4 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*.
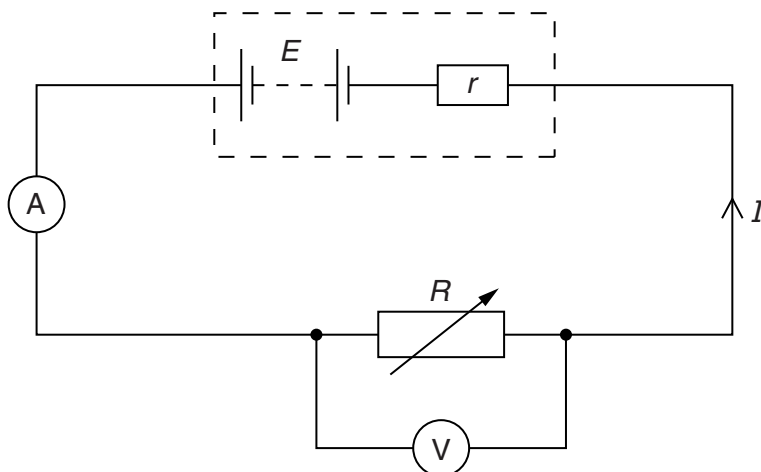

Fig. 4.1

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]

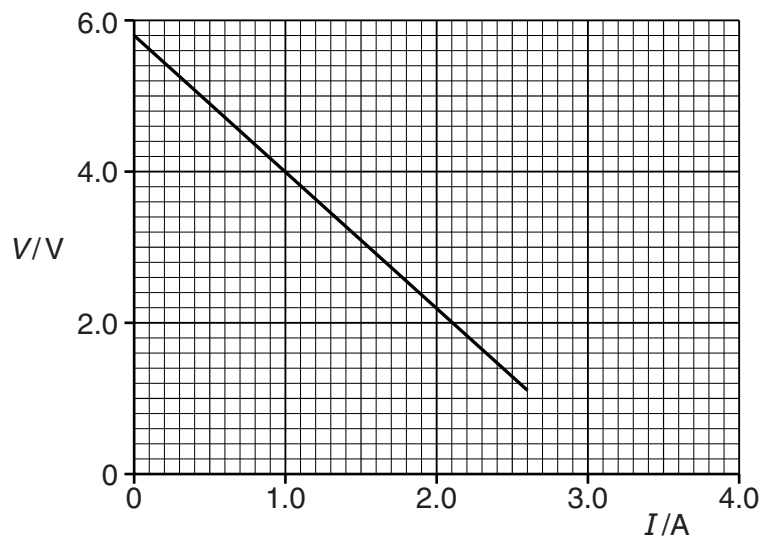**(c)** The variation with current I of the p.d. V across R is shown in Fig. 4.2.

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]