

Potential Dividers

Question paper 1

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|-------------------|-----------------------|
| Level | International A Level |
| Subject | Physics |
| Exam Board | CIE |
| Topic | D.C. Circuits |
| Sub Topic | Potential Dividers |
| Paper Type | Theory |
| Booklet | Question paper 1 |

Time Allowed: 54 minutes

Score: /45

Percentage: /100

| A* | A | B | C | D | E | U |
|------|--------|-----|-------|-------|-----|------|
| >85% | '77.5% | 70% | 62.5% | 57.5% | 45% | <45% |

- 1 A battery is connected in series with resistors X and Y, as shown in Fig. 6.1.

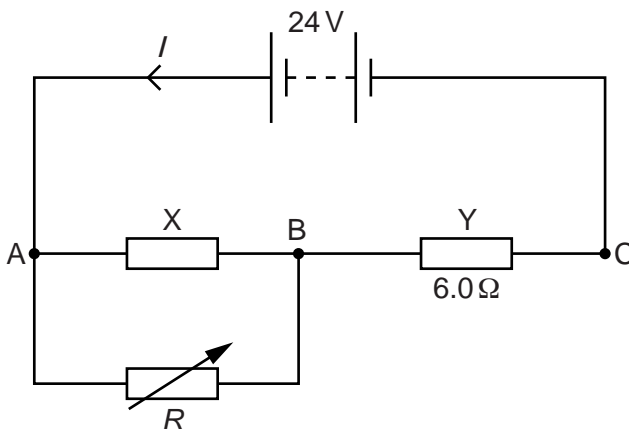


Fig. 6.1

The resistance of X is constant. The resistance of Y is 6.0Ω . The battery has electromotive force (e.m.f.) 24V and zero internal resistance. A variable resistor of resistance R is connected in parallel with X.

The current I from the battery is changed by varying R from 5.0Ω to 20Ω . The variation with R of I is shown in Fig. 6.2.

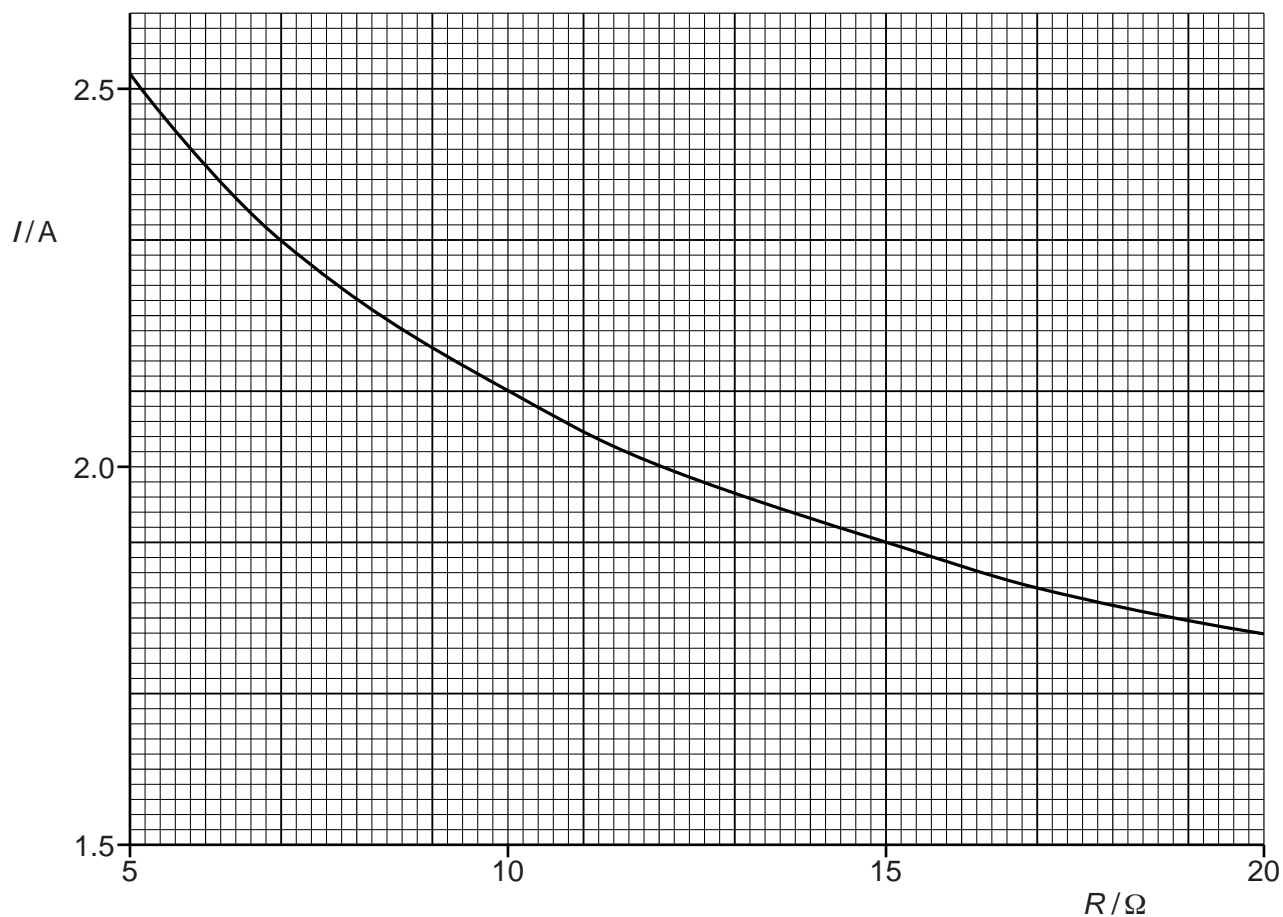


Fig. 6.2

(a) Explain why the potential difference (p.d.) between points A and C is 24V for all values of R .

.....
..... [1]

(b) Use Fig. 6.2 to state and explain the variation of the p.d. across resistor Y as R is increased. Numerical values are not required.

.....
.....
..... [2]

(c) For $R = 6.0\Omega$,

(i) show that the p.d. between points A and B is 9.6V,

[2]

(ii) calculate the resistance of X,

resistance = Ω [3]

(iii) calculate the power provided by the battery.

power = W [2]

(d) State and explain qualitatively how the power provided by the battery changes as the resistance R is increased.

.....
..... [1]

2 A potentiometer circuit that is used as a means of comparing potential differences is shown in Fig. 5.1.

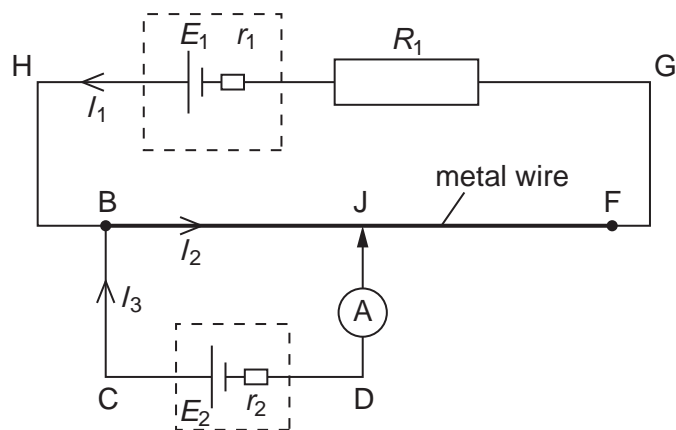


Fig. 5.1

A cell of e.m.f. E_1 and internal resistance r_1 is connected in series with a resistor of resistance R_1 and a uniform metal wire of total resistance R_2 . A second cell of e.m.f. E_2 and internal resistance r_2 is connected in series with a sensitive ammeter and is then connected across the wire at BJ. The connection at J is halfway along the wire. The current directions are shown on Fig. 5.1.

(a) Use Kirchhoff's laws to obtain the relation

(i) between the currents I_1 , I_2 and I_3 ,

.....[1]

(ii) between E_1 , R_1 , R_2 , r_1 , I_1 and I_2 in loop HBJFGH,

.....[1]

(iii) between E_1 , E_2 , r_1 , r_2 , R_1 , R_2 , I_1 and I_3 in the loop HBCDJFGH.

.....[2]

(b) The connection at J is moved along the wire. Explain why the reading on the ammeter changes.

.....

[2]

- 3 (a) A variable resistor is used to control the current in a circuit, as shown in Fig. 5.1.

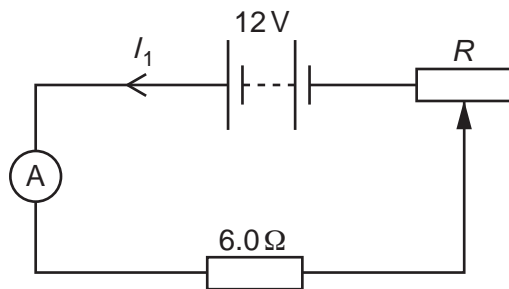


Fig. 5.1

The variable resistor is connected in series with a 12V power supply of negligible internal resistance, an ammeter and a 6.0Ω resistor. The resistance R of the variable resistor can be varied between 0 and 12Ω.

- (i) The maximum possible current in the circuit is 2.0A. Calculate the minimum possible current.

minimum current = A [2]

- (ii) On Fig. 5.2, sketch the variation with R of current I_1 in the circuit.

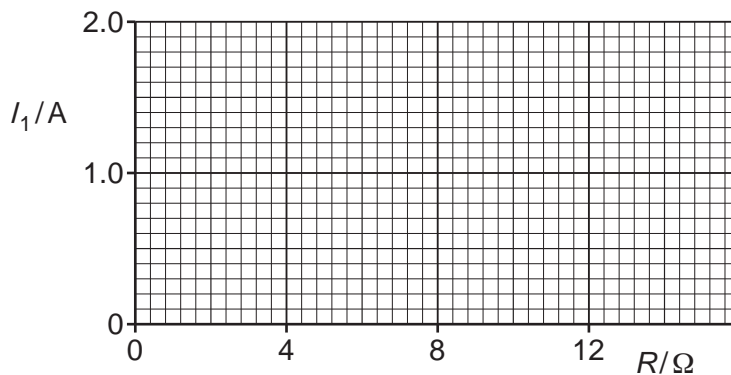


Fig. 5.2

[2]

(b) The variable resistor in (a) is now connected as a potential divider, as shown in Fig. 5.3.

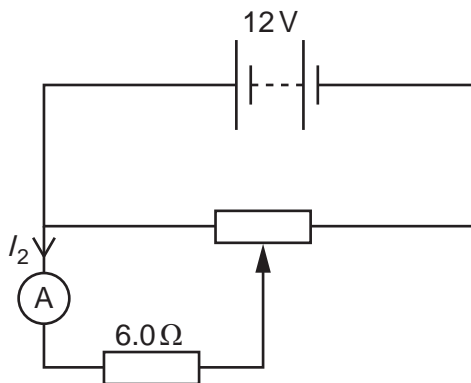


Fig. 5.3

Calculate the maximum possible and minimum possible current I_2 in the ammeter.

maximum $I_2 = \dots\dots\dots$ A

minimum $I_2 = \dots\dots\dots$ A
[2]

(c) (i) Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

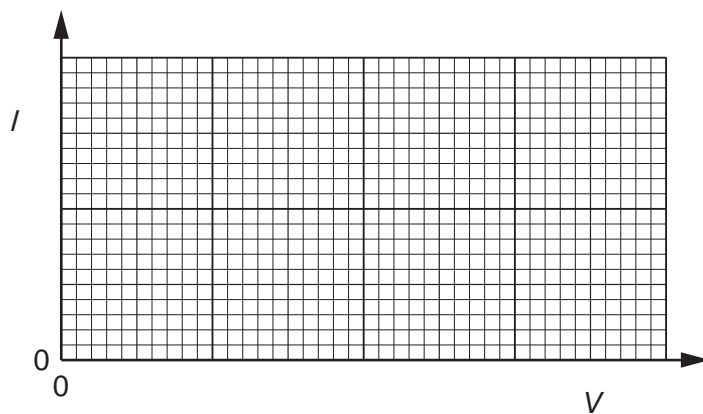


Fig. 5.4

[2]

- (ii) The resistor of resistance 6.0Ω is replaced with a filament lamp in the circuits of Fig. 5.1 and Fig. 5.3. State an advantage of using the circuit of Fig. 5.3, compared to the circuit of Fig 5.1, when using the circuits to vary the brightness of the filament lamp.

.....

.....

..... [1]

- 4 (a) A metal wire of constant resistance is used in an electric heater. In order not to overload the circuit for the heater, the supply voltage to the heater is reduced from 230V to 220V.

Determine the percentage reduction in the power output of the heater.

reduction = % [2]

- (b) A uniform wire AB of length 100cm is connected between the terminals of a cell of e.m.f. 1.5V and negligible internal resistance, as shown in Fig. 6.1.

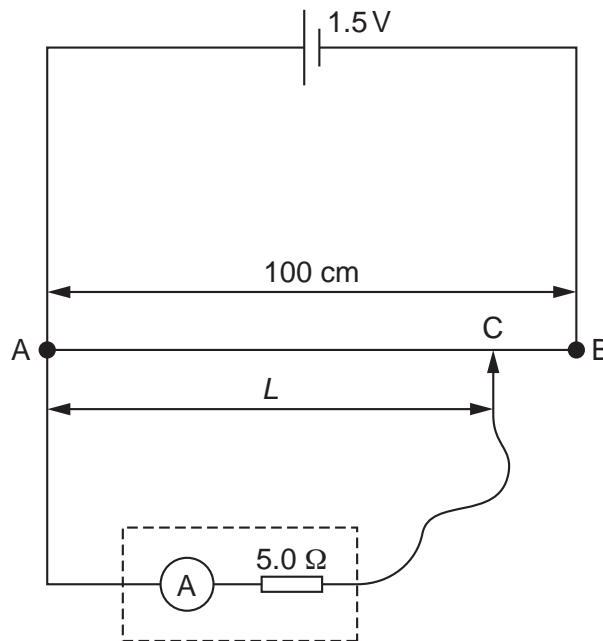


Fig. 6.1

An ammeter of internal resistance 5.0Ω is connected to end A of the wire and to a contact C that can be moved along the wire.

Determine the reading on the ammeter for the contact C placed

- (i) at A,

reading = A [1]

(ii) at B.

reading = A [1]

(c) Using the circuit in (b), the ammeter reading I is recorded for different distances L of the contact C from end A of the wire. Some data points are shown on Fig. 6.2.

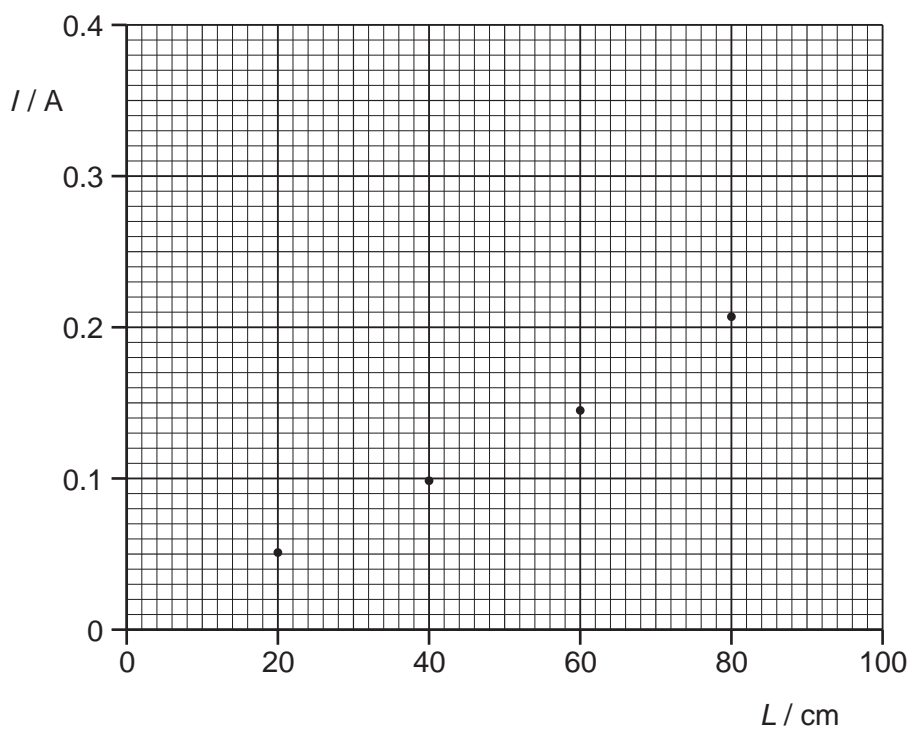


Fig. 6.2

(i) Use your answers in (b) to plot data points on Fig. 6.2 corresponding to the contact C placed at end A and at end B of the wire. [1]

(ii) Draw a line of best fit for all of the data points and hence determine the ammeter reading for contact C placed at the midpoint of the wire.

reading = A [1]

- (iii) Use your answer in (ii) to calculate the potential difference between A and the contact C for the contact placed at the midpoint of AB.

potential difference = V [2]

- (d) Explain why, although the contact C is at the midpoint of wire AB, the answer in (c)(iii) is **not** numerically equal to one half of the e.m.f. of the cell.

.....
.....
.....[2]

- 5 A potential divider circuit consists of two resistors of resistances P and Q , as shown in Fig. 7.1.

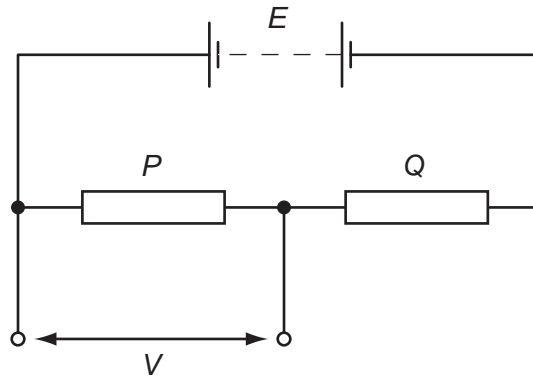


Fig. 7.1

The battery has e.m.f. E and negligible internal resistance.

- (a) Deduce that the potential difference V across the resistor of resistance P is given by the expression

$$V = \frac{P}{P + Q} E.$$

- (b) The resistances P and Q are $2000\ \Omega$ and $5000\ \Omega$ respectively. A voltmeter is connected in parallel with the $2000\ \Omega$ resistor and a thermistor is connected in parallel with the $5000\ \Omega$ resistor, as shown in Fig. 7.2.

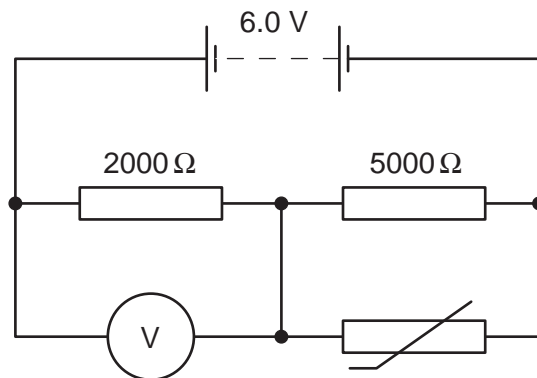


Fig. 7.2

The battery has e.m.f. 6.0V. The voltmeter has infinite resistance.

- (i) State and explain qualitatively the change in the reading of the voltmeter as the temperature of the thermistor is raised.

.....

.....

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..... [3]

- (ii) The voltmeter reads 3.6V when the temperature of the thermistor is 19°C . Calculate the resistance of the thermistor at 19°C .

resistance = Ω [4]