1.

The variation with potential difference (p.d.) V of current I for a semiconductor diode is shown in Fig. 5.1.

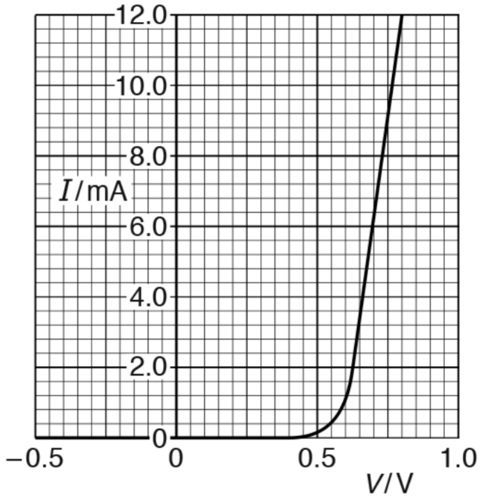


Fig. 5.1

(a) Use Fig. 5.1 to describe the variation of the resistance of the diode between $V = -0.5\text{V}$ and $V = 0.8\text{V}$.

Use the figure to describe the variation of resistance of the diode between V = −0.5V and V = 0.8V

- Infinite/ very high resistance for negative voltages up to about 0.4V.
- Resistance decreases from 0.4V.

2. Sketch the variation with p.d. V of current I for a filament lamp.
   - Initial straight line from (0,0) into curve with decreasing gradient but <u>NOT to horizontal.</u>
   - Repeated in negative quadrant.

3.

A resistor X of resistance 1.8 Ω is connected to a resistor Y of resistance 0.60 Ω and a battery P, as shown in Fig. 5.1.

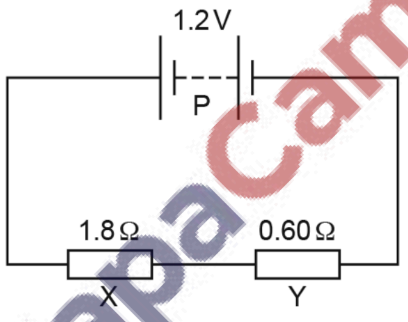


Fig. 5.1

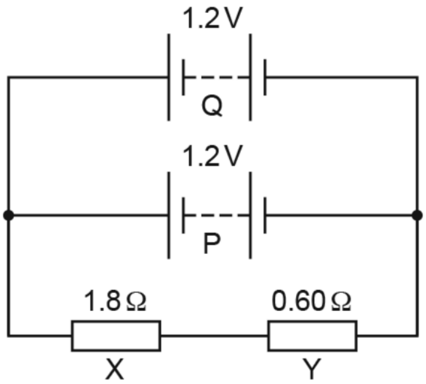
The battery P has an electromotive force (e.m.f.) of 1.2 V and negligible internal resistance.

Explain, in terms of energy, why the potential difference across resistor X is less than the e.m.f of the battery.

Thermal energy is dissipated in resistor Y

4.

Another battery Q of e.m.f. 1.2 V and negligible internal resistance is now connected into the circuit of Fig. 5.1 to produce the new circuit shown in Fig. 5.2.



State whether the addition of battery Q causes the current to decrease, increase or remain the same in:

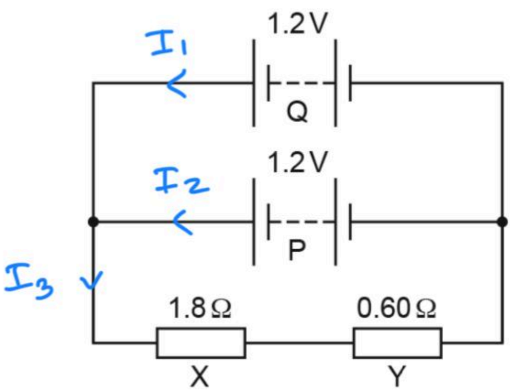
a. Resistor X

b. Battery P

Ans:

- Resistor X: remains the same
- Battery P: decreases

- Since batteries are connected in parallel, p.d remains same, which means that current in X and Y remains same.
- In battery P, current decreases due to kirchhoff's law.



$I_3 = I_1 + I_2$

I_3 remains same

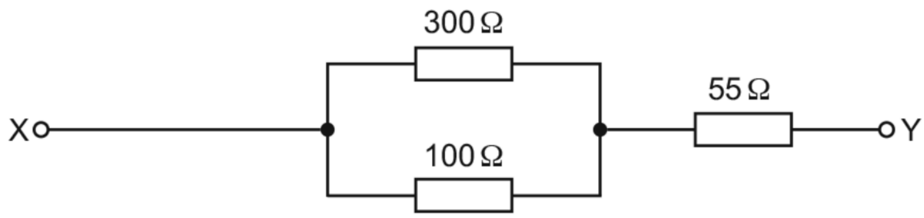
$I_2 = I_3 - I_1$

$\therefore I_2 < I_3$

5. A battery with internal resistance is connected in series to a filament lamp. Explain, in terms of energy, why the potential difference across the lamp must be less than the e.m.f of the battery.
   Energy is dissipated in the internal resistance.

6.

Fig. 5.1 shows a network of three resistors.



(c) The network in **(b)** is connected to a power supply so that there is a potential difference between terminals X and Y. The power dissipated in the resistor of resistance 55 Ω is 0.20 W.

(i) Calculate the current in the resistor of resistance:

1. 55 Ω

current = ... A

2. 300 Ω.

current = ... A

[3]

1. $P = I^2R$
or
$P = VI$ **and** $V = IR$

$I = (0.20 / 55)^{0.5}$

$= 0.060$ A

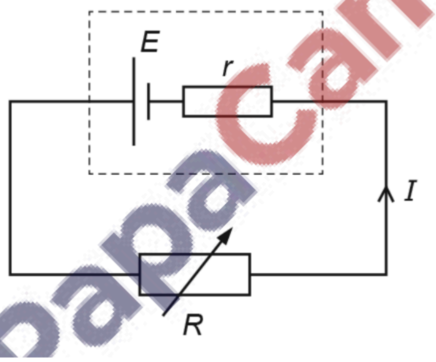
2. $I = 0.060 / 4$

$= 0.015$ A

For part 2, where the 300ohm and 100ohm resistors are in parallel, ratio between their currents =
300(ohm) : 100(ohm) = 1(A) : 3(A)
Thus divide the total current by 4, to get the equivalent of 1A.

7.

A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor of resistance R, as shown in Fig. 7.1.



(ii) State an expression for E in terms of I, R and r.

E = ... [1]

(iii) The resistance R of the variable resistor is changed so that it is equal to r.

Determine an expression, in terms of only E and r, for the power P dissipated in the variable resistor.

P = ... [2]

(c)(ii)	$E = IR + Ir$ **or** $E = I(R + r)$
(c)(iii)	$P = I^2R$ **or** $P = I^2r$
	$I = E / 2r$
	(so) $P = E^2 / 4r$

8.

A network of three resistors of resistances R_1, R_2 and R_3 is shown in Fig. 6.1.

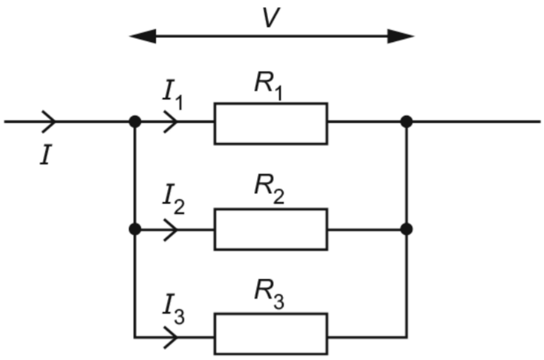


Fig. 6.1

The individual currents in the resistors are I_1, I_2 and I_3. The total current in the combination of resistors is I and the potential difference across the combination is V.

Show that the combined resistance R of the network is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

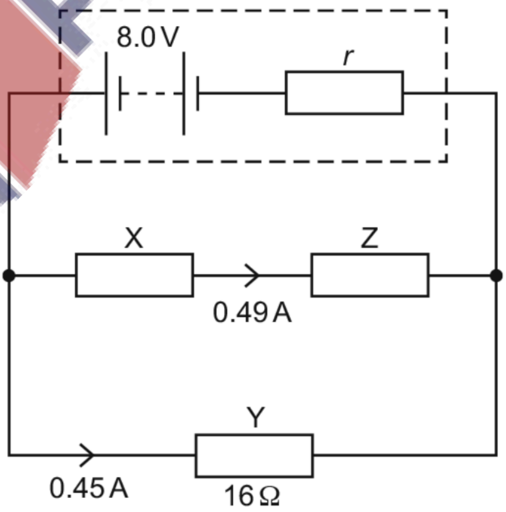
$I = I_1 + I_2 + I_3$

$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

$\therefore \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

9.

A battery of electromotive force (e.m.f.) 8.0 V and internal resistance *r* is connected to three resistors X, Y and Z, as shown in Fig. 6.2.



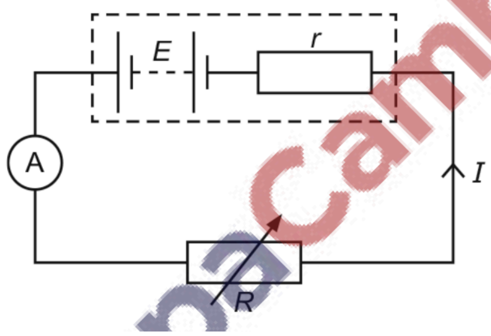
Resistor Z in Fig. 6.2 is replaced by a new resistor of smaller resistance.

State and explain the effect, if any, on the terminal potential difference of the battery.

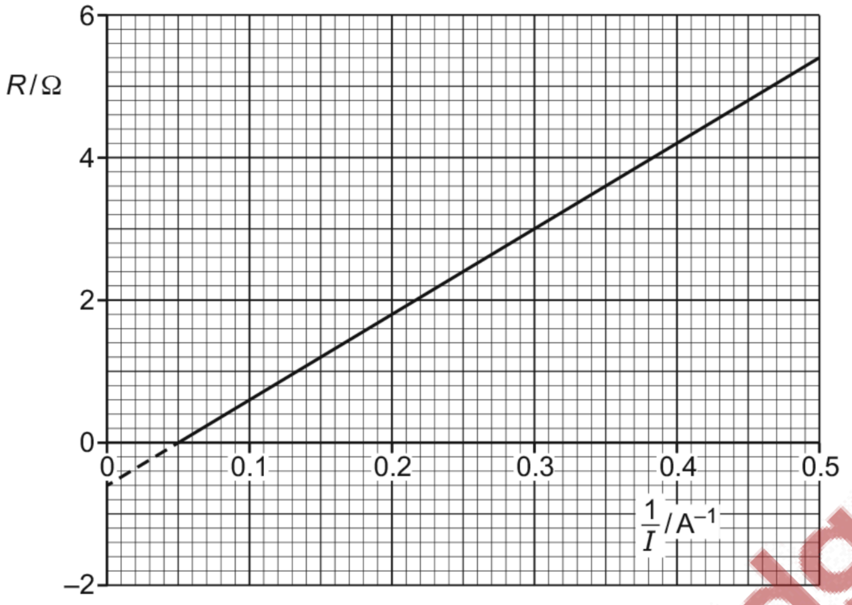
- Combined resistance decreases
- Current in the battery increases, so terminal potential difference decreases

10.

A battery of electromotive force (e.m.f.) *E* and internal resistance *r* is connected to a variable resistor of resistance *R*, as shown in Fig. 6.1.



An ammeter is used in the circuit in **(c)** to measure the current I as resistance R is varied. Fig. 6.2 is a graph of R against $\frac{1}{I}$.



(i) Use Fig. 6.2 to determine the power dissipated in the variable resistor when there is a current of 2.0 A in the circuit.

power = ... W [3]

(ii) Use Fig. 6.2 and the equation in **(c)** to:

1. state the internal resistance r of the battery

r = ... Ω

2. determine the e.m.f. E of the battery.

E = ... V [3]

i) $I = 2 \therefore \frac{1}{I} = 0.5$

$R = 5.4\ \Omega$

$P = I^2R = 2^2 \times 5.4 = 22W$

ii) $r = 0.6\ \Omega$ (the part of graph where there is no I, but there is R)

iii) E = gradient

$= \frac{5.4}{0.45} = 12V$

11. Describe the I–V characteristic of a metallic conductor at constant temperature.
    Straight line <u>through the origin</u>

12. Describe the I–V characteristic of a semiconductor diode
    - 0 current for one direction (–ve voltages) up to a few tenths of a volt
    - increasing gradient

13.

Two identical filament lamps are connected in series and then in parallel to a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance, as shown in Fig. 6.1a and Fig. 6.1b.

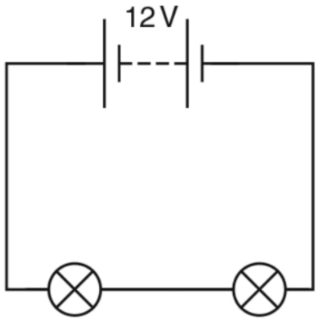


Fig. 6.1a

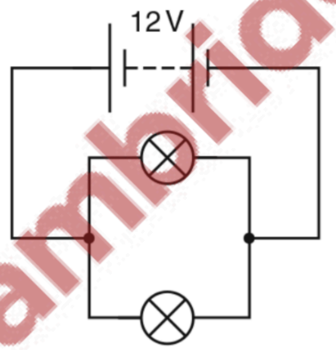


Fig. 6.1b

The I–V characteristic of each lamp is shown in Fig. 6.2.

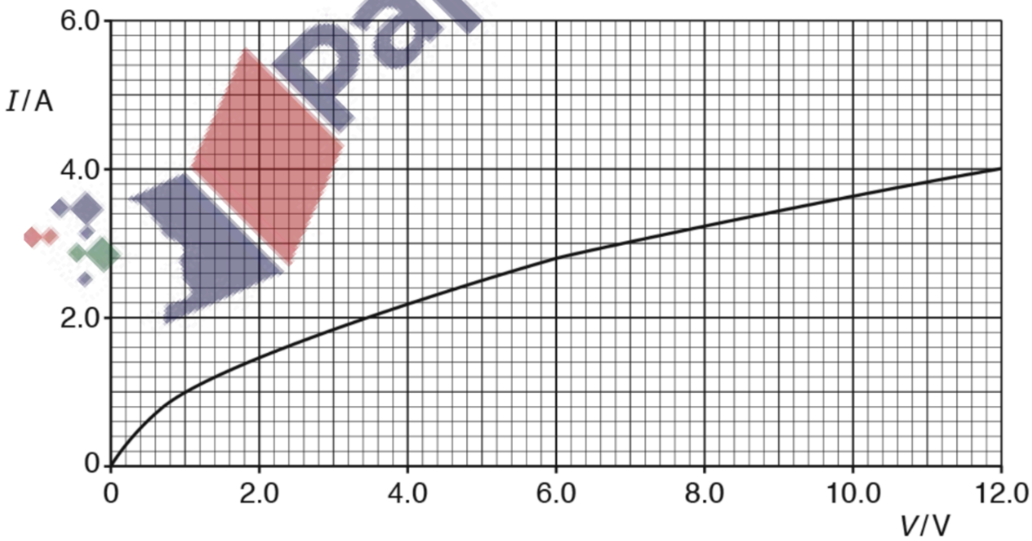


Fig. 6.2

(i) Use the information shown in Fig. 6.2 to determine the current through the battery in

1. the circuit of Fig. 6.1a,

current = ...A

2. the circuit of Fig. 6.1b.

current = ...A
[3]

(ii) Calculate the total resistance in

1. the circuit of Fig. 6.1a,

resistance = ...Ω

2. the circuit of Fig. 6.1b.

resistance = ...Ω
[3]

(iii) Calculate the ratio

$$\frac{\text{power dissipated in a lamp in the circuit of Fig. 6.1a}}{\text{power dissipated in a lamp in the circuit of Fig. 6.1b}}.$$

ratio = ...[2]

1. current = 2.8 A
2. 4(.0) A for each lamp
current in circuit = 8(.0) A
use of $R = V / I$ with correct values of V from graph for each arran
1. series resistance (= 2.1 + 2.1) = 4.2 or 4.3 Ω **or** (12 / 2.8) = 4.3 Ω
2. parallel resistance 1.5 Ω (each lamp 3.0 Ω) **or** (12 / 8.0) = 1.5 Ω
power = IV **or** V^2 / R **or** I^2R
ratio = (2.8 × 6.0) / (4.0 × 12) = 0.35

14.

A 12V battery with internal resistance 0.50Ω is connected to two identical filament lamps L_1 and L_2 as shown in Fig. 6.1.

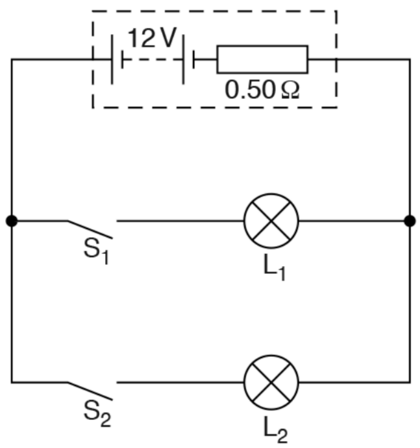


Fig. 6.1

The lamps are connected to the battery via switches S_1 and S_2. The power rating of each lamp is 48W for a potential difference of 12V.

(a) S_1 is closed and S_2 open.

State and explain whether the power transformed in L_1 is 48 W.

....

....

....[2]

(b) S_2 is now also closed.

(i) State and explain the effect on the current in L_1.

....

....

....[1]

(ii) State and explain the effect on the resistance of L_1.

....

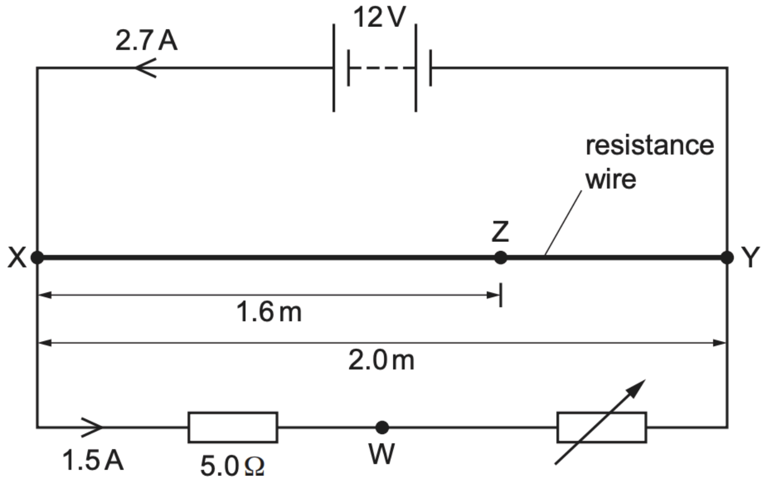
....

....[1]

(a)	internal resistance causes lost volts	B1	
	p.d. across lamp is less than 12 V, power is less than 48 W	B1	[2]
(b) (i)	greater lost volts or p.d. across cell/lamp reduced, less current in lamp	B1	[1]
(ii)	p.d. across lamp/current <u>in lamp</u> decreases, hence resistance decreases	B1	[1]

1.

A battery of electromotive force (e.m.f.) 12 V and negligible internal resistance is connected to a uniform resistance wire XY, a fixed resistor and a variable resistor, as shown in Fig. 6.2.



The resistance of the variable resistor is increased. By considering the currents in every part of the circuit, state and explain whether the total power produced by the battery decreases, increases or stays the same.

- Current in fixed/ variable resistor decreases
- Current in resistance wire is unchanged
- Current in battery decreases and same e.m.f so power decreases

2.

A cell with internal resistance r is connected to two resistors of resistances R_1 and R_2 as shown in Fig. 6.1.

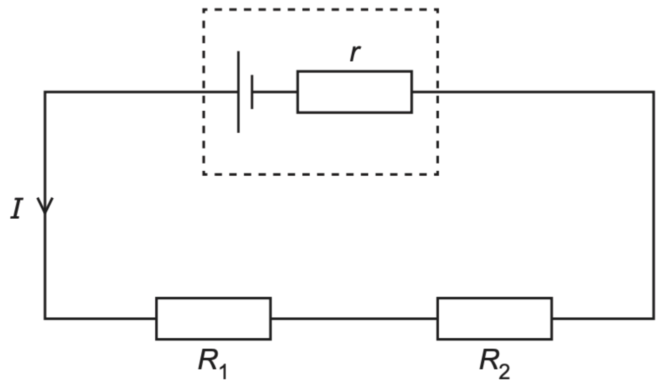
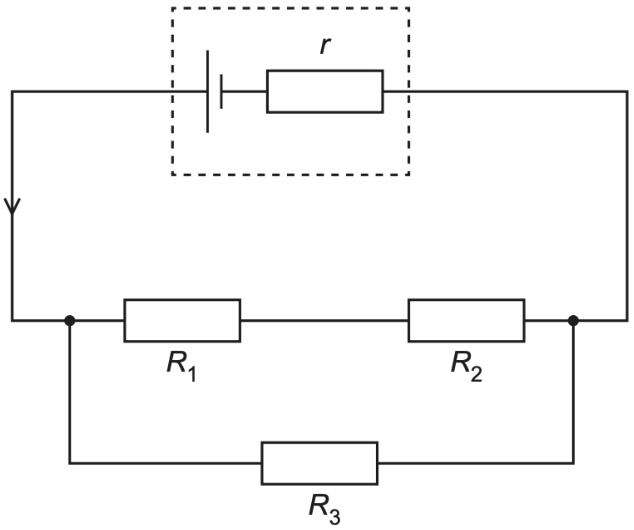


Fig. 6.1

The potential differences (p.d.s) across R_1 and R_2 are V_1 and V_2 respectively.
The terminal p.d. across the cell is V.
The current in the circuit is I.

A resistor of resistance R_3 is added to the circuit in Fig. 6.1, so that the circuit is as shown in Fig. 6.2.



State and explain the effect, if any, of this change on:

the current in the cell	- the total resistance of the circuit has decreased (and e.m.f. is unchanged) - the current in the cell will increase
the terminal p.d. of the cell	- the current is greater and so there is a larger p.d. across the internal resistance - terminal p.d. will decrease

3. State kirchhoff's laws

- Sum of currents entering a junction = sum of currents leaving the junctions
- Sum of electromotive forces = sum of potential differences around a closed loop