9 A battery of electromotive force (e.m.f.) E and internal resistance r is connected in series to a variable resistor R which has resistance between 0 Ω and 10 Ω, as shown in Fig. 9.1. The ammeter and the voltmeter are both ideal.

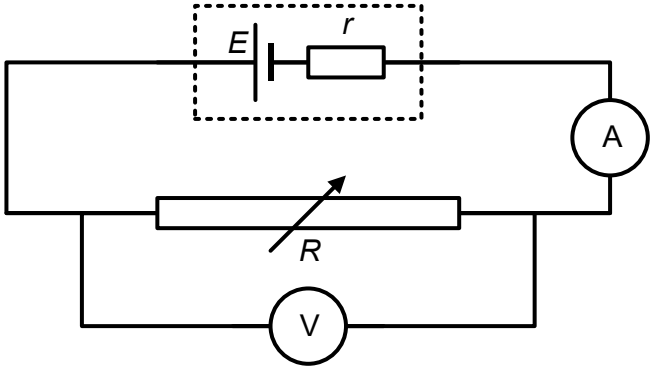

Fig. 9.1

Fig. 9.2 shows the variation of potential difference (p.d.) V across the variable resistor with the current I flowing through it.

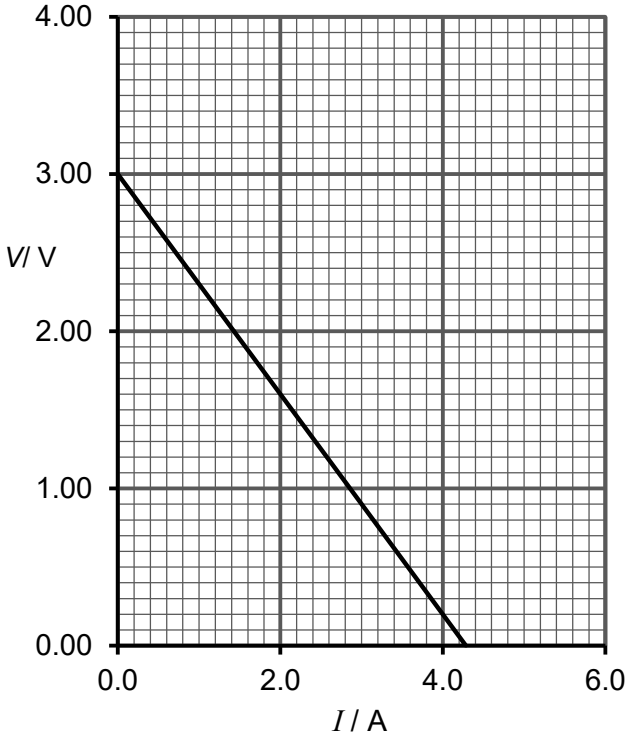

Fig. 9.2

(a) State how the graph in Fig. 9.2 can be obtained using the electrical circuit in Fig. 9.1.

……

…… [1]

(b) Comment on the following statements:

(i) "In Fig. 9.2, since the p.d. V across the variable resistor is not proportional to the current I flowing through it, the variable resistor does not obey Ohm's law."

……

……

…… [1]

(ii) "The battery supplies electrons to the circuit to produce current."

……

……

…… [1]

(c) Using Fig. 9.2,

(i) deduce the e.m.f. E of the battery,

E = …… V [1]

(ii) determine the internal resistance r of the battery.

r = …… Ω [2]

(d) **(i)** Using your answers to **(c)**, deduce the p.d. V across the variable resistor when the power delivered to it is maximum.

V = ... V [1]

(ii) Calculate the maximum power delivered to the variable resistor.

maximum power delivered = ... W [2]

(iii) On Fig. 9.3, sketch the variation of power P delivered to the variable resistor when the p.d. V across it is varied.

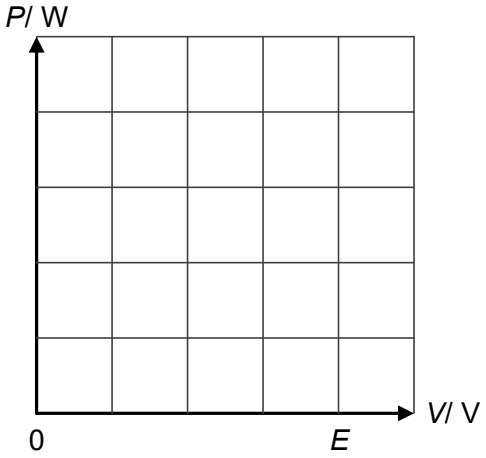

Fig. 9.3

[2]

(e) **(i)** Determine or deduce the efficiency of the circuit when the power delivered is maximum.

efficiency = ... % [1]

(ii) Determine or deduce the value of R to achieve maximum efficiency.

R = ... Ω [1]

(iii) A student designs a sound system that is analogous to the electrical circuit in Fig. 9.1. The e.m.f. source and the variable resistor represent the amplifier and the loudspeaker, respectively.

Explain whether a high-efficiency or high-power transfer is more desirable in this sound system.

.....

.....

.....

.....

.....

.....

..... [2]

(f) To calculate the e.m.f. E' of an unknown cell, a 2.00 V driver cell of negligible internal resistance is connected to a 4.00 Ω resistor and a metre-wire PQ of resistance 6.00 Ω, as shown in Fig. 9.4.

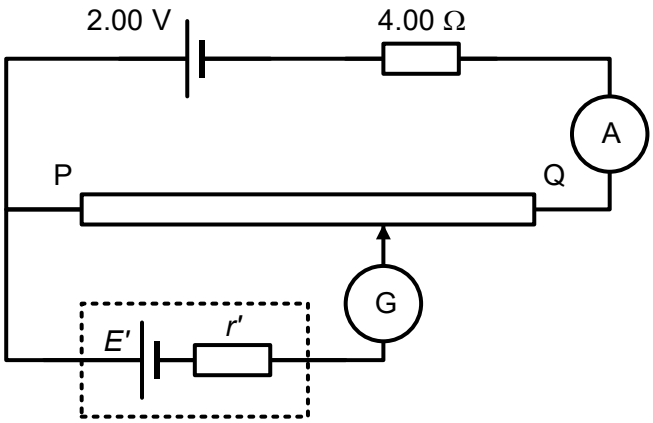

Fig. 9.4

(i) If the balance point is 0.600 m from P, determine the e.m.f. E' of the unknown cell.

E' = ... V [2]

(ii) By drawing an additional electrical component on Fig. 9.4, show how the circuit can be modified to determine the internal resistance r' of the unknown cell. [1]

(iii) If the 2.00 V driver cell is rated at 2000 mAh (milli-ampere hour), calculate the maximum duration that it can be used to power a device which draws 0.080 A of current.

maximum duration = ... h [2]

[Total: 20]