 V for every lamp, because all the lamps are in parallel with the battery.

(iii) Calculate the current a) in each 12 Ω lamp when lit. b) In each 4 Ω lamp when lit. (2)

a) I = V/R = 12/12 = 1 A

b) I = V/R = 12/4 = 3 A

OR (iv) Show, with calculations, which type of lamp, 4.0 Ω or 12 Ω, has the higher power.

$P = V^2/R$, and V is the same (12 V) for all lamps.

4 Ω lamp: $P = (12 \times 12)/4 = 36$ W. 12 Ω lamp: $P = (12 \times 12)/12 = 12$ W.

The 4 Ω lamps have the higher power.

8) *Swati, a class 10 student, observes that when she passes close to the refrigerator in her kitchen, she feels the heat, although the things kept inside the refrigerator are cool.*

(a) Describe the cause of heating in the above-mentioned case. (1)

Only part of the electrical energy does useful work. The rest turns into heat and warms the appliance (heating effect of current).

(b) A current I flows through a resistor of resistance R when the potential difference across it is V. Applying Ohm's law, write the formula for amount of heat produced by the resistor in time t. (1)

$H = VIt$, and $V = IR$, so $H = I^2Rt$

(c) (i) Write any two practical applications of heating effect of electric current. (2)

(refer 10th 2 mark question)

OR (c) (ii) Define the commercial unit of electric energy and express it in Joules (J).

1 kWh is the energy used when 1 kilowatt of power is used for 1 hour.

$1 \text{ kWh} = 3.6 \times 10^6$ J (refer 10th 2 mark question)

9) *When electric current flows in a purely resistive circuit electrical energy gets fully converted into heat energy. The amount of heat produced (H) in the circuit is found to be directly proportional to (i) the square of current (I^2) (ii) the resistance (R) of the conductor and (iii) the time (t) for which current flows. In other words $H = I^2Rt$. Electrical devices such an electric fuse, electric heater, electric iron etc. are all based on this effect called heating effect of electric current.*

(a) List two properties of heating elements. (1)

High resistivity, and they do not burn (oxidise) at high temperatures.

(b) List two properties of electric fuse. (1)

High resistivity and a low melting point.

(c) Name the principle on which an electric fuse works. Explain how a fuse wire is capable of saving electrical appliances from getting damaged due to accidently produced high currents. (2)

The heating effect of electric current.

When too much current flows by accident, the fuse wire gets hot, melts and breaks the circuit, so no current reaches the appliances.

OR (c) The power of an electric heater is 1100 W. If the potential difference between the two terminals of the heater is 220 V, find the current flowing in the circuit. What will happen to an electric fuse of rating 5 A connected in this circuit?

I = P/V = 1100/220 = 5 A

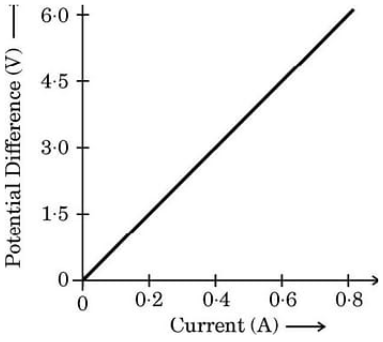
The current is equal to the fuse rating, so the 5 A fuse will not melt.

5 Mark Questions

1) *(a) State Ohm's Law.*

(b) Name and define the physical quantity determined by the slope of V – I curve given in the diagram. Use this graph to find the value of this physical quantity in SI units.

(c) Establish the relationship between 1 kWh and 1 joule.



(a) (refer 4th 3 mark question)

(b) Resistance: the property of a conductor to oppose the flow of charges.

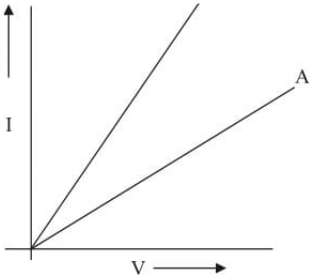
R = slope = (6 − 0)/(0.8 − 0) = 7.5 Ω

(c) (refer 10th 2 mark question)

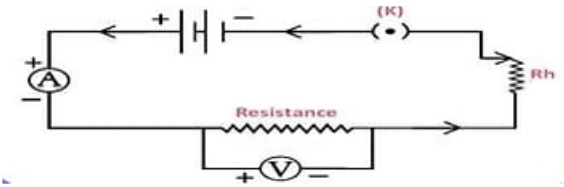
2) *(i) How is electric current related to the potential difference across the terminals of a conductor? Draw a labelled circuit diagram to verify this relationship.*

(ii) Why should an ammeter have low resistance?

(iii) Two V - I graphs A and B for series and parallel combinations of two resistors are as shown. Giving reason state which graph shows (a) series, (b) parallel combination of the resistors.



(i) The current through a conductor is directly proportional to the potential difference across it (V ∝ I).



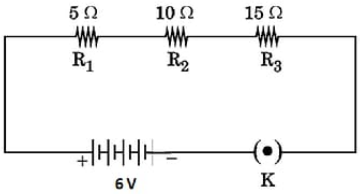
(ii) An ammeter is connected in series, so it must not add to the resistance of the circuit.

(iii) (a) Series: graph A, which has less slope, so more resistance.

(b) Parallel: graph B, which has more slope, so less resistance.

3) *(i) The potential difference across the two ends of a circuit component is decreased to one-third of its initial value, while its resistance remains constant. What change will be observed in the current flowing through it? Name and state the law which helps us to answer this question.*
(ii) Draw a schematic diagram of a circuit consisting of a battery of four 1.5 V cells, a 5 Ω resistor, a 10 Ω resistor and a 15 Ω resistor and a plug key, all connected in series. Now find (I) the electric current passing through the circuit, and (II) potential difference across the 10 Ω resistor when the plug key is closed.
(i) The current also becomes one-third.

Ohm's law: the potential difference across a conductor is directly proportional to the current through it, if the temperature stays the same.
(ii)



$V = 4 \times 1.5 = 6$ V; $R_s = 5 + 10 + 15 = 30\ \Omega$
(I) $I = V/R = 6/30 = 0.2$ A
(II) $V = IR = 0.2 \times 10 = 2$ V

4) *(i) What is meant by resistance of a conductor? Define its SI unit.*
(ii) List two factors on which the resistance of a rectangular conductor depends.
(iii) How will the resistance of a wire be affected if its (1) length is doubled, and (2) radius is also doubled? Give justification for your answer.
(i) Resistance is the property of a conductor to oppose the flow of charges through it.

1 ohm: the resistance of a conductor when a potential difference of 1 V across it makes a current of 1 A flow.

(ii) (refer 16th 3 mark question)
(iii) $R = \rho l/A = \rho l/\pi r^2$
(1) Length doubled: $R' = \rho(2l)/\pi r^2 = 2R$. The resistance doubles.
(2) Radius also doubled: $R' = \rho(2l)/\pi(2r)^2 = R/2$. The resistance becomes half.

5) *(i) Due to change in length and area of cross-section of a conductor, resistance of conductor changes while resistivity does not change. Why?*
(ii) Conductors of electric toasters and electric iron are made of an alloy rather than a pure metal. Why?
(iii) Define the S.I. unit of electric current.
(i) $R = \rho l/A$, so resistance changes when the length or area changes. But resistivity is a property of the material itself, so it does not change.
(ii) (refer 6th 3 mark question)
(iii) 1 ampere is the current when 1 coulomb of charge flows in 1 second.

6) *(i) Write the relation between resistance R and electrical resistivity ρ of the material of a conductor in the shape of cylinder of length l and area of cross-section A. Hence derive the SI unit of electrical resistivity.*
(ii) The resistance of a metal wire of length 3 m is 60 Ω. If the area of cross-section of the wire is 4×10^{-7} m^2, calculate the electrical resistivity of the wire.
(iii) State how would electrical resistivity be affected if the wire (of part 'ii') is stretched so that its length is doubled. Justify your answer.
(i) (refer 6th 3 mark question)
(ii) $\rho = RA/l = (60 \times 4 \times 10^{-7})/3 = 80 \times 10^{-7}\ \Omega\ m = 8 \times 10^{-6}\ \Omega\ m$
(iii) The resistivity does not change. It depends only on the material, not on the size of the wire.

7) *(i) When is the potential difference between two points said to be 1 volt?*
(ii) A copper wire has a diameter of 0.2 mm and resistivity of $1.6 \times 10^{-8}\ \Omega$

m. What will be the length of this wire to make its resistance 14 Ω? How much does the resistance change, if the diameter of the wire is doubled?
(i) (refer 1st 3 mark question)
(ii) d = 0.2 mm = 2×10^{-4} m, R = 14 Ω, ρ = 1.6×10^{-8} Ω m, A = $\pi d^2/4$

l = RA/ρ = $\pi d^2 R/4\rho$ = $(22/7) \times (2 \times 10^{-4})^2 \times 14 / (4 \times 1.6 \times 10^{-8})$ = 27.5 m

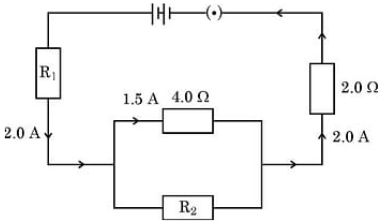
If the diameter is doubled, the area becomes 4 times, so R′ = R/4 = 3.5 Ω.

The resistance decreases by 14 − 3.5 = 10.5 Ω.

8) *(i) How many bulbs of resistance 8 Ω each should be connected in parallel combination to draw a current of 2 A from a battery of 4 V?*
(ii) Name the device used for measuring electric current. How is it connected in a circuit?
(iii) State Joule's law of heating.
(i) Total resistance needed: R = V/I = 4/2 = 2 Ω

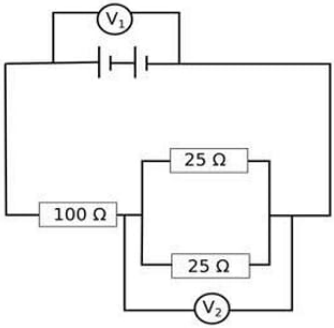
For n bulbs of 8 Ω in parallel: 1/R = n/8, so 1/2 = n/8 and n = 4. Four bulbs are needed.
(ii) Ammeter. It is connected in series.
(iii) (refer 16th 3 mark question)

9) *(i) The given electric circuit is a part of an electrical device. Use the information given in the electric circuit diagram to calculate: (I) Potential difference across the ends of resistor R_2. (II) Value of resistor R_2. (III) Value of resistor R_1.*
(ii) Write the factors on which resistance of a conductor depends and derive the formula for resistance of a given conductor.



(i) (I) R_2 is in parallel with the 4 Ω resistor, which carries 1.5 A. So V across R_2 = 1.5 × 4 = 6 V.
(II) Current through R_2 = 2.0 − 1.5 = 0.5 A, so R_2 = 6/0.5 = 12 Ω
(III) V across the 2 Ω resistor = 2 × 2 = 4 V. V across R_1 = 12 − (6 + 4) = 2 V, so R_1 = 2/2 = 1 Ω
(ii) (refer 5th 3 mark question)

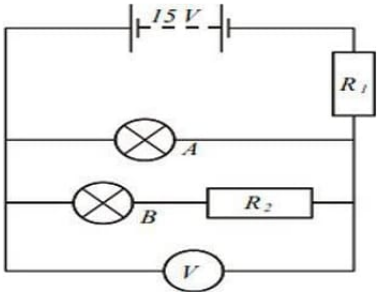
10) *The arrangement of resistors shown in the above figure is connected to a battery. The power dissipation in the 100 Ω resistor is 81 W. Calculate*
(i) the current in the circuit
(ii) the reading in the voltmeter V_2
(iii) the reading in the voltmeter V_1



(i) P = I^2R, so 81 = I^2 × 100, I^2 = 0.81 and I = 0.9 A
(ii) Two 25 Ω in parallel: 1/R = 1/25 + 1/25, so R = 12.5 Ω
V_2 = 0.9 × 12.5 = 11.25 V
(iii) V across 100 Ω = 0.9 × 100 = 90 V
V_1 = 90 + 11.25 = 101.25 V

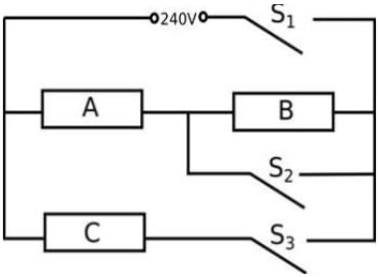
11) *As shown in the figure above A and B are two lamps. Lamp A is rated at 12 V, 24W. Lamp B is rated at 6.0 V. When lamp B operates at its rated voltage, the current in it is 3.0 A. The values of R_1 and R_2 are chosen so that both lamps operate at their rated voltages.*
(i) Calculate the current in Lamp A.
(ii) State and give reason for the reading of the Voltmeter.

(iii) Calculate the resistance of R_2.
(iv) Find the value of the resistance R_1.



(i) I = P/V = 24/12 = 2 A
(ii) 12 V. Lamp A and the branch with lamp B are in parallel, so both have 12 V across them.
(iii) V across R_2 = 12 − 6 = 6 V. The current through R_2 is the same as through B, 3 A. So R_2 = 6/3 = 2 Ω.
(iv) Current through R_1 = 3 + 2 = 5 A. V across R_1 = 15 − 12 = 3 V. So R_1 = 3/5 = 0.6 Ω.

12) *An electric heater consists of three similar heating elements A, B and C, connected as shown in the figure above. Each heating element is rated as 1.2 kW, 240 V and has constant resistance. S_1, S_2 and S_3 are respective switches. The circuit is connected to a 240 V supply.*
(i) Calculate the resistance of one heating element.
(ii) Calculate the current in each resistor when only S_1 and S_3 are closed.
(iii) Calculate the power dissipated across A when S_1, S_2 and S_3 are closed.



(i) $R = V^2/P = (240 \times 240)/1200 = 48\ \Omega$

(ii) Current in C: I = 240/48 = 5 A

A and B are in series (96 Ω): I = 240/96 = 2.5 A each

(iii) With all switches closed, A gets the full 240 V: $P = V^2/R$ = (240 × 240)/48 = 1200 W = 1.2 kW

13) *In an electric circuit three bulbs of 100 W each are connected in series to a source. In another circuit set of three bulbs of the same wattage are connected in parallel to the same source.*
(i) Will the bulb in the two circuits glow with the same brightness? Justify your answer.
(ii) Now, let one bulb in both the circuits get fused. Will the rest of the bulbs continue to glow in each circuit? Give reason for your answer.

(i) No.

In series, the total resistance is more, so the current is less, and the voltage is shared. Each bulb uses less power and glows dimly.

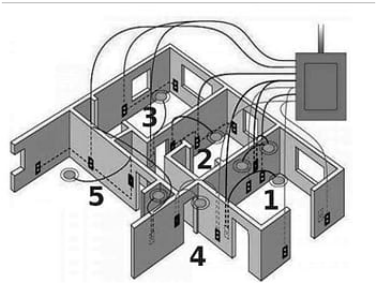
In parallel, each bulb gets the full voltage and its normal current, so it glows with normal brightness.

(ii) In series, none of the other bulbs glows, because the circuit is broken.

In parallel, the other two bulbs keep glowing as before, because they still get the full voltage.

14) *The diagram above is a schematic diagram of a household circuit. The house shown in the above diagram has 5 usable spaces where electrical connections are made. For this house, the mains have a voltage of 220 V and the net current coming from the mains is 22 A.*
(a) What is the mode of connection to all the spaces in the house from the mains?
(b) The spaces 5 and 4 have the same resistance and spaces 3 and 2 have respective resistances of 20 Ω and 30 Ω. Space 1 has a resistance double that of space 5. What is the net resistance for space 5.
(c) What is the current in space 3?

(d) What should be placed between the main connection and the rest of the house's electrical appliances to save them from accidental high electric current?



(a) All the spaces are connected in parallel.

(b) Let spaces 5 and 4 each have resistance R. Then space 1 = 2R, space 2 = 30 Ω, space 3 = 20 Ω.

Total resistance = V/I = 220/22 = 10 Ω

1/2R + 1/30 + 1/20 + 1/R + 1/R = 1/10, which gives R = 150 Ω

(c) Space 3 has 220 V across it: I = 220/20 = 11 A

(d) A fuse

15) *(i) Define electric power. Express it in terms of potential difference (V) and resistance (R).*

(ii) An electric oven is designed to work on the mains voltage of 220 V. This oven consumes 11 units of electrical energy in 5 hours. Calculate: (a) power rating of the oven (b) current drawn by the oven (c) resistance of the oven when it is red hot

(i) Electric power is the rate at which electrical energy is used up. $P = V^2/R$

(ii) (a) P = energy/time = 11 kWh / 5 h = 2.2 kW = 2200 W

(b) I = P/V = 2200/220 = 10 A

(c) $R = V^2/P = (220 \times 220)/2200 = 22\ \Omega$

16) *(i) How much electric current will an electric iron draw from 220 V source if the resistance of its heating element when hot, is 55 Ω? Calculate the power consumed by the electric iron when it is operated at 220 V.*

(ii) In a house, 3 bulbs of 100 watt each, are lit for 5 hours daily and an electric heater of 1.0 kW is used for half an hour daily. Calculate the total energy consumed in a month of 30 days and its cost at the rate of ₹ 3.60 per kWh.

(iii) With reason explain, why are alloys commonly used to make elements of electrical heating devices.

(i) $I = V/R = 220/55 = 4$ A

$P = VI = 220 \times 4 = 880$ W

(ii) Bulbs: 3×100 W $\times 5$ h $= 1500$ Wh $= 1.5$ kWh per day

Heater: 1.0 kW $\times 0.5$ h $= 0.5$ kWh per day

Total = 2 kWh per day, so 60 kWh in 30 days

Cost $= 60 \times 3.60 =$ ₹ 216

(iii) (refer 6th 3 mark question)

17) *(a) An electric iron consumes energy at a rate of 880 W when heating is at the maximum rate and 330 W when the heating is at the minimum. If the source voltage is 220 V, calculate the current and resistance in each case.*

(b) What is heating effect of electric current?

(c) Find an expression for the amount of heat produced when a current passes through a resistor for some time.

(a) Maximum: $I = P/V = 880/220 = 4$ A; $R = V/I = 220/4 = 55\ \Omega$

Minimum: $I = 330/220 = 1.5$ A; $R = 220/1.5 = 146.7\ \Omega$

(b) When current flows through a resistor, part of the electrical energy changes into heat. This is the heating effect of current.

(c) Heat = work done $= V \times Q = V \times It$. Since $V = IR$, $H = I^2Rt$.