Practical Circuits & Kirchoff's Law

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	D.C. Circuits
Sub Topic	Practical Circuits & Kirchoff's Law
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **78 minutes**

Score: **/65**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 A circuit used to measure the power transfer from a battery is shown in Fig. 4.1. The power is transferred to a variable resistor of resistance R.

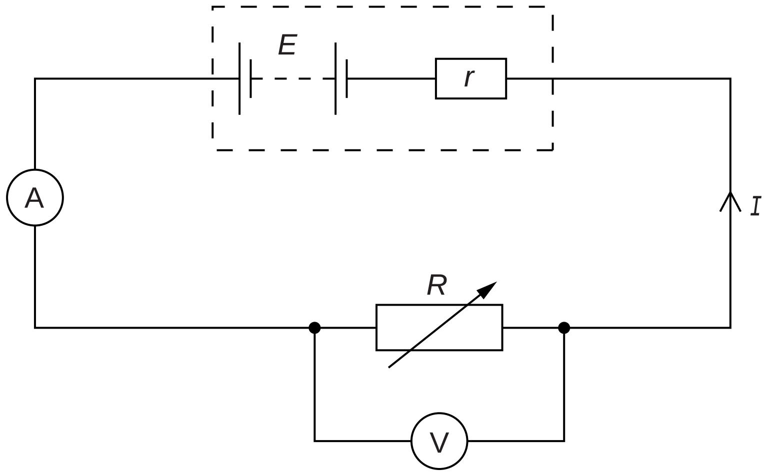

Fig. 4.1

The battery has an electromotive force (e.m.f.) E and an internal resistance r. There is a potential difference (p.d.) V across R. The current in the circuit is I.

(a) By reference to the circuit shown in Fig. 4.1, distinguish between the definitions of e.m.f. and p.d.

....

....

....

.... [3]

(b) Using Kirchhoff's second law, determine an expression for the current I in the circuit.

[1]

(c) The variation with current I of the p.d. V across R is shown in Fig. 4.2.

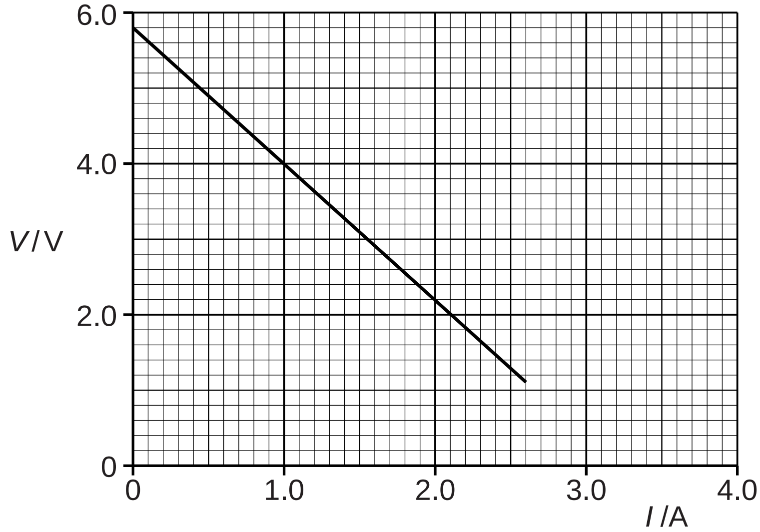

Fig. 4.2

Use Fig. 4.2 to determine

(i) the e.m.f. E,

E = ... V [1]

(ii) the internal resistance r.

r = ... Ω [2]

(d) **(i)** Using data from Fig. 4.2, calculate the power transferred to R for a current of 1.6 A.

power = ... W [2]

(ii) Use your answers from **(c)(i)** and **(d)(i)** to calculate the efficiency of the battery for a current of 1.6 A.

efficiency = ... % [2]

2 **(a)** **(i)** State Kirchhoff's second law.

....

.... [1]

(ii) Kirchhoff's second law is linked to the conservation of a certain quantity. State this quantity.

.... [1]

(b) The circuit shown in Fig. 5.1 is used to compare potential differences.

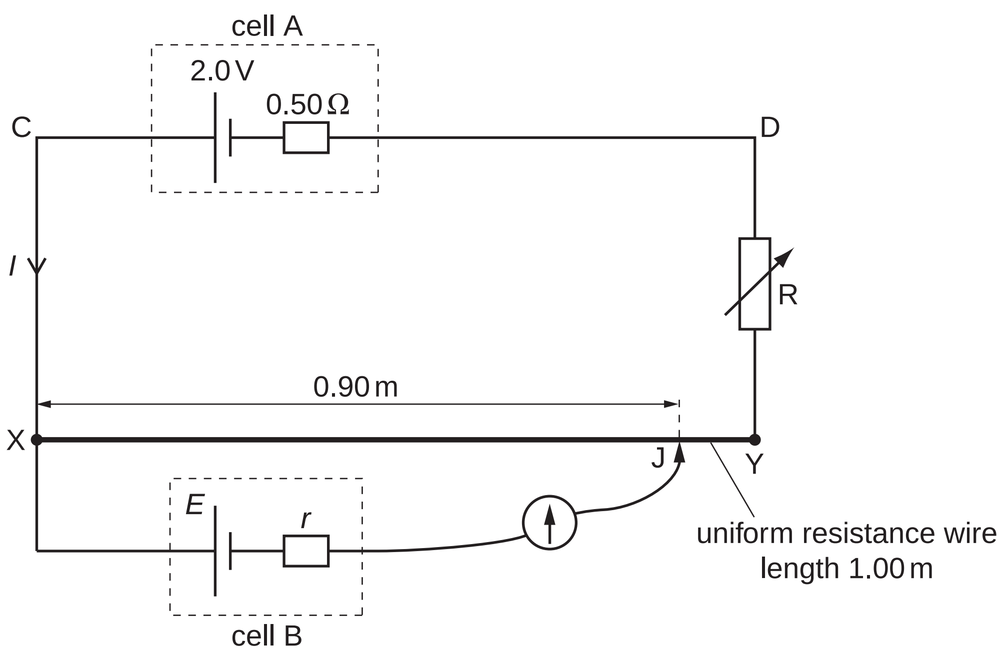

Fig. 5.1

The uniform resistance wire XY has length 1.00 m and resistance 4.0 Ω. Cell A has e.m.f. 2.0 V and internal resistance 0.50 Ω. The current through cell A is *I*. Cell B has e.m.f. *E* and internal resistance *r*.

The current through cell B is made zero when the movable connection J is adjusted so that the length of XJ is 0.90 m. The variable resistor R has resistance 2.5 Ω.

(i) Apply Kirchhoff's second law to the circuit CXYDC to determine the current *I*.

I = ... A [2]

(ii) Calculate the potential difference across the length of wire XJ.

potential difference = ... V [2]

(iii) Use your answer in **(ii)** to state the value of *E*.

E = ... V [1]

(iv) State why the value of the internal resistance of cell B is not required for the determination of *E*.

....

....[1]

3 **(a)** **(i)** State Kirchhoff's first law.

....

.... [1]

(ii) Kirchhoff's first law is linked to the conservation of a certain quantity. State this quantity.

.... [1]

(b) A variable resistor of resistance *R* is used to control the current in a circuit, as shown in Fig. 5.1.

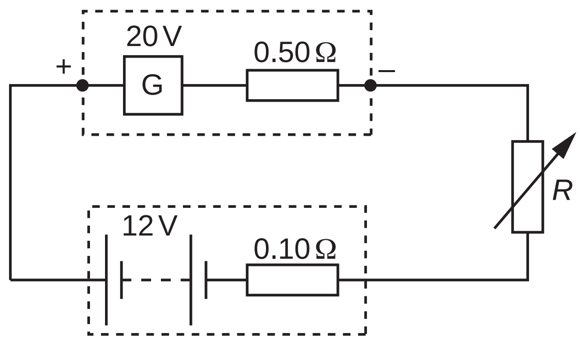

Fig. 5.1

The generator G has e.m.f. 20V and internal resistance 0.50Ω. The battery has e.m.f. 12V and internal resistance 0.10Ω. The current in the circuit is 2.0A.

(i) Apply Kirchhoff's second law to the circuit to determine the resistance *R*.

R = ... Ω [2]

(ii) Calculate the total power generated by G.

power = ... W [2]

(iii) Calculate the power loss in the total resistance of the circuit.

power = ... W [2]

(iv) The circuit is used to supply energy to the battery from the generator. Determine the efficiency of the circuit.

efficiency = ... [2]

4 **(a)** Distinguish between *potential difference* (p.d.) and *electromotive force* (e.m.f.) in terms of energy transformations.

....

....

....

.... [2]

(b) Two cells A and B are connected in series with a resistor R of resistance 5.5 Ω, as shown in Fig. 4.1.

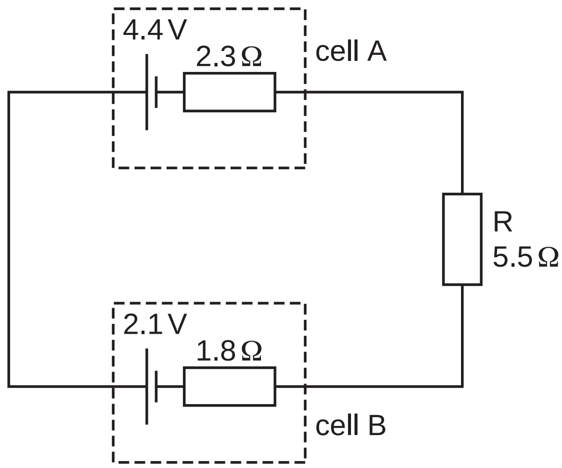

Fig. 4.1

Cell A has e.m.f. 4.4 V and internal resistance 2.3 Ω. Cell B has e.m.f. 2.1 V and internal resistance 1.8 Ω.

(i) State Kirchhoff's second law.

....

.... [1]

(ii) Calculate the current in the circuit.

current = ... A [2]

(iii) On Fig. 4.1, draw an arrow to show the direction of the current in the circuit. Label this arrow *I*. [1]

(iv) Calculate

1. the p.d. across resistor R,

p.d. = ... V [1]

2. the terminal p.d. across cell A,

p.d. = ... V [1]

3. the terminal p.d. across cell B.

p.d. = ... V [2]

5 **(a)** For a cell, explain the terms

(i) *electromotive force* (e.m.f.),

....

.... [1]

(ii) *internal resistance*.

....

.... [1]

(b) The circuit of Fig. 5.1 shows two batteries A and B and a resistor R connected in series.

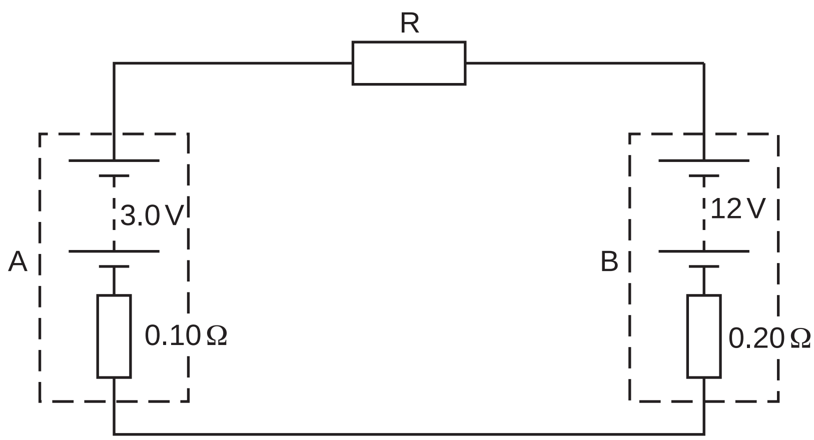

Fig. 5.1

Battery A has an e.m.f. of 3.0 V and an internal resistance of 0.10 Ω. Battery B has an e.m.f. of 12 V and an internal resistance of 0.20 Ω. Resistor R has a resistance of 3.3 Ω.

(i) Apply Kirchhoff's second law to calculate the current in the circuit.

current = ... A [2]

(ii) Calculate the power transformed by battery B.

power = ... W [2]

(iii) Calculate the total energy lost per second in resistor R and the internal resistances.

energy lost per second = ... $J\,s^{-1}$ [2]

(c) The circuit of Fig. 5.1 may be used to store energy in battery A. Suggest how your answers in **(b)** support this statement.

....

....

.... [1]

6 A cell has electromotive force (e.m.f.) *E* and internal resistance *r*. It is connected in series with a variable resistor R, as shown in Fig. 6.1.

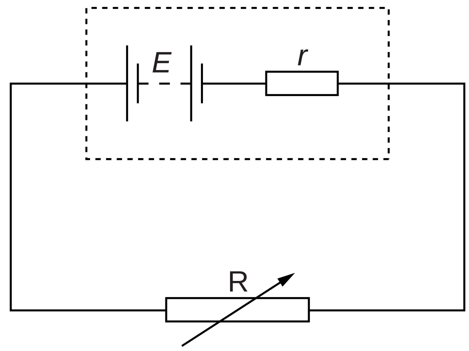

Fig. 6.1

(a) Define electromotive force (e.m.f.).

....

....

.... [2]

(b) The variable resistor R has resistance *X*. Show that

$$\frac{\text{power dissipated in resistor R}}{\text{power produced in cell}} = \frac{X}{X + r}.$$

[3]

(c) The variation with resistance X of the power P_R dissipated in R is shown in Fig. 6.2.

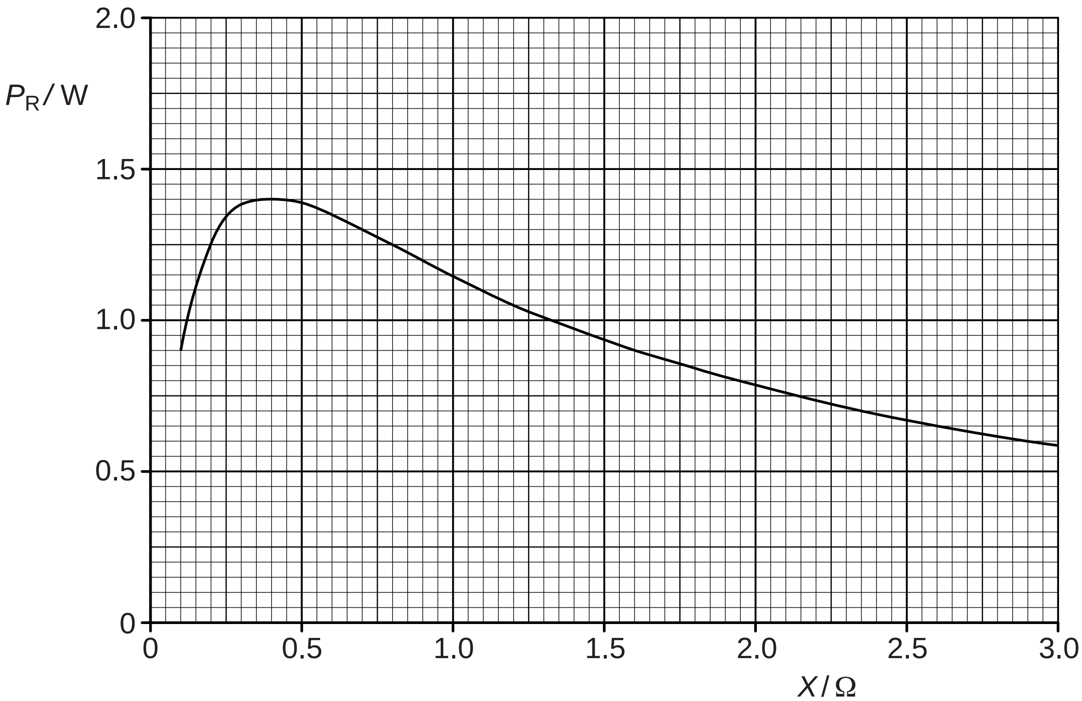

Fig. 6.2

(i) Use Fig. 6.2 to state, for maximum power dissipation in resistor R, the magnitude of this power and the resistance of R.

maximum power = ... W

resistance = ... Ω
[2]

(ii) The cell has e.m.f. 1.5 V.
Use your answers in **(i)** to calculate the internal resistance of the cell.

internal resistance = ... Ω [3]

(d) In Fig. 6.2, it can be seen that, for larger values of X, the power dissipation decreases. Use the relationship in **(b)** to suggest one advantage, despite the lower power output, of using the cell in a circuit where the resistance X is larger than the internal resistance of the cell.

....

.... [1]

7 A network of resistors, each of resistance *R*, is shown in Fig. 7.1.

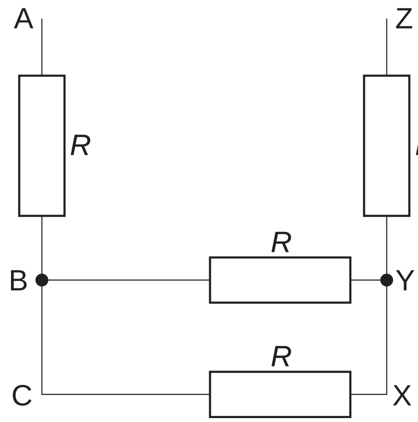

Fig. 7.1

(a) Calculate the total resistance, in terms of *R*, between points

(i) A and C,

resistance = ... [1]

(ii) B and X,

resistance = ... [1]

(iii) A and Z.

resistance = ... [1]

(b) Two cells of e.m.f. E_1 and E_2 and negligible internal resistance are connected into the network in **(a)**, as shown in Fig. 7.2.

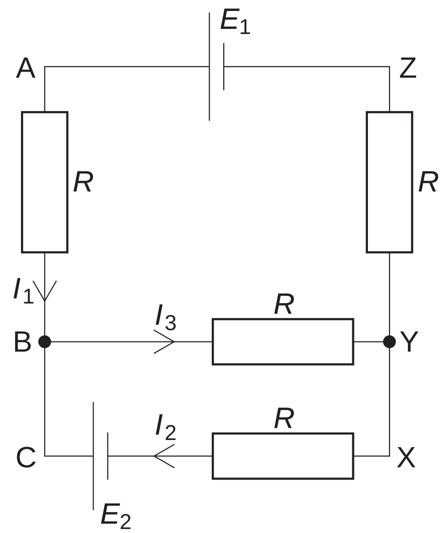

Fig. 7.2

The currents in the network are as indicated in Fig. 7.2.

Use Kirchhoff's laws to state the relation

(i) between currents I_1, I_2 and I_3,

.... [1]

(ii) between E_2, R, I_2 and I_3 in loop BCXYB,

.... [1]

(iii) between E_1, E_2, R, I_1 and I_2 in loop ABCXYZA.

.... [1]