## Practical Circuits & Kirchoff's Law

## **Question paper 3**

Level	International A Level
Subject	Physics
Exam Board	CIE
Торіс	D.C. Circuits
Sub Topic	Practical Circuits & Kirchoff's Law
Paper Type	Theory
Booklet	Question paper 3

Time Allowe	d:	72 minutes				
Score:		/60				
Percentage:		/100				
A*	A	В	С	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 (a) A network of resistors, each of resistance *R*, is shown in Fig. 7.1.



Switches  ${\rm S}_1$  and  ${\rm S}_2$  may be 'open' or 'closed'.

Complete Fig. 7.2 by calculating the resistance, in terms of R, between points X and Y for the switches in the positions shown.

switch S <sub>1</sub>	switch S <sub>2</sub>	resistance between points X and Y
open	open	
open	closed	
closed	closed	
Fig. 7.2		

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[3]

(b) Two cells of e.m.f.  $E_1$  and  $E_2$  and negligible internal resistance are connected into a network of resistors, as shown in Fig. 7.3.





The currents in the network are as indicated in Fig. 7.3.

Use Kirchhoff's laws to state the relation

(i)	between currents $I_1$ , $I_2$ , $I_3$ and $I_4$ ,
	[1]
(ii)	between $E_1$ , $E_2$ , $R$ , and $I_3$ in loop NKLMN,
	[1]
(iii)	between $E_2$ , $R$ , $I_3$ and $I_4$ in loop NKQN.
	[1]

2 An electric heater consists of three similar heating elements A, B and C, connected as shown in Fig. 6.1.



Each heating element is rated as 1.5kW, 240V and may be assumed to have constant resistance.

The circuit is connected to a 240V supply.

(a) Calculate the resistance of one heating element.

resistance = ... .....Ω [2]

(b) The switches  $S_1$ ,  $S_2$  and  $S_3$  may be either open or closed.

Complete Fig. 6.2 to show the total power dissipation of the heater for the switches in the positions indicated.

S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	total power / kW
open	closed	closed	
closed	closed	open	
closed	closed	closed	
closed	open	open	
closed	open	closed	





[5]

**3** A car battery has an internal resistance of 0.060Ω. It is re-charged using a battery charger having an e.m.f. of 14V and an internal resistance of 0.10Ω, as shown in Fig. 6.1.



- (a) At the beginning of the re-charging process, the current in the circuit is 42A and the e.m.f. of the battery is *E* (measured in volts).
  - (i) For the circuit of Fig. 6.1, state
    - 1. the magnitude of the total resistance,

resistance =  $\dots \Omega$ 

2. the total e.m.f. in the circuit. Give your answer in terms of *E*.

e.m.f. = ...... V [2]

(ii) Use your answers to (i) and data from the question to determine the e.m.f. of the car battery at the beginning of the re-charging process.

e.m.f. = ......V [2]

- (b) For the majority of the charging time of the car battery, the e.m.f. of the car battery is 12V and the charging current is 12.5 A. The battery is charged at this current for 4.0 hours. Calculate, for this charging time,
  - (i) the charge that passes through the battery,

energy = ......J [2]

(iii) the total energy dissipated in the internal resistance of the battery charger and the car battery.

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energy = ...... J [2]

(c) Use your answers in (b) to calculate the percentage efficiency of transfer of energy from the battery charger to stored energy in the car battery.

**4** (a) Distinguish between the electromotive force (e.m.f.) of a cell and the potential difference (p.d.) across a resistor.



(b) Fig. 7.1. is an electrical circuit containing two cells of e.m.f.  $E_1$  and  $E_2$ .



Fig. 7.1

The cells are connected to resistors of resistance  $R_1$ ,  $R_2$  and  $R_3$  and the currents in the branches of the circuit are  $I_1$ ,  $I_2$  and  $I_3$ , as shown.

(i) Use Kirchhoff's first law to write down an expression relating  $I_1$ ,  $I_2$  and  $I_3$ .

......[1]

- (ii) Use Kirchhoff's second law to write down an expression relating
  - **1.**  $E_2$ ,  $R_2$ ,  $R_3$ ,  $I_2$  and  $I_3$  in the loop XBCYX,
    - .....[1]
  - **2.**  $E_1$ ,  $E_2$ ,  $R_1$ ,  $R_2$ ,  $I_1$  and  $I_2$  in the loop AXYDA.
    - .....[1]

**5** A circuit contains three similar lamps A, B and C. The circuit also contains three switches,  $S_1$ ,  $S_2$  and  $S_3$ , as shown in Fig. 7.1.



One of the lamps is faulty. In order to detect the fault, an ohm-meter (a meter that measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 7.2 shows the readings of the ohm-meter for different switch positions.

		switch		meter reading	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	/ Ω	
	open	open	open	~	
	closed	open	open	15Ω	
-	open	closed	open	30 Ω	
	open	closed	closed	15Ω	

Fig. 7.2

 (c) Determine the resistance of one of the non-faulty lamps, as measured using the ohmmeter.

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resistance = \dots \Omega [1]
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(d) Each lamp is marked 6.0 V, 0.20 A.

Calculate, for one of the lamps operating at normal brightness,

(i) its resistance,

resistance = .....  $\Omega$  [2]

(ii) its power dissipation.

		power = W [2]
(e)	Comment on your answers to (c) and (d)(i).	
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**6** A battery of e.m.f. 4.50 V and negligible internal resistance is connected in series with a fixed resistor of resistance  $1200 \Omega$  and a thermistor, as shown in Fig. 7.1.



(a) At room temperature, the thermistor has a resistance of  $1800 \Omega$ . Deduce that the potential difference across the thermistor (across AB) is 2.70 V.

[2]

(b) A uniform resistance wire PQ of length 1.00 m is now connected in parallel with the resistor and the thermistor, as shown in Fig. 7.2.



A sensitive voltmeter is connected between point B and a moveable contact M on the wire.

(i) Explain why, for constant current in the wire, the potential difference between any two points on the wire is proportional to the distance between the points.

- (ii) The contact M is moved along PQ until the voltmeter shows zero reading.
  - 1. State the potential difference between the contact at M and the point Q.
    - potential difference = ..... V [1]
  - 2. Calculate the length of wire between M and Q.

length = ..... cm [2]

(iii) The thermistor is warmed slightly. State and explain the effect on the length of wire between M and Q for the voltmeter to remain at zero deflection.

\_\_\_\_\_[2]

7 (a) Define the *resistance* of a resistor.

.....[1]

(b) In the circuit of Fig. 7.1, the battery has an e.m.f. of 3.00 V and an internal resistance *r*. R is a variable resistor. The resistance of the ammeter is negligible and the voltmeter has an infinite resistance.





The resistance of R is varied. Fig. 7.2 shows the variation of the power P dissipated in R with the potential difference V across R.



- (i) Use Fig. 7.2 to determine
  - 1. the maximum power dissipation in R,

maximum power =		W
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2. the potential difference across R when the maximum power is dissipated.

potential difference =	V
	[1]

(ii) Hence calculate the resistance of R when the maximum power is dissipated.



resistance = .....  $\Omega$  [2]

(iii) Use your answers in (i) and (ii) to determine the internal resistance r of the battery.

 $r = \dots \Omega$  [3]

(c) By reference to Fig. 7.2, it can be seen that there are two values of potential difference V for which the power dissipation is 1.05 W. State, with a reason, which value of V will result in less power being dissipated in the internal resistance.