5 **(a)** 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. 5.1.

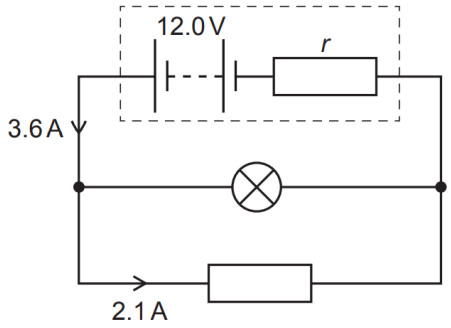

Fig. 5.1

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. 5.2.

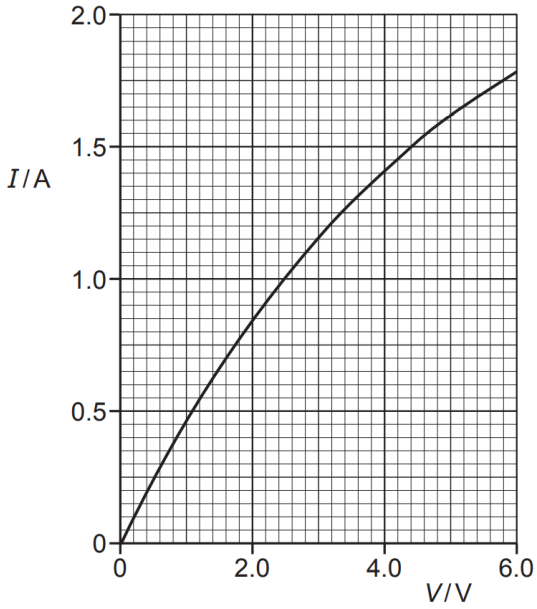

Fig. 5.2

(i) Explain, with reference to the graph, whether the resistance of filament lamp increases or decreases with increasing potential difference.

……

……

……

…… [2]

(ii) Determine the internal resistance *r* of the cell in Fig. 5.1.

internal resistance = …….. Ω [3]

(iii) The filament wire of the lamp is connected in series with the adjacent copper connecting wire of the circuit, as illustrated in Fig. 5.3.

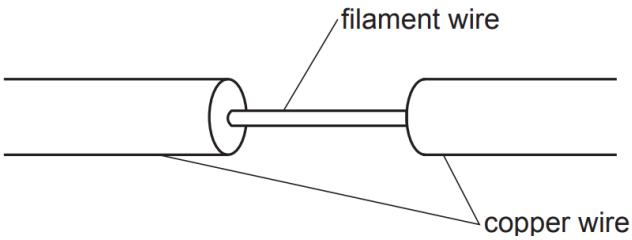

Fig. 5.3

Some data for the filament wire and the adjacent copper connecting wire are given in the table below.

	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 = …….. [1]

(b) Two identical filament lamps are connected first in series, and then in parallel, to a 12 V power supply that has negligible internal resistance.

The circuits are shown in Fig. 5.4 & Fig. 5.5 respectively.

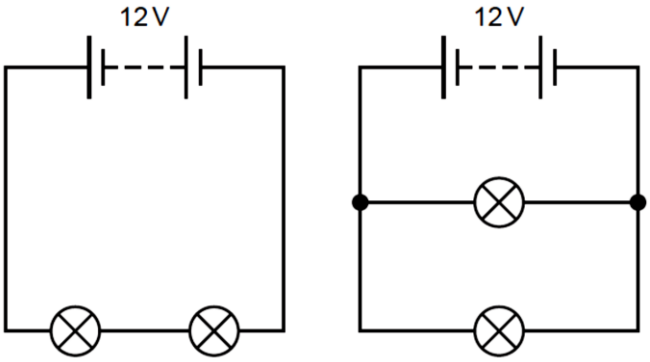

Fig. 5.4 **Fig. 5.5**

Explain why, after some time, the resistance of each lamp when they are connected in series is different from the resistance of each lamp when they are connected in parallel.

……

……

……

……

……

…….. [3]

(c) A potentiometer is setup as shown in Fig. 5.5. A resistive wire of 1.0 m is connected between point B and point D.

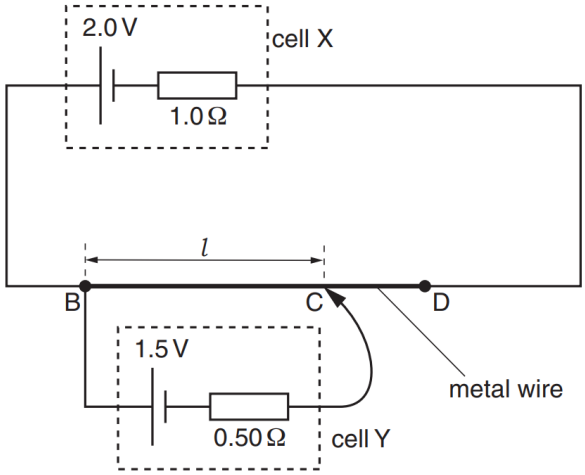

Fig. 5.5

When the length l is set at 93.75 cm, the current in cell Y is zero.
Two resistors are added to the potentiometer circuit, as shown in Fig. 5.6.

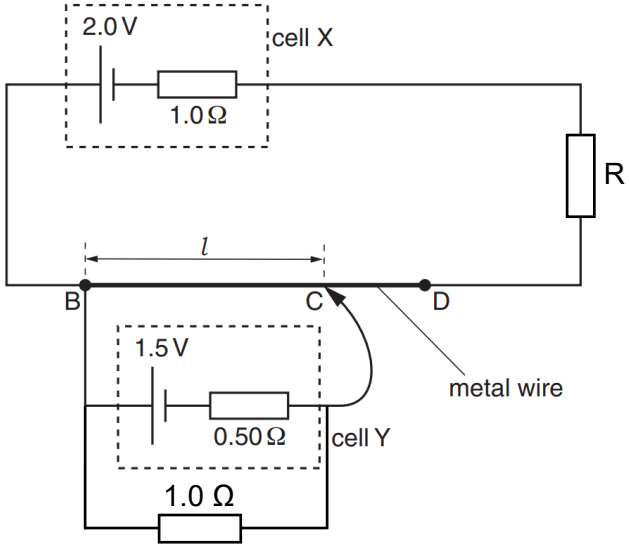

Fig. 5.6

Calculate the value of R such that the balance point of the circuit will be at point D.

R = …….. Ω [4]