6 **(a)** State Kirchhoff's first law.

.....

..... [1]

(b) A battery of electromotive force (e.m.f.) 12.0 V and internal resistance r is connected to a filament lamp and a resistor, as shown in Fig. 6.1.

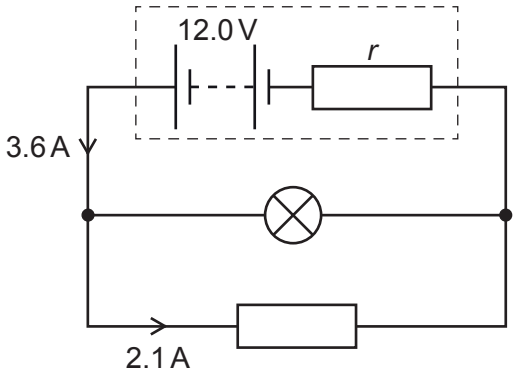

Fig. 6.1

The current in the battery is 3.6 A and the current in the resistor is 2.1 A. The I-V characteristic for the lamp is shown in Fig. 6.2.

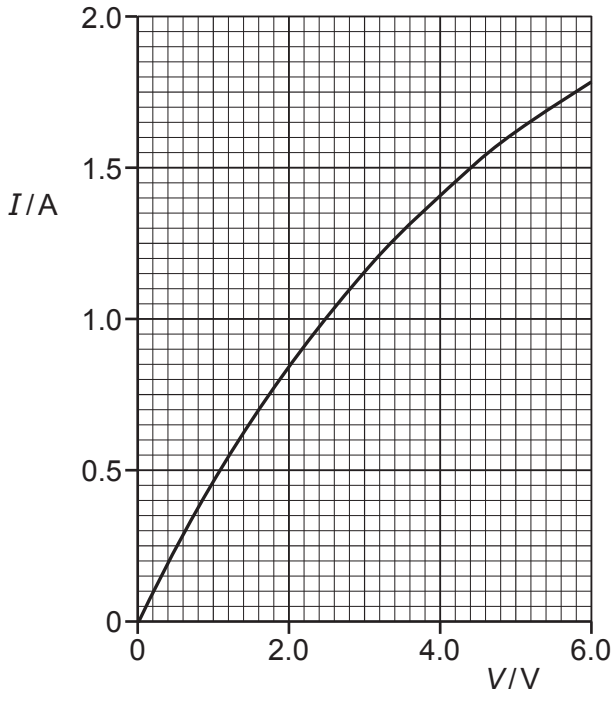

Fig. 6.2

(i) Determine the resistance of the lamp in Fig. 6.1.

resistance = ... Ω [3]

(ii) Determine the internal resistance *r* of the battery.

r = ... Ω [2]

(iii) The initial energy stored in the battery is 470 kJ. Assume that the e.m.f. and the current in the battery do not change with time.

Calculate the time taken for the energy stored in the battery to become 240 kJ.

time = ... s [2]

(iv) The filament wire of the lamp is connected in series with the adjacent copper connecting wire of the circuit, as illustrated in Fig. 6.3.

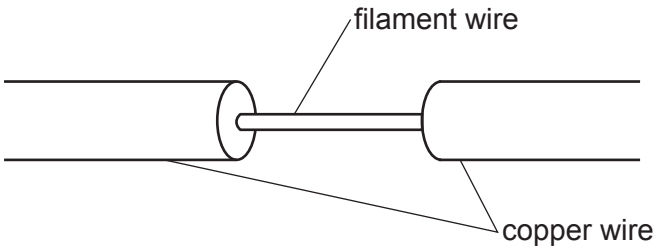

Fig. 6.3 (not to scale)

Some data for the filament wire and the adjacent copper connecting wire are given in Table 6.1.

Table 6.1

	filament wire	copper wire
cross-sectional area	A	$360A$
number density of free electrons	n	$2.5n$

Calculate the ratio

$$\frac{\text{average drift speed of free electrons in filament wire}}{\text{average drift speed of free electrons in copper wire}}.$$

ratio = ... [2]

[Total: 10]