5 **(a)** State Kirchhoff's second law.

.....

.....[2]

(b) Two batteries, each of electromotive force (e.m.f.) 6.0 V and negligible internal resistance, are connected in series with three resistors, as shown in Fig. 5.1.

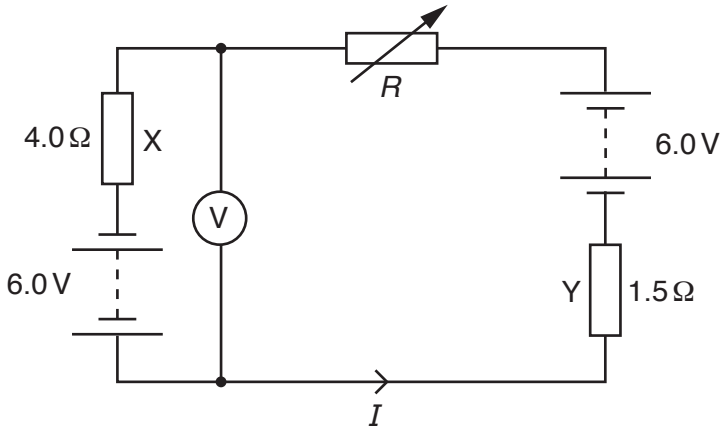

Fig. 5.1

Resistor X has resistance 4.0 Ω and resistor Y has resistance 1.5 Ω.

(i) The resistance *R* of the variable resistor is changed until the voltmeter in the circuit reads zero.

Calculate

1. the current *I* in the circuit,

I = ... A [1]

2. the resistance *R*.

R = ... Ω [2]

(ii) Resistors X and Y are wires made from the same material. The diameter of the wire of X is twice the diameter of the wire of Y.

Determine the ratio

$$\frac{\text{average drift speed of free electrons in X}}{\text{average drift speed of free electrons in Y}}.$$

ratio = ... [2]

(iii) The resistance R of the variable resistor is now increased.

State and explain the effect of the increase in R on the power transformed by each of the batteries.

.....

.....

.....

.....[3]

[Total: 10]