

AQA, Edexcel

A Level

A Level Physics

ELECTRICAL CIRCUITS:

Complete Circuits 1 (Answers)

Name:

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Total Marks: /30

1.

Total for Question 1: 8

- (a) Define electrical work, W , in terms of potential difference, V , and charge, Q . Using this relationship, show that $P = I^2R$ [2]

Solution: $W = VQ$
But, $Q = It$ and $P = W/t \rightarrow P = VIt/t = VI$
From Ohm's law, $V = IR \rightarrow P = I^2R$

- (b) The P.D. across a 5.0Ω resistor is measured as 6.0 V . What power is it dissipating? [2]

Solution: 7.2 W

- (c) An LED is connected in series with an ammeter and a power supply. A voltmeter is connected across the LED. They read 2.2 A and 4.6 V . If it is left on for 1 hour and 15 minutes, how much work is done by the LED? [2]

Solution: 45 kJ

- (d) Sketch how the electrical work done by the resistor at a given point in time would vary with the resistance of the resistor. Assume the P.D. across the resistor is constant. [2]

Solution: $y \propto 1/x$ graph i.e. nonlinear decrease

2. This question exploits Kirchoff's laws to determine the resistances of several components in Figure 1.

Total for Question 2: 10

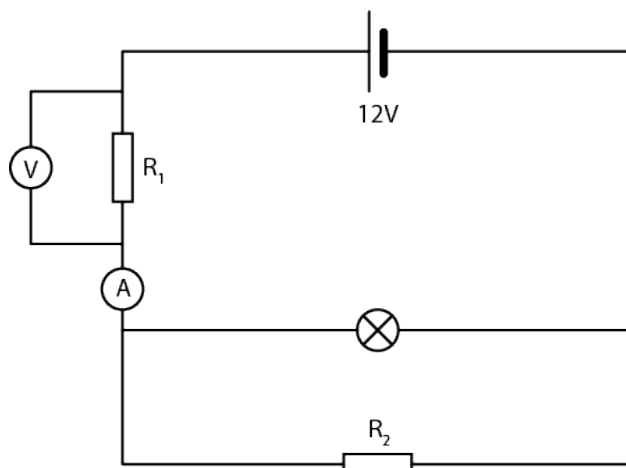


Figure 1: A circuit containing two resistors, a voltmeter, an ammeter, a cell and a bulb.

Tom notes that the the bulb has an effective resistance of 5.0Ω , that the voltmeter reads 2.0 V and that the ammeter reads 3.5 A .

- (a) State Kirchoff's First Circuit Law. What implications does it have for the charge entering and leaving a circuit junction? [2]

Solution: Sum of currents entering a junction equals the sum of currents leaving a junction
i.e. $\Sigma I_{\text{into junction}} = \Sigma I_{\text{out of junction}}$
Since $Q = It$, the same conservation applies at a junction for charge.

- (b) State Kirchoff's Second Circuit Law. [1]

Solution: In a given closed loop, the sum of the potential differences is equal to the sum of the EMFs: $\Sigma PD_i = \Sigma EMF_i$

- (c) Calculate R_1 . [1]

Solution: 0.57Ω

- (d) Calculate R_2 . [3]

Solution: 6.7Ω

- (e) Calculate the power dissipated by the bulb. [1]

Solution: 20 W

- (f) The bulb dissipates 75% of its power as heat and converts the rest to light. What is the efficiency of this circuit as a means of lighting? [2]

Solution: 12%

3. Based on the conservation of charge and of energy, it is possible to derive several laws that dictate how the total effective resistance in a circuit varies when a combination of resistors are used in series and/or parallel.

Total for Question 3: 8

- (a) Use Kirchoff's and Ohm's laws to derive an expression for the total effective resistance of two resistors, R_{1-2} , in series. [2]

Solution: From KSL and Ohm's : $IR = I_1R_1 + I_2R_2$
From KFL I is the same for all $\rightarrow R = R_1 + R_2$

- (b) Using a similar technique, show that for two resistors in parallel, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$. [3]

Solution: KFL: $I = I_1 + I_2$
Incorporating Ohms: $\frac{V}{R} = \frac{V_1}{R_1} + \dots$
KSL: V of each loop is the same $\rightarrow V = V_1 = V_2 \rightarrow \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

- (c) Two resistors (1.0Ω and 2.0Ω) connected in parallel are linked in series to a 3.0Ω resistor. All of this is in parallel with a fourth resistor. If the total effective resistance is 1.0Ω , what is the resistance of the fourth resistor? [3]

Solution: 1.4Ω

4. Most thermistors and LDRs rely on the properties of semiconductors to vary their resistance.

Total for Question 4: 4

- (a) Briefly explain how changes in temperature cause a change in the resistance of a thermistor. For an ntc thermistor. will the resistance increase or decrease as temperature rises? [2]

Solution: Thermal energy can excite electrons, allowing them to cross the bandgap. Therefore, at higher T we expect more electrons in the conduction band and consequently a lower resistance (for an ntc thermistor).

- (b) Outline the mechanism behind an LDR's variable resistance. [2]

Solution: Light landing on the SC material excites electrons from the valence to the conduction band. This results in there being more electrons free to carry charge and so the effective resistance is lowered.