CBSE CLASS X

Science (086)

ANSWER KEY

AI-generated question paper

Code: P8HPB7	Questions: 51	Maximum Marks: 148	Generated: 2026-06-25 17:52

SELECTIONS USED

Subject	Science
Lessons	11 Electricity
Level of understanding	Thorough understanding
Question selection	Curated chapter coverage (~5 questions per section + 8 synthesis)
Model	claude-sonnet-4-6

Composition — Difficulty: 4 straightforward · 28 medium · 19 deep | Types: 36 Short · 8 Long · 5 Very short · 2 MCQ

Q1. medium · thorough-understanding · § Chapter Introduction **[3]**

A switch in a torch circuit is opened (turned off). Explain, in terms of what happens to the electric charges, why the bulb stops glowing.

◆ **Electricity**

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Model Answer

When the switch is opened, the conducting link between the cell and the bulb is broken. This means the electric circuit is no longer closed (continuous). As a result, the electric charges (electrons) in the metallic wire stop flowing — there is no electric current in the circuit. Since no current flows through the bulb's filament, no heat is produced in it, so the filament does not get hot enough to emit light and the bulb stops glowing.

Source: Chapter 11 – Electricity, Section 11.1 Electric Current and Circuit; Section 11.7.1 Practical Applications of Heating Effect

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Explanation

Examiners look for **three distinct points** (1 mark each):

1. Opening the switch **breaks the closed/continuous path** (circuit is incomplete).
2. **Charges/electrons stop flowing** → no electric current.
3. No current means **no heating of filament** → bulb does not glow.

Avoid vague phrases like "electricity stops." Be specific: it is the **flow of charges** that stops, and it is the **heating effect** of current that makes the filament glow. Linking these two ideas explicitly secures full marks.

Q2. medium | thorough-understanding | § 11.1 ELECTRIC CURRENT AND CIRCUIT **[3]**

In a metallic wire, electrons are the actual charge carriers, yet the conventional direction of electric current is taken as opposite to the direction of electron flow. Why was this convention established, and what practical consequence does it have when analysing a circuit?

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Model Answer

When electricity was first studied, electrons were unknown. Scientists assumed current was due to the flow of positive charges, so the direction of current was defined as the direction of positive charge flow — from the positive terminal to the negative terminal of a cell. This convention was established before electrons were discovered.

Practical consequence: In circuit analysis, conventional current is always taken to flow from the positive to the negative terminal (through the external circuit), opposite to the actual electron flow. This does not affect calculations, as the results remain the same regardless of which direction is chosen as positive.

Source: Chapter 11, Section 11.1 — Electric Current and Circuit

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Explanation

- **Key fact examiners look for:** The convention was set *historically*, before electrons were known — state this clearly.
- Mention that current direction = opposite to electron flow.
- The practical consequence: circuits are analysed with conventional current (+ to −), and all laws (Ohm's law, Kirchhoff's laws) work correctly with this convention.
- Don't write a long essay — two short paragraphs covering "why" and "consequence" is sufficient for 3 marks.

Q3. medium | thorough-understanding | § 11.1 ELECTRIC CURRENT AND CIRCUIT **[1]**

A charge of 180 C flows through a conductor in 2 minutes. (i) Calculate the electric current through the conductor. (ii) If the potential difference across the conductor is 12 V, find its resistance. State the law you used in part (ii).

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Model Answer

(i) $I = Q/t = 180\text{ C} / (2 \times 60)\text{ s} = 180/120 =$ **1.5 A**

(ii) Using Ohm's Law: $R = V/I = 12/1.5 =$ **8 Ω**

Ohm's Law states that the potential difference across a conductor is directly proportional to the current through it at constant temperature ($V = IR$).

Explanation

- Convert time to seconds: 2 min = 120 s.
- Formula for current: $I = Q/t$.
- For resistance, apply Ohm's Law: $R = V/I$.
- Always name the law explicitly — examiners award a separate mark for it.

Q4. deep | thorough-understanding | § 11.1 ELECTRIC CURRENT AND CIRCUIT **[3]**

An ammeter of very low resistance (nearly zero) is accidentally connected in parallel with a resistor of 10 Ω in a circuit supplied by a 6 V cell. (i) What current will flow through the ammeter branch? (ii) What effect will this have on the circuit, and why is this connection incorrect for measuring current?

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Model Answer

(i) The ammeter has nearly zero resistance. When connected in parallel with the 10 Ω resistor, the parallel combination has an equivalent resistance ≈ 0 Ω.

Current through the ammeter branch:

$$I = \frac{V}{R} = \frac{6\ \text{V}}{0\ \Omega} \approx \text{very large (extremely high) current}$$

Almost the entire current flows through the ammeter branch (short circuit).

(ii) This causes a **short circuit** — the circuit resistance drops nearly to zero, so an extremely large current flows from the cell. This can damage the ammeter, the cell, or cause overheating.

This connection is **incorrect** because an ammeter must be connected in **series** to measure current. In parallel, it bypasses the resistor (its near-zero resistance provides an easier path), so it neither measures the correct current through the resistor nor protects the circuit.

Source: Chapter 11, Section 11.6.2 – Resistors in Parallel

Explanation

- Examiners expect you to apply Ohm's law (I = V/R) with R ≈ 0 for the ammeter, giving a dangerously large current — the key concept is **short circuit**.
- You must state the **correct usage** (ammeter in series) to explain why parallel connection is wrong.
- Part (ii) carries the reasoning marks — mention both the effect (excessive current/short circuit) and the reason (near-zero resistance of ammeter bypasses the resistor).

Q5. medium | thorough-understanding | § 11.2 ELECTRIC POTENTIAL AND POTENTIAL DIFFERENCE **[3]**

A cell maintains a fixed potential difference across its terminals even when no current is drawn from it. (a) When the cell is connected to a resistor, explain the role this potential difference plays in driving current through the circuit. (b) What energy transformation occurs inside the cell to sustain this current, and why does the potential difference across the external resistor fall if the internal resistance of the cell is taken into account?

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Model Answer

(a) The chemical action within the cell generates a potential difference across its terminals. When connected to a resistor, this potential difference sets the charges in motion through the conductor, producing an electric current. It acts like an "electric pressure" that drives electrons around the circuit.

(b) Inside the cell, **chemical energy is converted into electrical energy** to sustain the current. When internal resistance is considered, some potential difference is used up in driving current through the cell itself (voltage drop = $I \times r$). Thus, the terminal voltage available across the external resistor becomes $V = \varepsilon - Ir$, which is less than the cell's EMF.

Source: Chapter 11, Sections 11.2 and 11.7

Explanation

- For part (a), the key phrase from the textbook is: *"the potential difference sets the charges in motion in the conductor."* Use the water-pressure analogy if needed but keep it brief.
- For part (b), examiners expect two things: the energy transformation (chemical → electrical) AND the reason for voltage drop (internal resistance consumes part of the EMF). Writing $V = \varepsilon - Ir$ earns the formula mark even if not explicitly asked.
- Avoid writing long paragraphs; concise, pointed sentences score better in board exams.

Q6. deep | thorough-understanding | § 11.2 ELECTRIC POTENTIAL AND POTENTIAL DIFFERENCE **[3]**

A voltmeter connected across a resistor in a circuit reads 9 V, while an ammeter in series reads 3 A. (a) Calculate (i) the resistance of the resistor, and (ii) the work done in moving 6 C of charge through it. (b) A student claims that the potential difference across a resistor is a fixed property of the resistor alone, and will remain 9 V regardless of what else changes in the circuit. Evaluate this claim, explaining what factors in the circuit actually determine the potential difference across a given resistor.

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Model Answer

(a)(i) Using Ohm's law: $R = V/I = 9\text{ V}/3\text{ A} = \mathbf{3\ \Omega}$

(a)(ii) Work done = Potential difference × Charge

$$W = V \times Q = 9\text{ V} \times 6\text{ C} = \mathbf{54\ J}$$

(b) The student's claim is **incorrect**. Potential difference across a resistor is **not** a fixed property of the resistor alone. By Ohm's law, $V = IR$ — it depends on both the resistance *and* the current through it. The current itself depends on the total resistance of the circuit and the EMF of the source. For example, adding resistors in series reduces the current, which reduces the potential difference across any individual resistor, even though its resistance stays the same.

Source: Chapter 11, Section 11.4 (Ohm's Law) and Section 11.6.1 (Resistors in Series)

Explanation

- **Part (a)(i):** Straightforward application of $R = V/I$. Always write the formula first.
- **Part (a)(ii):** Work done $W = VQ$ (since $V = W/Q$ by definition). Don't confuse this with $W = VIt$; here charge Q is directly given.
- **Part (b):** Examiners want you to clearly say the claim is wrong, state that $V = IR$ means V depends on current, and link current to circuit conditions. One concrete example (series circuit changing current) earns full credit. Avoid vague answers like "it depends on other things."

Q7. straightforward | thorough-understanding | § 11.4 OHM'S LAW **[1]**

State Ohm's law. Under what conditions does a metallic conductor obey it?

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Model Answer

Ohm's Law: The potential difference across the ends of a resistor is directly proportional to the current through it, provided its **temperature remains constant**.

Explanation

Since this is a 1-mark question, state the law in one line and mention the one key condition (constant temperature). Examiners expect both parts — the law itself and the condition — to award full marks.

Q8. medium | thorough-understanding | § 11.4 OHM'S LAW **[2]**

The V–I graph of a nichrome wire is found to be a straight line passing through the origin. What two conclusions can you draw about the electrical nature of the conductor from this observation?

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Model Answer

From the straight-line V–I graph passing through the origin, two conclusions are:

1. **Ohm's law is obeyed**: The potential difference (V) across the nichrome wire is directly proportional to the current (I) through it (V ∝ I), as the ratio V/I remains constant.
1. **The resistance is constant**: Since V/I = R = constant, the resistance of the nichrome wire does not change with varying current or voltage (at constant temperature).

Source: Chapter 11, Section 11.4 – Ohm's Law

Explanation

Examiners expect two distinct, clearly stated points. The key ideas are: (i) direct proportionality → Ohm's law is followed, and (ii) the constant slope of the line means resistance is fixed. Avoid vague statements like "it's a good conductor" — stick to what the graph directly tells you.

Q9. medium | thorough-understanding | § 11.4 OHM'S LAW **[2]**

A student connects a resistor to a 4 V source and measures a current of 0.5 A. She then doubles the potential difference across the same resistor. Predict the new current and justify your answer using Ohm's law.

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Model Answer

Step 1: Find resistance using Ohm's law (V = IR)

$$R = \frac{V}{I} = \frac{4\text{ V}}{0.5\text{ A}} = 8\ \Omega$$

Step 2: New potential difference = 2 × 4 = 8 V

Since resistance remains constant (same resistor):

$$I_{new} = \frac{V_{new}}{R} = \frac{8\text{ V}}{8\ \Omega} = \mathbf{1\ A}$$

Justification: By Ohm's law, $V \propto I$ (R constant). Doubling the potential difference doubles the current.

Source: Chapter 11, Section 11.4 Ohm's Law

Explanation

- Examiners expect two clear steps: (1) calculate R from initial values, (2) apply Ohm's law with new V.
- Always state the justification explicitly — "V ∝ I when R is constant" is the key Ohm's law statement that earns the second mark.
- Don't just give the answer; show the formula and substitution for full credit.

Q10. medium | thorough-understanding | § 11.4 OHM'S LAW **[2]**

Ohm's law holds true for a metallic wire only under a specific condition. What is that condition, and why is it necessary?

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Model Answer

The condition is that the **temperature of the metallic wire must remain constant**.

This is necessary because resistance depends on temperature. If the temperature rises (due to heating by current), the resistance of the wire changes. Ohm's law states V ∝ I only when resistance R remains constant, which requires constant temperature.

Source: Chapter 11, Section 11.4 – Ohm's Law

Explanation

The examiner expects two things for 2 marks:

1. **The condition** – constant/same temperature (1 mark)
2. **Why it is necessary** – because resistance changes with temperature; V ∝ I holds only if R is constant (1 mark)

The textbook phrasing is: *"provided its temperature remains the same"* — use this or paraphrase it closely. Don't just state the law; you must explain the reason to earn full marks.

Q11. medium | thorough-understanding | § 11.4 OHM'S LAW **[3]**

Explain how a rheostat controls the current in a circuit without changing the voltage of the source. In your answer, relate its working to the relevant physical property of the conductor.

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Model Answer

A **rheostat** is a variable resistor. It works by changing the **effective length** of the resistance wire in the circuit — a longer length increases resistance, a shorter length decreases it. Since resistance depends directly on the length of the conductor, sliding the contact alters the resistance without touching the source.

By **Ohm's law**: $I = \frac{V}{R}$

The source voltage V remains constant. When the rheostat increases resistance R, current I decreases; when it decreases R, current increases. Thus, the rheostat controls current by varying the resistance of the circuit.

Source: Chapter 11 (Electricity), Sections 11.3 and 11.4

Explanation

- Examiners expect three clear points: (1) what a rheostat does physically (changes effective length → changes resistance), (2) the relevant property (resistance ∝ length of conductor), and (3) Ohm's law to show how changed resistance controls current at fixed voltage.
- Writing the formula $I = V/R$ is essential for full marks — it directly links resistance to current.
- Don't confuse "voltage of the source" with "potential difference across the rheostat"; the source EMF is unchanged, which is what the question asks about.

Q12. deep | thorough-understanding | § 11.4 OHM'S LAW **[3]**

Two resistors P and Q are made of the same material and have the same length, but Q has twice the cross-sectional area of P. When both are connected one at a time to the same battery, compare the currents flowing through them. Show your reasoning clearly.

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Model Answer

Since P and Q are made of the same material, their resistivity (ρ) is the same. Let length = l and area of P = A, so area of Q = $2A$.

Using $R = \rho\dfrac{l}{A}$:

$$R_P = \rho\frac{l}{A}, \quad R_Q = \rho\frac{l}{2A} = \frac{1}{2}R_P$$

So R_Q is **half** the resistance of R_P.

Since both are connected to the **same battery** (same V), by Ohm's law $I = V/R$:

$$\frac{I_Q}{I_P} = \frac{R_P}{R_Q} = 2$$

Conclusion: The current through Q is **twice** the current through P.

Source: Chapter 11, Section 11.5 – Factors on which the resistance of a conductor depends

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Explanation

- The key formula is $R = \rho l/A$. Same material → same ρ; same length → only area differs.
- Q has double the area, so half the resistance.
- Same voltage, half the resistance → double the current (Ohm's law: $I = V/R$).
- Examiners award marks for: writing the formula, substituting correctly for both resistors, stating the ratio of resistances, and applying Ohm's law to get the current ratio. Don't skip steps.

Q13. deep | thorough-understanding | § 11.4 OHM'S LAW **[5]**

(a) A student claims: 'If the resistance of a conductor is high, no current can flow through it at all.' Critically evaluate this statement using Ohm's law, giving a suitable example to support your answer.
(b) An electric heater coil (R = 50 Ω) and an electric bulb filament (R = 1000 Ω) are connected separately to the same 200 V supply. Calculate the current drawn by each. Which draws more current, and by what factor? Explain why heating appliances are designed to have lower resistance than lighting appliances.

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Model Answer

(a) The student's claim is **incorrect**. According to Ohm's law, $V = IR$, which gives $I = V/R$. A high resistance *reduces* the current but does not make it zero — current will still flow as long as a potential difference is applied. For example, the filament of an electric bulb has a high resistance (~1000 Ω), yet when connected to 220 V, a current of 0.22 A flows through it. Current becomes zero only if the circuit is broken, not merely because resistance is high.

(b)

- Heater: $I = V/R = 200/50 = \mathbf{4\ A}$
- Bulb: $I = V/R = 200/1000 = \mathbf{0.2\ A}$

The heater draws **more current**, by a factor of **20**.

Since power $P = I^2R = V^2/R$, a lower resistance draws more current and dissipates more heat. Heating appliances (irons, heaters) need large amounts of heat energy, so they are designed with **low resistance** to allow high current and maximum heat production.

Source: Chapter 11 – Electricity, Sections 11.3 (Ohm's Law) and 11.7.1 (Heating Effect Applications)

Explanation

- **Part (a):** Examiners want you to explicitly state Ohm's law as $I = V/R$, identify the logical flaw (high R ≠ zero I), and give a concrete numerical or real-life example.
- **Part (b):** Show both calculations clearly with formula, substitution, and result. State which draws more current and calculate the factor (4 ÷ 0.2 = 20). The final explanation linking $P = V^2/R$ to design logic earns the last conceptual mark.
- Do **not** write vague statements like "resistance opposes current" without connecting it to Ohm's law mathematically.

Q14. deep | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[3]**

A nichrome wire of length l and cross-sectional area A has a resistance R. If you stretch the same wire so that its length becomes 2l (assume the volume remains constant, so the area becomes A/2), what will be the new resistance? Show your reasoning.

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Model Answer

Using the formula $R = \rho \frac{l}{A}$, the original resistance is:

$$R = \rho \frac{l}{A}$$

When the wire is stretched, the new length = $2l$ and new area = $A/2$ (volume constant).
New resistance:

$$R' = \rho \frac{2l}{A/2} = \rho \frac{2l \times 2}{A} = 4\rho \frac{l}{A} = 4R$$

The new resistance is 4R.

Reasoning: Doubling the length doubles the resistance, and halving the area doubles it again. Both effects multiply, giving $2 \times 2 = 4$ times the original resistance.

Source: Chapter 11, Section 11.5 – Factors on which the resistance of a conductor depends.

Explanation

- Examiners expect you to **state the formula** $R = \rho \frac{l}{A}$, apply it to both old and new dimensions, and show the algebraic steps clearly.
- The key insight is that stretching changes **both** length and area simultaneously, so both changes must be accounted for — this is what the volume-constant condition tells you.
- Writing the final answer as **4R** (in terms of the original) is sufficient; no numerical value is needed.
- Avoid skipping steps — in a 3-mark question, 1 mark is typically for the formula, 1 for correct substitution, and 1 for the final answer.

Q15. deep | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[3]**

Two wires P and Q are made of the same material. Wire P has twice the length and twice the diameter of wire Q. What is the ratio of resistance of P to resistance of Q?

◆ **Electricity**

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Model Answer

Given:

- Length of P = 2l, Length of Q = l
- Diameter of P = 2d, Diameter of Q = d → Radius of P = 2r, Radius of Q = r

Using the formula $R = \rho\frac{l}{A}$, where $A = \pi r^2$:

$$R_P = \rho \cdot \frac{2l}{\pi(2r)^2} = \rho \cdot \frac{2l}{4\pi r^2} = \frac{\rho l}{2\pi r^2}$$

$$R_Q = \rho \cdot \frac{l}{\pi r^2}$$

$$\frac{R_P}{R_Q} = \frac{\rho l/2\pi r^2}{\rho l/\pi r^2} = \frac{1}{2}$$

∴ **Ratio of resistance of P to Q = 1 : 2**

Source: Chapter 11 (Electricity), Section 11.5 – Factors on which the resistance of a conductor depends

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Explanation

- The key formula is $R = \rho\frac{l}{A}$, where $A = \pi r^2 = \pi(d/2)^2$.
- Doubling the length **doubles** R, but doubling the diameter **quadruples** the area, which **quarters** R. Net effect: $2 \times \frac{1}{4} = \frac{1}{2}$.
- Examiners expect you to substitute values clearly and show the cancellation step. Writing the final ratio in the form **1 : 2** is mandatory.

Q16. medium | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[3]**

Why does doubling the length of a conducting wire double its resistance, while doubling its cross-sectional area halves its resistance? Explain with reference to the factors that govern resistance in a conductor.

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Model Answer

The resistance of a conductor is given by:

$$R = \rho \frac{l}{A}$$

where l is length, A is area of cross-section, and ρ is the resistivity of the material.

Effect of length: Since $R \propto l$, doubling the length doubles the resistance. A longer wire means electrons must travel farther, encountering more opposition.

Effect of area: Since $R \propto \dfrac{1}{A}$, doubling the cross-sectional area halves the resistance. A wider wire provides more paths for electrons to flow, reducing opposition to current.

Thus, resistance depends directly on length and inversely on area of cross-section.

Source: Chapter 11, Section 11.5 – Factors on which the resistance of a conductor depends.

Explanation

- Examiners expect the formula $R = \rho \frac{l}{A}$ to be written — this is the core of the answer and earns a mark directly.
- One mark each for explaining the effect of length and area using the proportionality relationships ($R \propto l$ and $R \propto 1/A$).
- Avoid lengthy analogies; state the relationship, then give a brief physical reason. That's all that's needed for 3 marks.

Q17. medium | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[1]**

Which of the following changes to a copper wire will reduce its resistance to one-quarter of its original value?
(A) Halving its length and doubling its cross-sectional area
(B) Doubling its length and halving its cross-sectional area
(C) Halving both its length and cross-sectional area
(D) Doubling both its length and cross-sectional area

A Halving its length and doubling its cross-sectional area
B Doubling its length and halving its cross-sectional area
C Halving both its length and cross-sectional area
D Doubling both its length and cross-sectional area

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Model Answer

(A) Halving its length and doubling its cross-sectional area

Using $R = \rho\dfrac{l}{A}$: new resistance $= \rho\dfrac{l/2}{2A} = \dfrac{1}{4}\rho\dfrac{l}{A} = \dfrac{R}{4}$.

Source: Chapter 11, Section 11.5 (Example 11.6)

Explanation

The formula $R = \rho\frac{l}{A}$ shows resistance is directly proportional to length and inversely proportional to area. Halving l gives factor ½; doubling A gives another factor ½ — together reducing R to ¼. This is directly solved in Example 11.6 of the textbook. For MCQs, always substitute the changes into the formula quickly to verify.

Q18. medium | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[3]**

Nichrome has a much higher resistivity than copper, yet nichrome — not copper — is used as the heating element in electric toasters. Justify this choice by comparing the relevant properties of the two materials.

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Model Answer

Nichrome is preferred over copper as a heating element due to the following reasons:

1. **High resistivity:** Nichrome has resistivity 100×10^{-6} Ω m, far greater than copper's 1.62×10^{-8} Ω m. Higher resistivity means more heat is generated (by Joule's heating, $H = I^2Rt$) for the same current.
1. **Does not oxidise at high temperatures:** Alloys like nichrome do not burn or oxidise readily at high temperatures, making them suitable for repeated heating.
1. **Copper's low resistivity** makes it an excellent conductor but a poor heat generator, so it is used for transmission lines, not heating devices.

Source: Chapter 11, Section 11.5 (Table 11.2) and Section 11.7.1

Explanation

Examiners expect two clear points: (i) high resistivity → more heat generated, with values from Table 11.2 as evidence, and (ii) alloys don't oxidise at high temperatures. Mentioning Joule's heating formula adds precision. Avoid writing lengthy paragraphs — crisp, labelled points score better in 3-mark answers.

Q19. medium | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[2]**

A student claims: 'If I replace the wire in a circuit with one made of a different material but keep the length and thickness exactly the same, the current will not change.' Is this claim correct? Explain.

◆ Electricity

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Model Answer

The claim is **incorrect**.

Resistance depends not only on length and area of cross-section but also on the **nature (material) of the conductor**, given by $R = \rho\frac{l}{A}$, where ρ is the electrical resistivity of the material. Different materials have different resistivities (e.g., copper has 1.62×10^{-8} Ωm, nichrome has 100×10^{-6} Ωm). So changing the material changes the resistance, which in turn changes the current ($I = V/R$).

Source: Chapter 11, Section 11.5 – Factors on which the resistance of a conductor depends

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Explanation

- Examiners want you to state clearly that the claim is wrong, then give the reason using the formula $R = \rho l/A$.
- Name resistivity (ρ) as the material-dependent factor — this is the key term.
- Quoting one example of contrasting resistivity values (e.g., copper vs. nichrome) strengthens the answer and shows you've read the table.
- Linking back to $I = V/R$ shows you understand *why* current changes — good for full marks.

Q20. medium | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[2]**

Define electrical resistivity of a material. A copper wire and a nichrome wire have exactly the same dimensions. Can you use the resistance of these wires alone (without knowing the material) to compare the materials? Explain why resistivity is a more suitable property for this comparison.

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Model Answer

Electrical resistivity is the resistance offered by a material of unit length and unit cross-sectional area. It is given by $\rho = \frac{RA}{l}$, with SI unit ohm-metre (Ω m).

Yes, since both wires have identical dimensions (same l and A), the wire with higher resistance is the poorer conductor. However, resistance depends on dimensions too. **Resistivity** is an intrinsic property of the material, independent of shape or size — making it more suitable for comparing materials directly.

Source: Chapter 11, Section 11.5 – Factors on which the resistance of a conductor depends

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Explanation

- Define resistivity using the formula $\rho = RA/l$ and state its unit (Ω m) — this alone is worth 1 mark.
- For the second part, acknowledge that yes, since dimensions are identical, resistance comparison works here, but then explain **why resistivity is better**: it is a material property independent of dimensions. This distinction is what examiners look for in the second mark.
- Don't write lengthy explanations — two focused points are enough for 2 marks.

Q21. medium | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[3]**

Wire X is made of copper and wire Y is made of manganin. Both wires have identical dimensions. In which wire will electrons experience greater opposition to their flow? Given that the resistivity of manganin is approximately 2700 times that of copper, by what factor is the resistance of wire Y greater than that of wire X?

◆ **Electricity**

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Model Answer

Wire Y (manganin) offers greater opposition to electron flow.

This is because resistance depends on the material's resistivity ($R = \rho \frac{l}{A}$). Since both wires have identical dimensions (same l and A), the resistance depends only on resistivity.

Manganin has resistivity approximately **2700 times** that of copper. Therefore:

$$\frac{R_Y}{R_X} = \frac{\rho_{\text{manganin}}}{\rho_{\text{copper}}} = 2700$$

The resistance of wire Y is 2700 times greater than that of wire X.

Source: Chapter 11, Section 11.5 – Factors on which the resistance of a conductor depends

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Explanation

- The key formula examiners expect is $R = \rho \frac{l}{A}$. Since l and A are identical, the ratio of resistances equals the ratio of resistivities directly.
- State *which* wire clearly first, then justify with the formula — this earns the first mark.
- The factor calculation is straightforward substitution — show the ratio setup to secure the final mark.
- Manganin is an alloy; alloys generally have much higher resistivity than pure metals, which is why they are used in heating devices.

Q22. deep | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[3]**

Resistivity of a conductor changes with temperature. If the resistivity of a nichrome wire increases when it is heated, what happens to the current through it if it is connected to the same voltage source before and after heating? Justify your answer using relevant relationships.

◆ **Electricity**

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Model Answer

When a nichrome wire is heated, its resistivity increases. Since resistance $R = \rho \dfrac{l}{A}$, an increase in resistivity causes an increase in resistance.

By Ohm's law: $I = \dfrac{V}{R}$

Since the voltage V remains the same but resistance R increases, the current through the wire **decreases**. Current is inversely proportional to resistance — if resistance increases, current decreases proportionally.

Source: Chapter 11 (Electricity), Sections 11.4 and 11.5

Explanation

- **Key relationships to quote:** $R = \rho \frac{l}{A}$ (links resistivity to resistance) and $I = V/R$ (Ohm's law linking current to resistance and voltage).
- Examiners want you to clearly state: resistivity ↑ → resistance ↑ → current ↓ (at same V), with the formulas justifying each step.
- Don't just say "current decreases" — you must justify *why* using both equations to earn full 3 marks.

Q23. deep | thorough-understanding | § 11.5 FACTORS ON WHICH THE RESISTANCE OF A CONDUCTOR DEPENDS **[3]**

A wire of resistance 12 Ω is bent into a closed square loop. What is the resistance measured between two diagonally opposite corners of the square?

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Model Answer

Total resistance of wire = 12 Ω. When bent into a square, each side has resistance = 12/4 = **3 Ω**.

Between two diagonally opposite corners (say A and C), the wire splits into two paths:

- Path 1: A→B→C = 3 + 3 = 6 Ω
- Path 2: A→D→C = 3 + 3 = 6 Ω

These two 6 Ω resistors are in **parallel**:

$$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6}$$

$$R_p = 3\ \Omega$$

The resistance between diagonally opposite corners = 3 Ω.

Source: Chapter 11, Section 11.6 (Resistance of a System of Resistors)

Explanation

- First find resistance of each side by dividing total resistance by 4.
- Identify the two parallel paths between opposite corners (each path has 2 sides in series = 6 Ω).
- Apply the parallel combination formula. Examiners award marks for: correctly finding each side's resistance, correctly identifying series/parallel arrangement, and the final calculation.

Q24. deep | thorough-understanding | § 11.6 RESISTANCE OF A SYSTEM OF RESISTORS **[5]**

A student connects three identical resistors, each of resistance 6 Ω, first in series and then in parallel across the same 12 V battery.
(i) Calculate the equivalent resistance and total current drawn from the battery in each case.
(ii) Using your calculated values, find the ratio of currents drawn in the parallel and series combinations. Explain, in terms of how equivalent resistance changes with configuration, why such a large difference in current arises.
(iii) In a household, electrical appliances are connected in parallel rather than in series. Using your findings above, give TWO distinct reasons why parallel connection is preferred.

◆ Electricity

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Model Answer

(i) Series combination:

$R_s = 6 + 6 + 6 = 18\ \Omega$

$I_s = V/R_s = 12/18 = 0.67\ \text{A}$

Parallel combination:

$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} = \frac{3}{6}$, so $R_p = 2\ \Omega$

$I_p = V/R_p = 12/2 = 6\ \text{A}$

(ii) Ratio of currents:

$$\frac{I_p}{I_s} = \frac{6}{0.67} = 9 : 1$$

In series, equivalent resistance **increases** (equals sum of all resistances = 18 Ω). In parallel, equivalent resistance **decreases** below the smallest individual resistance (= 2 Ω). Since $I = V/R$ and voltage is the same, the 9-fold lower resistance in parallel draws 9 times more current.

(iii) Two reasons parallel connection is preferred in households:

1. **Each appliance gets the full supply voltage** (220 V), so every device operates at its rated capacity independently.
2. **If one appliance fails, the others continue to work**, since each is on a separate branch — unlike series, where one failure breaks the entire circuit.

Source: Chapter 11, Sections 11.6.1 and 11.6.2

Explanation

- For part (i), always show the formula, substitution, and unit — examiners award step marks.
- For part (ii), the ratio $I_p : I_s = 9 : 1$ directly follows from $R_s/R_p = 18/2 = 9$; state this link clearly.
- For part (iii), the textbook explicitly lists these two advantages in Section 11.6.2 — use those exact points. Do not invent new ones.
- Keep calculations neat; a missing unit can cost half a mark.

Q25. straightforward | thorough-understanding | § 11.6.1 Resistors in Series **[1]**

[very_short_answer] Three resistors of 4 Ω, 6 Ω, and 10 Ω are connected in series to a 20 V battery. Calculate the potential difference across the 6 Ω resistor.

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Model Answer

Total resistance $R_s = 4 + 6 + 10 = 20\ \Omega$. Current $I = V/R_s = 20/20 = 1\ \text{A}$. Potential difference across 6 Ω $= IR = 1 \times 6 = \mathbf{6\ V}$.

Explanation

In a series circuit, the same current flows through all resistors. Find total resistance, then current using Ohm's law, then apply $V = IR$ to the individual resistor. Examiner expects all three steps shown briefly even in a 1-mark answer.

Q26. straightforward | thorough-understanding | § 11.6.1 Resistors in Series **[1]**

In a series circuit, an ammeter placed before the first resistor shows a reading of 0.3 A. Without any calculation, what will the ammeter read if it is moved to a position between the second and third resistors? Justify your answer.

◆ Electricity

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Model Answer

The ammeter will read **0.3 A**. In a series circuit, the current remains the same throughout; it does not change with the position of the ammeter in the circuit.

Source: Chapter 11, Section 11.6.1 – Resistors in Series

Explanation

The key principle tested here is: **current is constant at every point in a series circuit**. The examiner wants the correct value (0.3 A) AND the justification (series circuit → same current everywhere). Both parts are needed for full credit even in a 1-mark question. Avoid saying "no calculation needed" as your justification — state the physics law instead.

Q27. medium | thorough-understanding | § 11.6.1 Resistors in Series **[3]**

When resistors are connected in series, the equivalent resistance is always greater than any individual resistance in the combination. Explain why this must be true, using the physics of what resistance represents.

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Model Answer

Resistance opposes the flow of electric current through a conductor. In a series combination, resistors are joined end to end, so the **same current** must pass through each resistor one after another, experiencing opposition from every resistor in its path.

The equivalent resistance is given by:

$$R_s = R_1 + R_2 + R_3$$

Since all individual resistances are positive values, their sum must be greater than any single resistance alone. Each additional resistor adds more opposition to current flow, so R_s is always greater than R_1, R_2, or R_3 individually.

Source: Chapter 11, Section 11.6.1

Explanation

Examiners look for three things here:

1. **What resistance means** — it opposes/resists current flow (don't just say "it's a property").
2. **Why series adds resistances** — same current passes through each resistor sequentially, facing opposition at every stage.
3. **The formula** $R_s = R_1 + R_2 + R_3$ with the logical conclusion that a sum of positive numbers exceeds any one term.

Avoid vague statements like "resistance increases." Tie it directly to the physics: sequential opposition experienced by the same current.

Q28. medium | thorough-understanding | § 11.6.1 Resistors in Series **[5]**

[long_answer] Three resistors of 5 Ω, 10 Ω, and 15 Ω are connected in series across a 30 V supply. (a) Calculate the current through the circuit and the potential difference across each resistor. (b) Which resistor dissipates the most power? Justify using an appropriate formula. (c) If the 15 Ω resistor is now removed and the remaining two resistors stay connected in series to the same 30 V supply, how does the power dissipated in the 5 Ω resistor change? Support your answer with calculations.

◆ Electricity

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Model Answer

(a) Current and potential difference:

Total resistance: $R_s = 5 + 10 + 15 = 30\ \Omega$

Current: $I = V/R_s = 30/30 = \mathbf{1\ A}$

Potential difference across each resistor (V = IR):

- $V_1 = 1 \times 5 = \mathbf{5\ V}$
- $V_2 = 1 \times 10 = \mathbf{10\ V}$
- $V_3 = 1 \times 15 = \mathbf{15\ V}$

(b) Resistor dissipating most power:

Using $P = I^2R$ (current is same in series):

- $P_1 = 1^2 \times 5 = 5\ \text{W}$
- $P_2 = 1^2 \times 10 = 10\ \text{W}$
- $P_3 = 1^2 \times 15 = \mathbf{15\ W}$

The **15 Ω resistor** dissipates the most power. In a series circuit, since current is constant, $P \propto R$, so the largest resistor dissipates maximum power.

(c) Change in power dissipated in 5 Ω resistor:

New circuit: 5 Ω and 10 Ω in series, V = 30 V

New total resistance: $R_s = 5 + 10 = 15\ \Omega$

New current: $I' = 30/15 = 2\ \text{A}$

New power in 5 Ω: $P' = I'^2 \times 5 = 4 \times 5 = \mathbf{20\ W}$

Previously, $P = 1^2 \times 5 = 5\ \text{W}$. The power dissipated in the 5 Ω resistor **increases from 5 W to 20 W** (4 times) because removing the 15 Ω resistor reduces total resistance, increasing current.

Source: Chapter 11, Sections 11.6.1 and 11.8

Explanation

- Examiners award 1 mark each for correct R_s and I in part (a), and 1 mark for all three V values.
- In part (b), you **must** quote the formula $P = I^2R$ and state why the largest R wins (same I throughout series circuit).
- In part (c), you must recalculate both current and power — just stating "power increases" without numbers earns no marks. Show the before and after comparison explicitly.

Q29. deep | thorough-understanding | § 11.6.1 Resistors in Series **[3]**

A torch uses two identical cells, each of 1.5 V, and the bulb has a resistance of 5 Ω. A fault develops so that one cell is inserted in reverse (opposing the other). Explain what happens to the current through the bulb, and why this is consistent with the series-circuit principles you have studied.

◆ **Electricity**

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Model Answer

Normally, both cells (each 1.5 V) add up in series to give a total EMF of 3 V, producing a current of $I = \frac{3}{5} = 0.6$ A through the bulb.

When one cell is reversed, it opposes the other. The net EMF = 1.5 V − 1.5 V = **0 V**. By Ohm's law, $I = \frac{V}{R} = \frac{0}{5} = 0$ A.

The bulb goes out completely — no current flows.

This is consistent with series-circuit principles: in a series circuit the same current flows throughout, and the total potential difference equals the algebraic sum of all individual EMFs. With equal and opposing cells, they cancel, leaving zero net driving voltage and hence zero current.

Source: Chapter 11 – Electricity, Section 11.6.1 Resistors in Series

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Explanation

- The key series principle here is that EMFs in series **add algebraically** — a reversed cell subtracts.
- Examiners expect the numerical calculation ($I = V/R$) showing zero current, plus the reasoning using series-circuit rules.
- Do not just say "current decreases" — two identical cells reversed give **exactly zero** net EMF and **zero** current, not merely a reduced current.

Q30. deep | thorough-understanding | § 11.6.1 Resistors in Series **[3]**

[short_answer] Explain, with reference to how current and potential difference behave in a series circuit, why a series arrangement is NOT suitable for connecting domestic electrical appliances such as a refrigerator and a ceiling fan.

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Model Answer

In a series circuit, **the same current flows through all components**, but the **total potential difference (voltage) is shared** (divided) among them.

This makes series arrangement unsuitable for domestic appliances because:

1. **Different appliances need different voltages** to operate correctly. In series, the supply voltage is split across each appliance, so no appliance gets the required voltage.
2. **If one appliance is switched off or fails, the circuit breaks**, and all other appliances stop working.
3. **All appliances must operate at the same current**, which is not practical since different appliances (e.g., refrigerator and ceiling fan) have different current requirements.

Thus, a series circuit cannot provide independent control or correct operating conditions for domestic appliances.

Source: Chapter 11 – Electricity, Section 11.6.1 (Resistors in Series)

Explanation

Examiners look for **three specific disadvantages** clearly linked to the properties of series circuits — shared voltage, same current, and circuit breaking on failure. Mention both the electrical property (what happens in series) and why it's a problem for appliances. Don't just state facts — **connect** them to the real-life problem. This question often appears as Q18(c) in board exams; the answer should be concise but cover all three points to secure full 3 marks.

Q31. straightforward | thorough-understanding | § 11.6.2 Resistors in Parallel **[1]**

Three resistors of 6 Ω, 12 Ω, and 4 Ω are connected in parallel across a 12 V battery. (i) Calculate the equivalent resistance of the combination. (ii) What total current does the battery supply? Comment on how the equivalent resistance compares with the smallest individual resistor.

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Model Answer

$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{12} + \frac{1}{4} = \frac{2+1+3}{12} = \frac{6}{12}$, so $R_p = 2\ \Omega$; total current $I = 12/2 = 6\ \text{A}$. The equivalent resistance (2 Ω) is less than the smallest resistor (4 Ω), as expected in parallel combination.

Source: Chapter 11, Section 11.6.2

Explanation

This is actually a multi-part calculation question compressed into 1 mark, so keep each step brief. Examiners look for: correct parallel formula, correct $R_p = 2\ \Omega$, correct $I = 6\ \text{A}$, and the concluding observation that parallel equivalent resistance is always **less than** the smallest individual resistor. Show the reciprocal calculation clearly — it's the key formula for parallel circuits.

Q32. medium | thorough-understanding | § 11.6.2 Resistors in Parallel **[2]**

In a parallel combination of resistors, the potential difference across each resistor is the same, yet the current through each resistor is different. Explain why this is so.

◆ **Electricity**

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Model Answer

In a parallel combination, all resistors are connected between the same two points, so the **same potential difference (V)** acts across each of them.

However, by Ohm's law, current through each resistor is $I = V/R$. Since the resistors have **different resistances**, the current through each is different:

$$I_1 = \frac{V}{R_1}, \quad I_2 = \frac{V}{R_2}, \quad I_3 = \frac{V}{R_3}$$

A resistor with lower resistance allows more current, and one with higher resistance allows less current, even though the potential difference across each is the same.

Source: Chapter 11, Section 11.6.2 – Resistors in Parallel

Explanation

- **Key concept 1:** In parallel, both ends of every resistor are connected to the same two nodes → same V across each. This is a direct consequence of the circuit arrangement.
- **Key concept 2:** Ohm's law ($I = V/R$) then gives different currents because R values differ.
- Examiners award **1 mark** for explaining *why V is the same* and **1 mark** for applying Ohm's law to explain *why I differs*.
- Write the formula $I = V/R$ explicitly — it shows you're grounding the answer in Ohm's law, not just stating it vaguely.

Q33. medium | thorough-understanding | § 11.6.2 Resistors in Parallel **[3]**

Two resistors, P (10 Ω) and Q (40 Ω), are connected in parallel to a 20 V supply. A student claims that more current flows through Q because it is connected to the same voltage as P. Is the student correct? Justify your answer with a calculation.

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Model Answer

The student is **incorrect**. In a parallel circuit, the same voltage (20 V) acts across both resistors, but current depends on resistance: higher resistance means lower current (by Ohm's law, $I = V/R$).

Calculation:

$$I_P = \frac{V}{R_P} = \frac{20}{10} = 2 \text{ A}$$

$$I_Q = \frac{V}{R_Q} = \frac{20}{40} = 0.5 \text{ A}$$

Since P has lower resistance (10 Ω), **more current flows through P (2 A), not Q (0.5 A)**. The student confused equal voltage with equal current — while voltage is the same across parallel branches, current is inversely proportional to resistance.

Source: Chapter 11, Section 11.6.2 — Resistors in Parallel

Explanation

- Examiners expect you to clearly state the student is wrong, give the reason (Ohm's law in parallel), and show both calculations.
- Key concept: In parallel, **voltage is the same** across all branches, but **current divides** — more current takes the path of least resistance.
- Write $I = V/R$ explicitly; don't skip steps in a calculation question.
- The phrase "inversely proportional to resistance" scores a conceptual mark even without numbers.

Q34. medium | thorough-understanding | § 11.6.2 Resistors in Parallel **[3]**

When resistors are connected in parallel, the equivalent resistance of the combination is always less than the smallest individual resistance. Explain why this must be so, and verify your reasoning with a numerical example using two resistors of your choice.

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Model Answer

In a parallel combination, the same potential difference V acts across each resistor. Each branch provides an **additional path** for current, so total current increases. Since $R_p = V/I$, a larger total current means a smaller equivalent resistance.

The formula confirms this:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

Since $\frac{1}{R_p}$ is greater than any individual term (e.g., $\frac{1}{R_1}$), it follows that $R_p < R_1$ and $R_p < R_2$.

Numerical Example: Take $R_1 = 6\ \Omega$, $R_2 = 3\ \Omega$ (smallest = 3 Ω).

$$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{3} = \frac{1}{6} + \frac{2}{6} = \frac{3}{6} = \frac{1}{2}$$

$$R_p = 2\ \Omega$$

$R_p = 2\ \Omega < 3\ \Omega$ (smallest resistor). ✓

Source: Chapter 11, Section 11.6.2 — Resistors in Parallel

Explanation

- **Key idea**: Parallel connection adds extra current paths without changing voltage, so total current rises → equivalent resistance falls. This is the physical reason, and examiners expect it.
- **Formula logic**: $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ means $\frac{1}{R_p} > \frac{1}{R_{\text{min}}}$, so $R_p < R_{\text{min}}$. State this explicitly.
- Always **verify with numbers** when the question asks for it — full marks require both reasoning and the example.
- Keep the calculation neat and boxed/highlighted so the examiner spots it quickly.

Q35. medium | thorough-understanding | § 11.6.2 Resistors in Parallel **[3]**

An electric lamp (100 Ω), a toaster (50 Ω), and a water filter (500 Ω) are connected in parallel to a 220 V source. A fourth appliance — an electric iron — is then connected in parallel to the same source and draws the same total current as all three original appliances combined. Calculate the resistance of the electric iron.

◆ Electricity

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Model Answer

Step 1: Find total current drawn by the three appliances (in parallel, V = 220 V)

$$I_1 = \frac{220}{100} = 2.2\text{ A}, \quad I_2 = \frac{220}{50} = 4.4\text{ A}, \quad I_3 = \frac{220}{500} = 0.44\text{ A}$$

$$I_{total} = 2.2 + 4.4 + 0.44 = 7.04\text{ A}$$

Step 2: The electric iron draws the same current = 7.04 A

Step 3: Resistance of electric iron

$$R_{iron} = \frac{V}{I} = \frac{220}{7.04} \approx 31.25\ \Omega$$

The resistance of the electric iron is approximately 31.25 Ω.

Source: Chapter 11 (Electricity), Section 11.6 – Resistance of a System of Resistors

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Explanation

- In a parallel circuit, each appliance has the full 220 V across it, so use $I = V/R$ separately for each.
- Add all three currents to get the total; the iron draws this same total current.
- Apply Ohm's law ($R = V/I$) to find the iron's resistance.
- Examiners award marks for: correct individual currents (1 mark), correct total current (1 mark), and correct resistance of iron (1 mark). Show each step clearly.

Q36. medium | thorough-understanding | § 11.6.2 Resistors in Parallel **[3]**

Household electrical appliances such as lights, fans, and refrigerators are always wired in parallel rather than in series. Give TWO distinct reasons to justify this practice.

◆ Electricity

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Model Answer

Household appliances are wired in **parallel** for the following reasons:

1. **Each appliance gets the same voltage (220 V):** In a parallel circuit, every appliance is connected directly across the supply, so it operates at its rated voltage. In series, the supply voltage would be divided, causing appliances to work below their rated capacity.

1. **Independent operation:** Each appliance has its own separate branch. It can be switched on or off independently without affecting the others. In series, if one appliance fails or is switched off, the circuit breaks and all appliances stop working.

Source: Electricity, Chapter 11 (Exercise Q.18c; Section 11.6)

Explanation

Examiners expect **two clearly distinct points**. The two most scoring reasons are (i) equal/full voltage across each device and (ii) independent operation. Avoid repeating the same idea in different words — that scores only 1 mark. Mention the contrast with series briefly to strengthen each point. "Same rated voltage" and "independent switching/failure" are the two standard answers in the NCERT context.

Q37. deep · thorough-understanding · § 11.6.2 Resistors in Parallel **[5]**

A battery of EMF 24 V has an internal resistance of 2 Ω. Three resistors of 10 Ω, 15 Ω, and 30 Ω are connected in parallel and this parallel combination is then connected in series with the battery's internal resistance. (a) Find the equivalent resistance of the parallel combination. (b) Find the total current drawn from the battery. (c) Find the potential difference actually available across the parallel combination. (d) Hence, determine the current through the 30 Ω resistor. Show your reasoning at each step.

◆ Electricity

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Model Answer

Given: EMF (E) = 24 V, internal resistance (r) = 2 Ω, R_1 = 10 Ω, R_2 = 15 Ω, R_3 = 30 Ω (in parallel)

(a) Equivalent resistance of parallel combination:

$$\frac{1}{R_p} = \frac{1}{10} + \frac{1}{15} + \frac{1}{30} = \frac{3+2+1}{30} = \frac{6}{30} = \frac{1}{5}$$

$$\therefore R_p = 5\ \Omega$$

(b) Total current from battery:

Total resistance = $R_p + r = 5 + 2 = 7\ \Omega$

$$I = \frac{E}{R_p + r} = \frac{24}{7} \approx 3.43\ \text{A}$$

(c) Potential difference across parallel combination:

Voltage drop across internal resistance = $I \times r = 3.43 \times 2 = 6.86$ V

$$V_{parallel} = E - Ir = 24 - 6.86 \approx 17.14\ \text{V}$$

(d) Current through 30 Ω resistor:

Same potential difference (17.14 V) appears across each branch.

$$I_3 = \frac{V_{parallel}}{R_3} = \frac{17.14}{30} \approx 0.57\ \text{A}$$

Source: Chapter 11, sections 11.6.1 and 11.6.2

Explanation

- Examiners award 1 mark each for parts (a), (b), (c), and (d), with 1 mark for correct formula/method shown at any step.
- Show the formula before substituting values — this earns method marks even if arithmetic slips.
- Key concept: the same PD acts across every branch of a parallel combination, so Ohm's law applies directly to each branch for part (d).
- Internal resistance acts as a series resistor; voltage is "lost" across it, so the terminal voltage (PD across the external circuit) is less than the EMF.

Q38. medium | thorough-understanding | § 11.7 HEATING EFFECT OF ELECTRIC CURRENT **[2]**

An electric heater and the connecting cord supplying it are both carrying the same current. The heating element glows red-hot, but the cord remains cool. Explain why, using the relevant physical law.

◆ **Electricity**

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Model Answer

According to **Joule's law of heating**, heat produced is given by $H = I^2 Rt$.

Since both carry the **same current**, the heat produced depends on **resistance**. The heating element has **very high resistance**, so it produces much more heat and glows red-hot. The connecting cord has **very low resistance**, so negligible heat is produced and it stays cool.

Source: Chapter 11, Section 11.7 – Heating Effect of Electric Current

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Explanation

- The key law to quote is **Joule's law**: $H = I^2 Rt$.
- Since current I is the same, the only variable is resistance R.
- Examiners expect you to explicitly state that the heating element has **high resistance** and the cord has **low resistance** — this is the direct cause.
- Don't write a long explanation; two crisp points earn full marks.

Q39. medium | thorough-understanding | § 11.7 HEATING EFFECT OF ELECTRIC CURRENT **[3]**

A fuse wire must melt quickly when an excessive current flows, yet it must not melt during normal operation. Explain how the choice of material and design of a fuse wire allows it to fulfil both these requirements.

◆ Electricity

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Model Answer

A fuse wire is made of a metal or alloy with a **low melting point** (e.g., aluminium, lead, or their alloys). During normal operation, the current is within the rated value, so the heat produced ($H = I^2Rt$) is not enough to melt the wire.

When an **excessive current** flows, heat produced increases rapidly (proportional to I^2), raising the fuse wire's temperature above its low melting point. The wire melts quickly, breaking the circuit and protecting the appliance.

The fuse is connected **in series** so that the entire circuit current passes through it. The material's low melting point ensures fast response to overload, while its rated thickness ensures it survives normal current without melting.

Source: Chapter 11, Section 11.7.1

Explanation

- Examiners expect three distinct points: (1) material has low melting point, (2) normal current → insufficient heat → wire intact, (3) excess current → heat $\propto I^2$ rises sharply → wire melts and breaks circuit.
- Mentioning Joule's law ($H = I^2Rt$) scores a mark and shows understanding.
- "Series connection" is a useful design point but don't spend too many words on it — focus on material + heating effect.
- Avoid vague phrases like "it melts easily" — always link to low melting point and Joule's heating for full marks.

Q40. deep | thorough-understanding | § 11.7 HEATING EFFECT OF ELECTRIC CURRENT **[5]**

Two resistors P (2 Ω) and Q (8 Ω) are connected in series to a battery. A student claims that Q will produce more heat per second than P. Is the student correct? Justify your answer with a calculation. How would the ratio of heat produced per second in P and Q change if the two resistors were instead connected in parallel to the same battery? Support your answer with a calculation.

◆ **Electricity**

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Model Answer

Series Combination:

Total resistance = 2 + 8 = 10 Ω. Let battery voltage = V.

Current through both resistors: $I = V/10$

Heat produced per second (Power) = I^2R

- In P: $H_P = I^2 \times 2 = \frac{V^2}{100} \times 2 = \frac{2V^2}{100}$
- In Q: $H_Q = I^2 \times 8 = \frac{V^2}{100} \times 8 = \frac{8V^2}{100}$

Since Q has a higher resistance and current is the same in series, **Q produces more heat per second. The student is correct.**

Ratio $H_P : H_Q = 2 : 8 = \mathbf{1 : 4}$

Parallel Combination:

Both resistors have the same potential difference V across them.

Heat produced per second = V^2/R

- In P: $H_P = V^2/2$
- In Q: $H_Q = V^2/8$

Ratio $H_P : H_Q = \frac{V^2}{2} : \frac{V^2}{8} = 4 : 1$

In parallel, P produces more heat per second than Q. The ratio reverses to **4 : 1**.

Source: Chapter 11 – Electricity, Section 11.8 Electric Power

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Explanation

- In **series**, current is the same → use $P = I^2R$; the larger resistor dissipates more power.
- In **parallel**, voltage is the same → use $P = V^2/R$; the smaller resistor dissipates more power.
- Examiners want the formula stated, a numerical ratio calculated, and a clear conclusion for each case. Both parts are mandatory for full marks.

Q41. deep | thorough-understanding | § 11.7 HEATING EFFECT OF ELECTRIC CURRENT **[3]**

Tungsten is used for electric bulb filaments while aluminium or copper is used for transmission lines. Both situations involve current flowing through a metal conductor. What property of tungsten makes it suitable for a bulb filament but unsuitable for transmission lines, and what property of copper/aluminium makes them preferable for transmission?

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Model Answer

Tungsten for bulb filaments: Tungsten has a very high melting point (3380°C). When current flows, it generates a large amount of heat (Joule's heating). This heat raises the filament to very high temperatures, causing it to emit light. Since tungsten does not melt at such temperatures, it is ideal. However, this same property — converting most electrical energy into heat — makes it unsuitable for transmission lines, where energy loss is undesirable.

Copper/Aluminium for transmission lines: Copper and aluminium have very low resistivity, so they produce minimal heat (low energy loss) when current passes through them. This ensures efficient transfer of electrical energy over long distances with negligible wastage.

Source: Chapter 11, Section 11.7.1 (Practical Applications of Heating Effect of Electric Current)

Explanation

- The key contrast is **high resistivity + high melting point** (tungsten) vs **low resistivity** (copper/aluminium).
- For a filament: high resistance → more heat → light emission; high melting point → doesn't melt.
- For transmission: low resistance → less heat loss → efficient energy transfer.
- Examiners expect you to use the term **Joule's heating** and mention **melting point** for tungsten and **low resistivity/resistance** for copper/aluminium. These are the scoring keywords.

Q42. medium | thorough-understanding | § 11.7.1 Practical Applications of Heating Effect of Electric Current **[3]**

An electric fuse is rated 5 A. An electric iron rated 1.5 kW operates on a 220 V supply. Will this fuse protect the electric iron safely? Justify your answer with a calculation.

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Model Answer

Calculation:

Power of electric iron, P = 1.5 kW = 1500 W
Voltage, V = 220 V

Current drawn by the iron:

$$I = \frac{P}{V} = \frac{1500}{220} \approx 6.82 \text{ A}$$

Conclusion: No, the 5 A fuse will **not** protect the electric iron safely. Since the iron draws approximately 6.82 A, which is greater than the fuse rating of 5 A, the fuse will blow (melt) and break the circuit every time the iron is used. A fuse of higher rating (e.g., 7 A or 10 A) should be used instead.

Source: Chapter 11, Section 11.7.1

Explanation

- The key formula is $I = P/V$. Convert kW to W first (1.5 kW = 1500 W).
- Since the calculated current (6.82 A) **exceeds** the fuse rating (5 A), the fuse will blow during normal operation — so it does **not** protect the iron safely; it simply keeps tripping.
- Examiners expect: the formula, correct substitution, correct answer (~6.82 A), and a clear justified conclusion. All three steps carry marks.

Q43. deep | thorough-understanding | § 11.7.1 Practical Applications of Heating Effect of Electric Current **[5]**

[long_answer] Tungsten is used as the filament in electric bulbs, while alloys such as nichrome are preferred for the heating coils of devices like toasters and electric irons. Both applications exploit the heating effect of electric current. (i) Explain why tungsten is chosen for a bulb filament rather than for a heating coil. (ii) Why is an alloy preferred over a pure metal for the heating element of a toaster or electric iron?

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Model Answer

(i) Why tungsten is used for a bulb filament (not a heating coil):

In an electric bulb, the filament must become extremely hot so that it emits light. Tungsten has a very high melting point (3380°C), so it does not melt even at the high temperatures needed to produce light. It is also a strong metal that can retain the heat generated. However, tungsten is not preferred for heating coils because it would oxidise easily at high temperatures when exposed to air, making it less suitable for open heating elements.

(ii) Why an alloy is preferred over a pure metal for heating elements:

Alloys such as nichrome are preferred for heating coils because:

- They have **higher resistivity** than pure metals, so they produce more heat for the same current.
- They have a **high melting point**, so they do not melt or deform easily at high operating temperatures.
- They **do not oxidise** (corrode) readily at high temperatures, giving them a longer working life.

Source: Chapter 11, Section 11.7.1 (Practical Applications of Heating Effect of Electric Current)

Explanation

- The textbook (Exercise 18a & 18b) directly asks these two questions, so examiners expect answers rooted in the three properties: **melting point, resistivity, and oxidation resistance**.
- For (i), the key contrast is: tungsten's high melting point suits the extreme temperatures needed for light emission in a sealed bulb; but heating coils need a material that also resists oxidation in open air — which tungsten doesn't do as well as nichrome.
- For (ii), always mention **all three** alloy advantages (high resistivity, high melting point, resistance to oxidation) — each is worth marks separately.
- Avoid writing vague statements like "alloys are better" without specifying *why*.

Q44. medium | thorough-understanding | § 11.8 ELECTRIC POWER **[3]**

An electric kettle is rated 2 kW at 240 V. Assuming the resistance of the heating element remains constant, calculate the power consumed when it is connected to a 120 V supply. A student argues that halving the voltage will halve the power. Is the student correct? Justify your answer with the appropriate formula.

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Model Answer

Step 1: Find the resistance of the kettle.

Using $P = \dfrac{V^2}{R}$:

$$R = \frac{V^2}{P} = \frac{(240)^2}{2000} = \frac{57600}{2000} = 28.8\ \Omega$$

Step 2: Find power at 120 V.

$$P' = \frac{V'^2}{R} = \frac{(120)^2}{28.8} = \frac{14400}{28.8} = 500\ \text{W}$$

Is the student correct?

No. The student is wrong. Since $P = \dfrac{V^2}{R}$, power is proportional to the **square** of voltage. Halving the voltage reduces the power to **one-fourth** (not one-half): $2000 \times \frac{1}{4} = 500$ W.

Source: Chapter 11 – Electricity, Section 11.8 Electric Power

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Explanation

- Examiners expect you to use $P = V^2/R$ (not $P = VI$) when resistance is constant, because R doesn't change but I does.
- The common error the student makes is assuming $P \propto V$, but the correct relation is $P \propto V^2$. Always state this clearly to earn the justification mark.
- Show all three steps: find R, find new P, then answer the conceptual part. Each step carries roughly 1 mark.

Q45. medium | thorough-understanding | § (whole-chapter synthesis) **[3]**

A student connects three identical bulbs first in series and then in parallel across the same battery. In which arrangement do the bulbs glow brighter, and why? Your answer must refer to both current distribution and equivalent resistance.

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Model Answer

Bulbs glow brighter in parallel arrangement.

Equivalent Resistance: In series, the equivalent resistance $R_s = R_1 + R_2 + R_3 = 3R$, which is higher than a single bulb's resistance. In parallel, $\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R}$, giving $R_p = R/3$, which is much lower.

Current Distribution: Since the same battery is used, the lower equivalent resistance in parallel allows a greater total current to flow. Each bulb in parallel receives the full battery voltage, drawing more current individually. In series, the same small current flows through all bulbs and the voltage is divided among them.

Therefore, each bulb receives more power ($P = I^2R$ or $P = V^2/R$) in the parallel arrangement and glows brighter.

Source: Electricity, sections 11.6.1 and 11.6.2

Explanation

- Examiners award marks for three clear points: (1) comparison of equivalent resistance, (2) current distribution/behavior, and (3) conclusion about brightness.
- Always mention **both** series formula ($R_s = R_1 + R_2 + R_3$) and parallel formula to show higher vs. lower resistance — this directly earns marks.
- The key insight: in parallel, each bulb gets the **full terminal voltage**; in series, voltage is **shared**, so current and power per bulb are less.
- Quoting $P = V^2/R$ or $P = I^2R$ as justification for brightness is a valued finishing touch.

Q46. medium | thorough-understanding | § (whole-chapter synthesis) **[1]**

Assertion (A): Connecting several household appliances in parallel across the mains is preferred over connecting them in series.
Reason (R): In a parallel combination, the equivalent resistance decreases, allowing each appliance to receive the full supply voltage and draw the current it requires independently.

Choose the correct option:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

A Both A and R are true and R is the correct explanation of A.
B Both A and R are true but R is not the correct explanation of A.
C A is true but R is false.
D A is false but R is true.

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Model Answer

(A) Both A and R are true and R is the correct explanation of A.

In parallel combination, each appliance gets the full supply voltage and operates independently; equivalent resistance decreases, allowing each device to draw its required current.

Explanation

The textbook (section 11.6.2) explicitly states that in a parallel circuit, the potential difference across each gadget is the same (full supply voltage), each draws its own required current independently, and the total equivalent resistance decreases. Both the Assertion and the Reason are correct, and R directly explains why parallel connection is preferred — making option (A) the right choice.

Q47. medium | thorough-understanding | § (whole-chapter synthesis) **[3]**

Two resistors, P (nichrome, length l, cross-sectional area A) and Q (copper, same length l, same cross-sectional area A), are connected in series across a battery. Even though the same current flows through both, the heat generated per second in P is much greater than in Q. (i) Name the physical property of the material responsible for this difference, and state how it differs between nichrome and copper. (ii) Using the expression for electrical power dissipated in a resistor, explain why P generates more heat per second than Q despite carrying the same current.

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Model Answer

(i) The physical property responsible is **electrical resistivity**. Nichrome has a very high resistivity (100×10^{-6} Ω m), whereas copper has a very low resistivity (1.62×10^{-8} Ω m). Since both wires have the same length and cross-sectional area, nichrome has a much higher resistance than copper.

(ii) The power (heat per second) dissipated in a resistor is given by:

$$P = I^2R$$

Since both P and Q carry the same current I, the heat generated per second depends directly on resistance R. As nichrome has far greater resistance than copper, resistor P dissipates much more heat per second than Q.

Source: Chapter 11 — Sections 11.5 (Factors affecting resistance/resistivity) and 11.7 (Heating effect of electric current)

Explanation

- **Part (i)** tests knowledge of resistivity as a material property. Examiners expect you to name "resistivity," state that nichrome's resistivity is much higher than copper's, and link this to higher resistance (same l and A).
- **Part (ii)** requires the formula $P = I^2R$ (from Joule's law). Since I is the same in series, more R → more heat/second. Always write the formula and then reason from it — that's what examiners award marks for.
- Do not confuse **resistance** (depends on dimensions too) with **resistivity** (material property only). Part (i) specifically asks for the material property, so "resistivity" is the key term.

Q48. deep | thorough-understanding | § (whole-chapter synthesis) **[5]**

A fuse wire, the heating element of a toaster, and the connecting copper wires in a household circuit all carry the same current simultaneously. (i) Using the relationship R = ρl/A and P = I²R, explain why the heating element becomes very hot while the copper connecting wires remain cool during normal operation. (ii) The fuse wire does not melt during normal operation but melts during a fault (when current exceeds the rated value). Explain what property of the fuse wire material and its design makes this possible. (iii) Why is copper preferred for connecting wires despite all three conductors carrying the same current?

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Model Answer

(i) Heating element vs. copper wires:

From $R = \rho l / A$, resistance depends on resistivity (ρ), length, and cross-sectional area. The heating element of a toaster is made of an alloy (e.g., nichrome) which has very high resistivity ($\sim 100 \times 10^{-6}$ Ω m), whereas copper has very low resistivity (1.62×10^{-8} Ω m). Since $P = I^2 R$, for the same current I, power dissipated is directly proportional to resistance. The heating element therefore has much higher resistance and dissipates far more heat, becoming very hot, while copper wires have negligible resistance and remain cool.

(ii) Fuse wire — property and design:

The fuse wire is made of a metal or alloy (e.g., aluminium, lead) with a **low melting point**. During normal operation, the current is within the rated value, so heat produced is insufficient to melt it. During a fault, excess current increases heat generation ($H = I^2 Rt$) rapidly, raising the fuse wire's temperature above its melting point — it melts and breaks the circuit, protecting the appliances.

(iii) Why copper is preferred for connecting wires:

Copper has very low resistivity (1.62×10^{-8} Ω m), so its resistance is extremely small. This means minimal power is wasted as heat ($P = I^2 R$) in the connecting wires, ensuring efficient transmission of electrical energy to the appliance.

Source: Chapter 11, Sections 11.5 and 11.7.1

Explanation

- Examiners look for explicit linking of $R = \rho l / A \rightarrow$ high $\rho \rightarrow$ high $R \rightarrow$ high $P = I^2 R$ for part (i). Just saying "resistance is high" without linking to resistivity loses marks.
- For part (ii), the key phrases are **low melting point** and the contrast between normal vs. fault current — both must appear.
- For part (iii), keep it brief: low resistivity → low resistance → less heat wasted. Don't repeat part (i) at length.
- Alloys are used for heating elements (not pure metals) because alloys have higher resistivity and don't oxidise at high temperatures — useful to mention if the question asks, but here focus on the contrast with copper.

Q49. deep | thorough-understanding | § (whole-chapter synthesis) **[3]**

A resistor is connected across a potential difference V and carries current I. (i) If the potential difference is tripled while the resistance remains fixed, what happens to the current? (ii) The resistor is replaced by one made of the same material but with double the length and half the cross-sectional area. By what factor does the resistance change? Show your working. (iii) With this new resistor connected across the tripled potential difference, calculate the ratio of the new current to the original current I.

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Model Answer

(i) By Ohm's law, $I = V/R$. If V is tripled and R is unchanged, the current also triples to **3I**.

(ii) Resistance $R = \rho L/A$. New length = 2L, new area = A/2.

$$R_{\text{new}} = \rho \cdot \frac{2L}{A/2} = \frac{4\rho L}{A} = 4R$$

The resistance increases by a factor of **4**.

(iii) Original current: $I = V/R$

New current: $I_{\text{new}} = \frac{3V}{4R} = \frac{3}{4} \cdot \frac{V}{R} = \frac{3I}{4}$

$$\frac{I_{\text{new}}}{I} = \boxed{\frac{3}{4}}$$

Source: Chapter 11, Sections 11.4 and 11.5 (Ohm's Law; Resistance of a Conductor)

Explanation

- **Part (i):** Direct application of $I = V/R$ — if R is constant, I is proportional to V.
- **Part (ii):** Examiners expect the formula $R = \rho L/A$ with substitution shown step by step. Both changes (doubled L and halved A) each double the resistance, giving a combined factor of 4.
- **Part (iii):** Combine both changes: voltage ×3, resistance ×4. The net effect is $3/4$, so the new current is **less** than the original despite the higher voltage. Always show the ratio explicitly.

Q50. deep | thorough-understanding | § (whole-chapter synthesis) **[3]**

An electric circuit has a battery, a resistor of resistance R, and a fuse, all in series. The battery maintains a constant potential difference V. (i) Write an expression for the power dissipated in the resistor. (ii) If R is halved (by replacing it with a shorter wire of the same material and cross-section), what happens to the power dissipated? (iii) Explain why this change could cause the fuse to melt.

◆ **Electricity**

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Model Answer

(i) Power dissipated in the resistor:

$$P = \frac{V^2}{R}$$

(ii) When R is halved (R becomes R/2):

$$P' = \frac{V^2}{R/2} = \frac{2V^2}{R} = 2P$$

The power dissipated **doubles**.

(iii) Higher power means a larger current flows through the circuit (since $I = V/R$, halving R doubles the current). A fuse melts when current exceeds its rated value. The doubled current produces excess heat in the fuse wire, causing it to melt and break the circuit.

Source: Chapter 11, Section 11.7 Heating Effect of Electric Current

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Explanation

- Examiners award 1 mark each for the three parts. Part (i) needs the correct formula (V^2/R); part (ii) needs to show working and state "doubles"; part (iii) needs to link increased current → excess heating → fuse melts.
- The key formula here is $P = V^2/R$ (not I^2R), because V is **constant** in this circuit.
- Always state the conclusion explicitly ("power doubles", "fuse melts") — don't leave the examiner to infer it.

Q51. deep | thorough-understanding | § (whole-chapter synthesis) **[5]**

A 220 V electric iron rated 1000 W and a 220 V electric bulb rated 100 W are connected in parallel across a 220 V supply. (i) Calculate the resistance of each device. (ii) Calculate the total current drawn from the supply. (iii) If both devices are instead connected in series across the same 220 V supply, calculate the current through the circuit and explain why this series arrangement is unsuitable for practical household use, giving at least two distinct reasons.

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Model Answer

(i) Resistance of each device:

Using $R = V^2/P$:

- Electric iron: $R_1 = \frac{(220)^2}{1000} = \frac{48400}{1000} = **48.4\ \Omega**$
- Electric bulb: $R_2 = \frac{(220)^2}{100} = \frac{48400}{100} = **484\ \Omega**$

(ii) Total current in parallel:

Current through iron: $I_1 = \frac{220}{48.4} \approx 4.55\ \text{A}$

Current through bulb: $I_2 = \frac{220}{484} \approx 0.45\ \text{A}$

Total current $I = I_1 + I_2 = 4.55 + 0.45 = **5\ \text{A}**$

(iii) Series connection:

Total resistance $R_s = 48.4 + 484 = 532.4\ \Omega$

Current $I = \frac{220}{532.4} \approx **0.41\ \text{A}**$

Why series is unsuitable:

1. Both devices share the same small current (≈0.41 A), but the iron needs ~4.55 A and the bulb ~0.45 A to work properly — neither device operates at its rated power.
2. If one device fails/fuses, the circuit breaks and the other stops working too.

Source: Chapter 11 — Electricity, Sections 11.6.1 and 11.6.2

Explanation

- The formula $R = V^2/P$ is the quickest route here since rated voltage and power are given directly.
- For part (ii), you can also use $I = P/V$ for each device — same result, equally accepted.
- In part (iii), the series current calculation must come first, then the two distinct reasons. Examiners award marks separately for the calculation and each reason, so state both reasons clearly. The textbook explicitly states that different gadgets need different currents and that series circuits fail completely when one component breaks — use these points.
- Do not confuse "unsuitable because voltage is divided" (that is a consequence) with the key reasons above; stick to what the textbook states.