

Resistance, Kirchhoff's rules and steady-state RC circuits

AP Physics 2 (algebra-based) · Test answers (mark scheme)

The marking guide follows AP conventions: marks go for a correct relationship, a correct substitution and a final answer with the right unit. Follow-through credit is given when an earlier mistake is carried forward consistently.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 11

Question 1 Two wires (2 marks)

$R = \rho L/A$. Doubling L doubles R . Halving d makes A four times smaller, so R becomes four times larger. Combined: $R_Y / R_X = 2 \times 4 = 8$.

Marking: 1 for length factor of 2; 1 for area factor 4 and final ratio 8.

Question 2 Series and parallel (3 marks)

(a) $1/R_p = 1/6.0 + 1/3.0 = 1/2.0$, so $R_p = 2.0 \, \Omega$ and $R_{eq} = 2.0 + 2.0 = 4.0 \, \Omega$.

(b) $I = 15 / 4.0 = 3.75 \, A$.

(c) V across the pair $= 3.75 \times 2.0 = 7.5 \, V$, so $I_2 = 7.5 / 6.0 = 1.25 \, A$.

Marking: 1 mark for each part; allow follow-through from (a).

Question 3 Kirchhoff checks (3 marks)

(a) $2.5 + 4.0 = 6.5 \, A$ in. Out: $1.0 + I = 6.5$, so $I = 5.5 \, A$.

(b) $24 - (2.0)(5.0) - (2.0)X = 0$, so $2.0X = 14$ and $X = 7.0 \, \Omega$.

Marking: (a) 1 mark; (b) 1 for loop equation with correct signs, 1 for answer with unit.

Question 4 Capacitor after a long time (3 marks)

(a) The capacitor branch carries no current, so $I = 10 / 2000 = 5.0 \, mA$.

(b) $V_c = V$ across $R_2 = 5.0 \, mA \times 1500 \, \Omega = 7.5 \, V$. $Q = CV = 20 \times 10^{-6} \times 7.5 = 1.5 \times 10^{-4} \, C$.

(c) The uncharged capacitor acts like a wire across R_2 , so only R_1 limits the current: $I = 10 / 500 = 20 \, mA$.

Marking: 1 mark for each part.

Question 5 Household wiring (2 marks)

In parallel each lamp receives the full mains voltage, so every lamp has its normal brightness. Each lamp can also be switched off independently, and the others keep working. In series, the voltage would be shared and one broken lamp would cut the whole circuit.

Marking: 1 mark for full voltage on each lamp; 1 mark for independent operation.

Question 6 Heater current (2 marks)

$$I = P/V = 1500 / 230 = \mathbf{6.5 \text{ A}}. R = V/I = 230 / 6.52 = \mathbf{35 \Omega}.$$

Marking: 1 mark for current; 1 mark for resistance (follow-through allowed).

Question 7 Predicting brightness (3 marks)

Closing the switch puts B and C in parallel, so the total resistance of the circuit decreases and the battery current increases. A carries the whole current, so **A becomes brighter**. The current now splits between B and C, and each carries only half of the new current, which is less than the original current in B, so **B becomes dimmer**. (Before: $I = \epsilon/2R$. After: $I = \epsilon/1.5R$ in A and $\epsilon/3R$ in B.)

Marking: 1 for total resistance falling; 1 for A brighter with reason; 1 for B dimmer with reason.

Question 8 Charging curve (2 marks)

The curve starts at zero, rises steeply and levels off at a dashed horizontal line labelled ϵ . At $t = \tau = RC$ the curve is at 0.63ϵ .

Marking: 1 for the rising curve that flattens at ϵ ; 1 for τ marked at about 63 % of ϵ .