Questions compiled by Leong Yee Pak

19.1 Electric current
19.2 Potential difference

****1 June 03 P1 Q29**

29 What physical quantity would result from a calculation in which a potential difference is multiplied by an electric charge?

A electric current

B electric energy

C electric field strength

D electric power

*****2 June 03 P1 Q30**

30 The current in a component is reduced uniformly from 100 mA to 20 mA over a period of 8.0 s.

What is the charge that flows during this time?

A 160 mC **B** 320 mC **C** 480 mC **D** 640 mC

***3 Nov 03 P1 Q29**

29 Which electrical quantity would be the result of a calculation in which energy is divided by charge?

A current

B potential difference

C power

D resistance

*****4 Nov 03 P1 Q30**

30 A wire carries a current of 2.0 amperes for 1.0 hour.

How many electrons pass a point in the wire in this time?

A 1.2×10^{-15}

B 7.2×10^{3}

C 1.3×10^{19}

D 4.5×10^{22}

****5 June 04 P1 Q32**

32 What is an equivalent unit to 1 volt?

A $1\,J\,A^{-1}$ **B** $1\,J\,C^{-1}$ **C** $1\,W\,C^{-1}$ **D** $1\,W\,s^{-1}$

****6 June 04 P1 Q34**

34 The potential difference between point X and point Y is 20 V. The time taken for charge carriers to move from X to Y is 15 s, and, in this time, the energy of the charge carriers changes by 12 J.

What is the current between X and Y?

A 0.040 A **B** 0.11 A **C** 9.0 A **D** 25 A

***7 Nov 04 P1 Q31**

31 Which of the following describes the electric potential difference between two points in a wire that carries a current?

A the force required to move a unit positive charge between the points

B the ratio of the energy dissipated between the points to the current

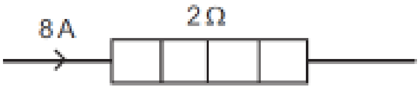
C the ratio of the power dissipated between the points to the current

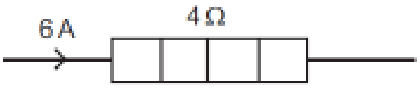
D the ratio of the power dissipated between the points to the charge moved

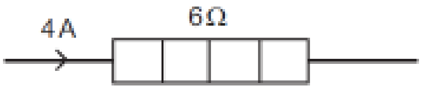
****8 Nov 04 P1 Q32**

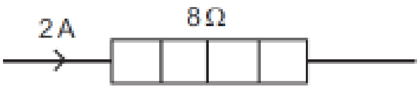
32 The diagram shows four heaters and the current in each.

Which heater has the greatest power dissipation?

A 

B 

C 

D 

****9 June 05 P1 Q32**

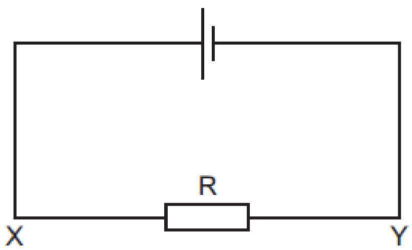
32 A copper wire of cross-sectional area 2.0 mm^2 carries a current of 10 A.

How many electrons pass through a given cross-section of the wire in one second?

A 1.0×10^1 **B** 5.0×10^6 **C** 6.3×10^{19} **D** 3.1×10^{25}

****10 June 06 P1 Q31**

31 The current in the circuit is 4.8 A.



What is the rate of flow and the direction of flow of electrons through the resistor R?

A $3.0 \times 10^{19}\,s^{-1}$ in direction X to Y

B $6.0 \times 10^{18}\,s^{-1}$ in direction X to Y

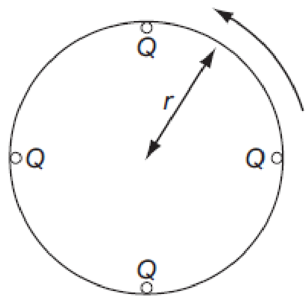
C $3.0 \times 10^{19}\,s^{-1}$ in direction Y to X

D $6.0 \times 10^{18}\,s^{-1}$ in direction Y to X

*****11 Nov 06 P1 Q31**

31 Four point charges, each of charge Q, are placed on the edge of an insulating disc of radius r.

The frequency of rotation of the disc is f.



What is the equivalent electric current at the edge of the disc?

A $4Qf$ **B** $\frac{4Q}{f}$ **C** $8\pi rQf$ **D** $\frac{2Qf}{\pi r}$

****12 June 07 P1 Q32**

32 The current in a resistor is 8.0 mA.

What charge flows through the resistor in 0.020 s?

A 0.16 mC **B** 1.6 mC **C** 4.0 mC **D** 0.40 C

***13 Nov 07 P1 Q28**

28 Which electrical quantity would be the result of a calculation in which energy transfer is divided by charge?

A current

B potential difference

C power

D resistance

****14 Nov 07 P1 Q29**

29 Two heating coils X and Y, of resistance R_X and R_Y respectively, deliver the same power when 12 V is applied across X and 6 V is applied across Y.

What is the ratio R_X / R_Y?

A ¼ B ½ C 2 D 4

****15 June 08 P1 Q32**

32 A power cable X has a resistance R and carries current I.

A second cable Y has a resistance $2R$ and carries current $\frac{1}{2}I$.

What is the ratio $\frac{\text{power dissipated in Y}}{\text{power dissipated in X}}$?

A $\frac{1}{4}$ B $\frac{1}{2}$ C 2 D 4

****16 June 08 P1 Q33**

33 A total charge of 100 C flows through a 12 W light bulb in a time of 50 s.

What is the potential difference across the bulb during this time?

A 0.12 V B 2.0 V C 6.0 V D 24 V

****17 June 08 P1 Q35**

35 The potential difference across a resistor is 12 V. The current in the resistor is 2.0 A.

4.0 C passes through the resistor.

What is the energy transferred and the time taken?

	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

****18 Nov 08 P1 Q34**

34 The charge that a fully-charged 12 V car battery can supply is 100 kC. The starter motor of the car requires a current of 200 A for an average period of 2.0 s. The battery does not recharge because of a fault.

What is the maximum number of times the starter motor of the car can be used?

A 21 **B** 25 **C** 42 **D** 250

****19 June 09 P1 Q30**

30 Which amount of charge, flowing in the given time, will produce the largest current?

	charge / C	time / s
A	4	$\frac{1}{4}$
B	4	1
C	1	4
D	$\frac{1}{4}$	4

Section B

1 Nov 03 P2 Q7

7 An electric heater is rated as 240 V, 1.2 kW and has constant resistance.

(a) For the heater operating at 240 V,

(i) show that the current in the heater is 5.0 A,

(ii) calculate its resistance.

resistance = ... Ω
[4]

(b) The heater in **(a)** is connected to a mains supply by means of two long cables, as illustrated in Fig. 7.1.

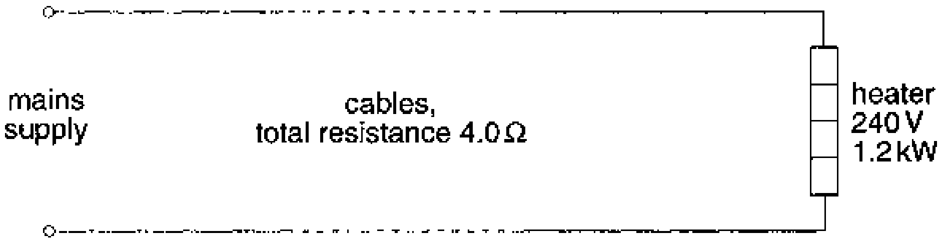


Fig. 7.1

The cables have a total resistance of 4.0 Ω. The voltage of the mains supply is adjusted so that the heater operates normally at 240 V. Using your answers in **(a)**, where appropriate, calculate

(i) the potential difference across the cables,

potential difference = ... V

(ii) the voltage of the mains supply,

voltage = ... V

(iii) the power dissipated in the cables.

power dissipated = ... W
[3]

(c) Using information from **(b)**, determine the efficiency ε at which power is transferred from the supply to the heater. That is, calculate

$$\varepsilon = \frac{\text{power dissipated in heater}}{\text{power input from supply}}.$$

efficiency = ...[2]

2 Nov 07 P12 Q6

6 An electric shower unit is to be fitted in a house. The shower is rated as 10.5 kW, 230 V. The shower unit is connected to the 230 V mains supply by a cable of length 16 m, as shown in Fig. 6.1.

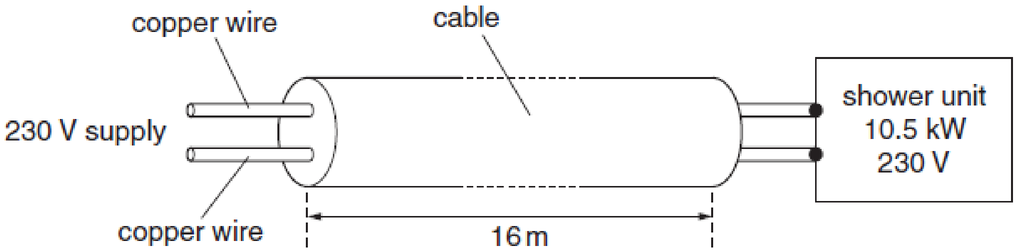


Fig. 6.1

(a) Show that, for normal operation of the shower unit, the current is approximately 46 A.

[2]

(b) The resistance of the two wires in the cable causes the potential difference across the shower unit to be reduced. The potential difference across the shower unit must not be less than 225 V.
The wires in the cable are made of copper of resistivity $1.8 \times 10^{-8}\,\Omega\,m$.
Assuming that the current in the wires is 46 A, calculate

(i) the maximum resistance of the cable,

resistance = ... Ω [3]

(ii) the minimum area of cross-section of each wire in the cable.

area = ... m^2 [3]

(c) Connecting the shower unit to the mains supply by means of a cable having wires with too small a cross-sectional area would significantly reduce the power output of the shower unit.

(i) Assuming that the shower is operating at 210V, rather than 230V, and that its resistance is unchanged, determine the ratio

$$\frac{\text{power dissipated by shower unit at 210 V}}{\text{power dissipated by shower unit at 230 V}}.$$

ratio = ... [2]

(ii) Suggest and explain one further disadvantage of using wires of small cross-sectional area in the cable.

....

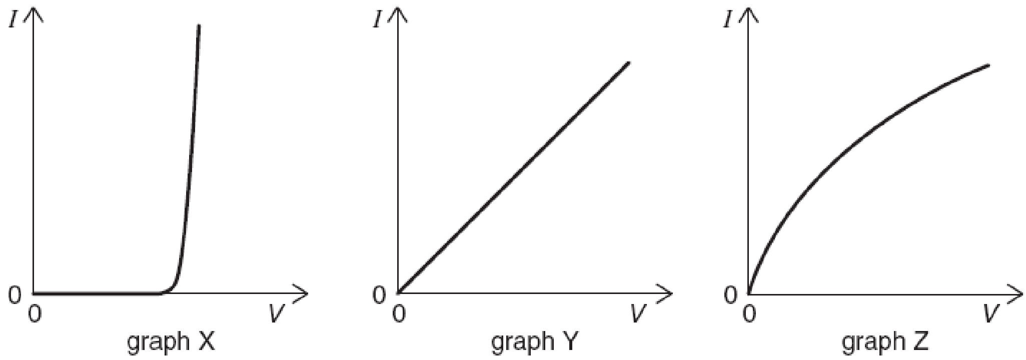
....

.... [2]

19.3 Resistance and resistivity
19.4 Sources of electromotive force

***1 June 02 P1 Q30**

30 The graphs show the variation with potential difference V of the current I for three circuit elements.



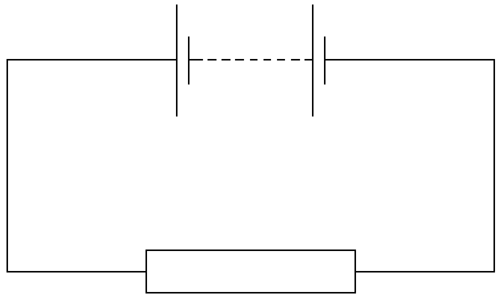
The three circuit elements are a metal wire at constant temperature, a semiconductor diode and a filament lamp.

Which row of the table correctly identifies these graphs?

	metal wire at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

****2 June 02 P1 Q31**

31 In the circuit below, the battery converts an amount E of chemical energy to electrical energy when charge Q passes through the resistor in time t.



Which expressions give the e.m.f. of the battery and the current in the resistor?

	e.m.f.	current
A	EQ	Q/t
B	EQ	Qt
C	E/Q	Q/t
D	E/Q	Qt

***3 Nov 02 P1 Q30**

30 Which equation is used to define resistance?

A power = (current)^2 × resistance

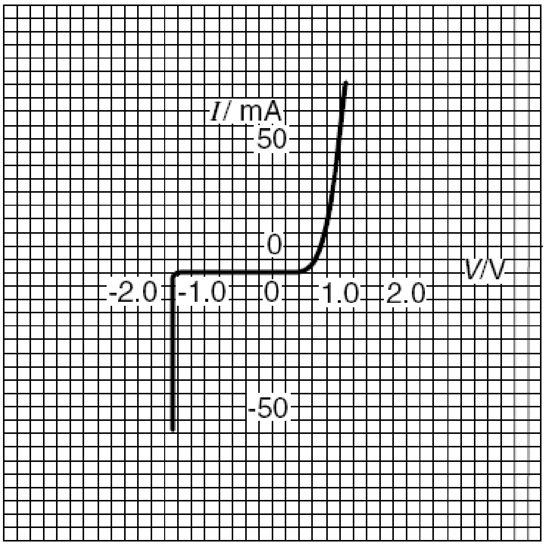
B resistivity = resistance × area ÷ length

C potential difference = current × resistance

D energy = (current)^2 × resistance × time

****4 Nov 02 P1 Q32**

32 The variation with potential difference V of the current I in a semiconductor diode is shown below.

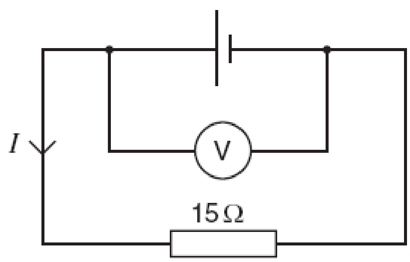


What is the resistance of the diode for applied potential differences of +1.0 V and –1.0 V?

	resistance	
	at +1.0 V	at –1.0 V
A	20 Ω	infinite
B	20 Ω	zero
C	0.05 Ω	infinite
D	0.05 Ω	zero

****5 June 03 P1 Q32**

32 The e.m.f. of the cell in the following circuit is 9.0 V. The reading on the high-resistance voltmeter is 7.5 V.



What is the current I?

A 0.1 A **B** 0.5 A **C** 0.6 A **D** 2.0 A

****6 June 04 P1 Q31**

31 Two wires made of the same material and of the same length are connected in parallel to the same voltage supply. Wire P has a diameter of 2 mm. Wire Q has a diameter of 1 mm.

What is the ratio $\dfrac{\text{current in P}}{\text{current in Q}}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4

****7 June 04 P1 Q33**

33 The terminal voltage of a battery is observed to fall when the battery supplies a current to an external resistor.

What quantities are needed to calculate the fall in voltage?

A the battery's e.m.f. and its internal resistance

B the battery's e.m.f. and the current

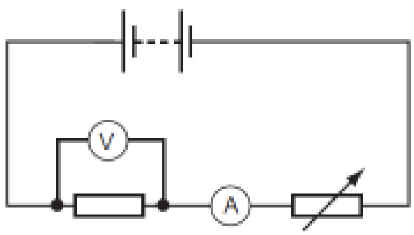
C the current and the battery's internal resistance

D the current and the external resistance

****8 June 04 P1 Q35**

35 The diagram shows a battery, a fixed resistor, an ammeter and a variable resistor connected in series.

A voltmeter is connected across the fixed resistor.



The value of the variable resistor is reduced.

Which correctly describes the changes in the readings of the ammeter and of the voltmeter?

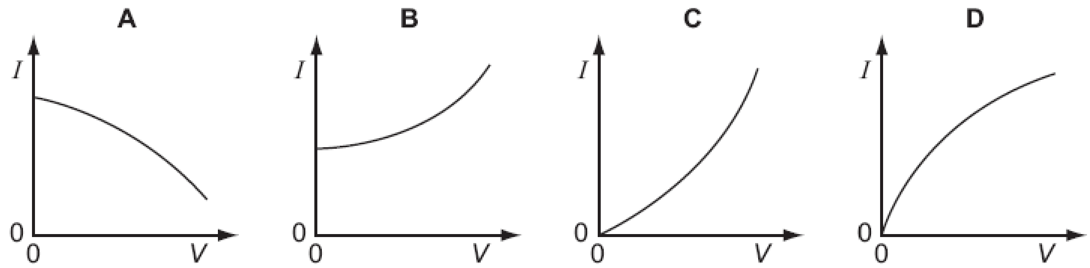
	ammeter	voltmeter
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

****9 Nov 04 P1 Q34**

34 The resistance of a thermistor decreases significantly as its temperature increases.

The thermistor is kept in air. The air is at room temperature.

Which graph best represents the way in which the current I in the thermistor depends upon the potential difference V across it?



****10 June 05 P1 Q33**

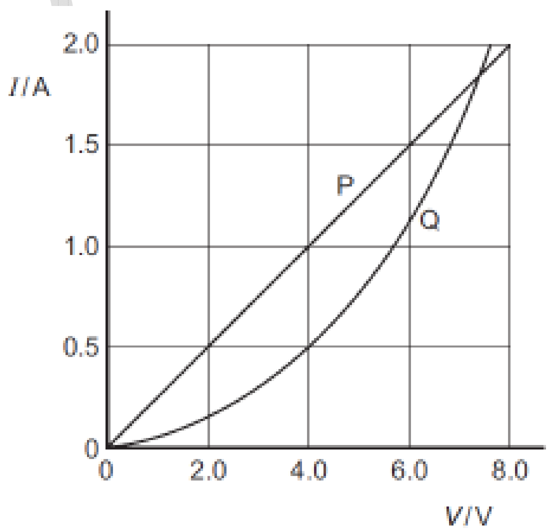
33 A cylindrical piece of a soft, electrically-conducting material has resistance R. It is rolled out so that its length is doubled but its volume stays constant.

What is its new resistance?

A $\frac{R}{2}$ **B** R **C** $2R$ **D** $4R$

****11 June 05 P1 Q34**

34 The I-V characteristics of two electrical components P and Q are shown below.



Which statement is correct?

A P is a resistor and Q is a filament lamp.

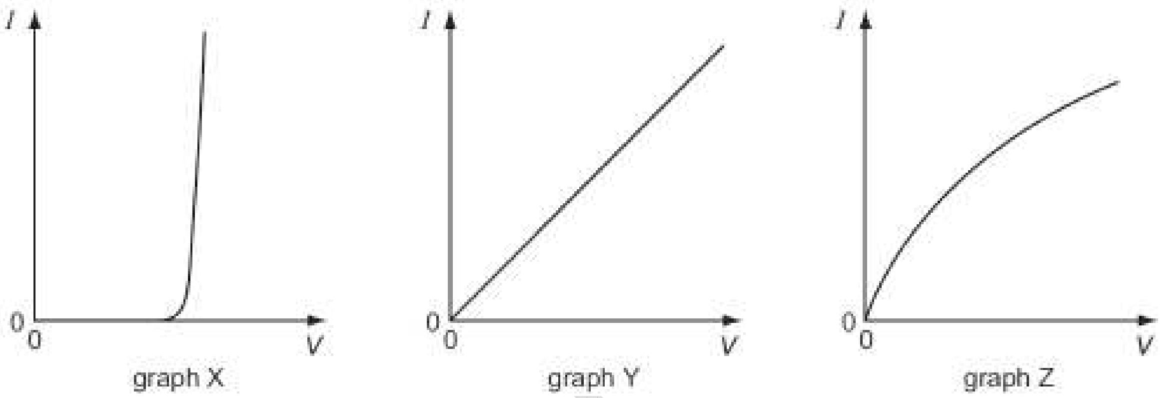
B The resistance of Q increases as the current in it increases.

C At 1.9 A the resistance of Q is approximately half that of P.

D At 0.5 A the power dissipated in Q is double that in P.

***12 Nov 05 P1 Q32**

32 The graphs show the variation with potential difference V of the current I for three circuit components.



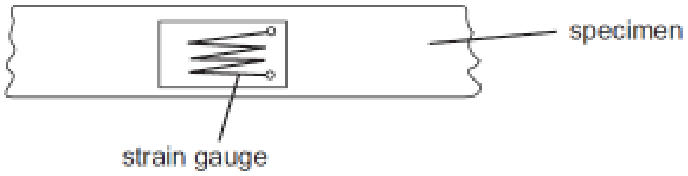
The components are a metal wire at constant temperature, a semiconductor diode and a filament lamp.

Which row of the table correctly identifies these graphs?

	metal wire at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

***13 Nov 05 P1 Q33**

33 Tensile strain may be measured by the change in electrical resistance of a strain gauge. A strain gauge consists of folded fine metal wire mounted on a flexible insulating backing sheet. The strain gauge is firmly attached to the specimen, so that the strain in the metal wire is always identical to that in the specimen.



When the strain in the specimen is increased, what happens to the resistance of the wire?

A It decreases, because the length decreases and the cross-sectional area increases.

B It decreases, because the length increases and the cross-sectional area decreases.

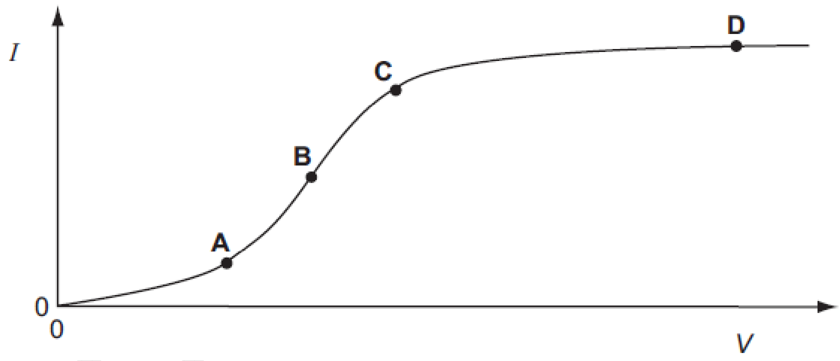
C It increases, because the length decreases and the cross-sectional area increases.

D It increases, because the length increases and the cross-sectional area decreases.

*****14 Nov 05 P1 Q34**

34 The graph shows how the electric current I through a conducting liquid varies with the potential difference V across it.

At which point on the graph does the liquid have the smallest resistance?



****15 June 06 P1 Q32**

32 Which equation is used to define resistance?

A energy = (current)^2 × resistance × time

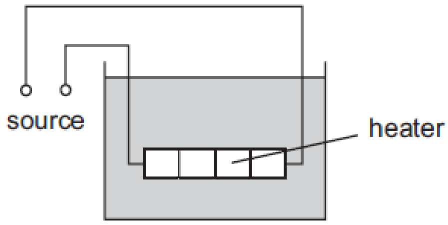
B potential difference = current × resistance

C power = (current)^2 × resistance

D resistivity = resistance × area ÷ length

*****16 June 06 P1 Q34**

34 The diagram shows a low-voltage circuit for heating the water in a fish tank.



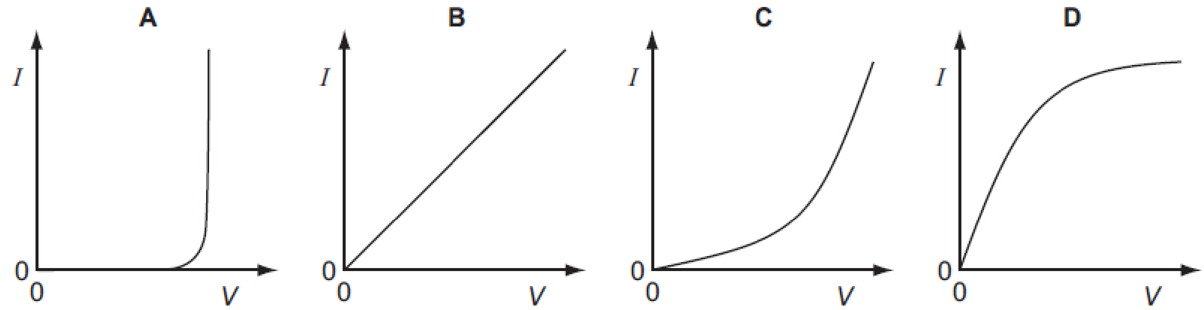
The heater has a resistance of 3.0 Ω. The voltage source has an e.m.f. of 12 V and an internal resistance of 1.0 Ω.

At what rate does the voltage source supply energy to the heater?

A 27 W **B** 36 W **C** 48 W **D** 64 W

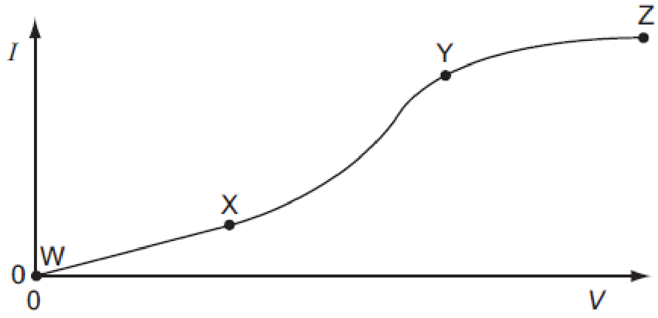
***17 Nov 06 P1 Q32**

32 Which graph shows the I – V characteristic of a filament lamp?



*****18 Nov 06 P1 Q33**

33 An electrical component has a potential difference V across it and a current I through it. A graph of I against V is drawn and is marked in three sections WX, XY and YZ.



In which ways does the resistance of the component vary within each of the three sections?

	WX	XY	YZ
A	constant	decreases	increases
B	constant	increases	increases
C	increases	decreases	constant
D	increases	increases	decreases

***19 June 07 P1 Q31**

31 What is a correct statement of Ohm's law?

A The potential difference across a component equals the current providing the resistance and other physical conditions stay constant.

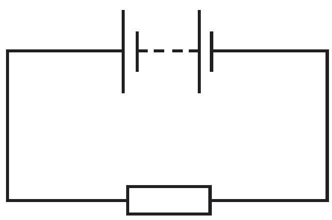
B The potential difference across a component equals the current multiplied by the resistance.

C The potential difference across a component is proportional to its resistance.

D The potential difference across a component is proportional to the current in it providing physical conditions stay constant.

****20 June 07 P1 Q35**

35 In the circuit below, the battery converts an amount E of chemical energy to electrical energy when charge Q passes through the resistor in time t.

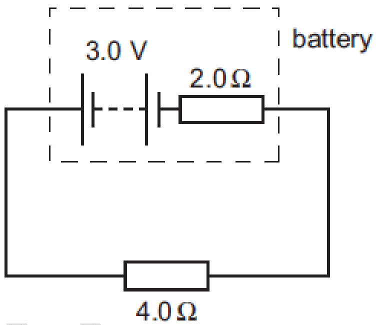


Which expressions give the e.m.f. of the battery and the current in the resistor?

	e.m.f.	current
A	EQ	Q/t
B	EQ	Qt
C	E/Q	Q/t
D	E/Q	Qt

*****21 June 07 P1 Q36**

36 A battery has an e.m.f. of 3.0 V and an internal resistance of 2.0 Ω.



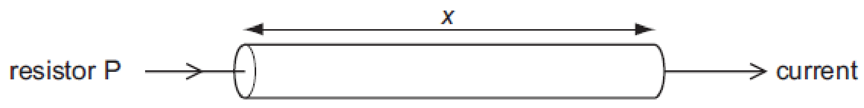
The battery is connected to a load of 4.0 Ω.

What are the terminal potential difference V and output power P?

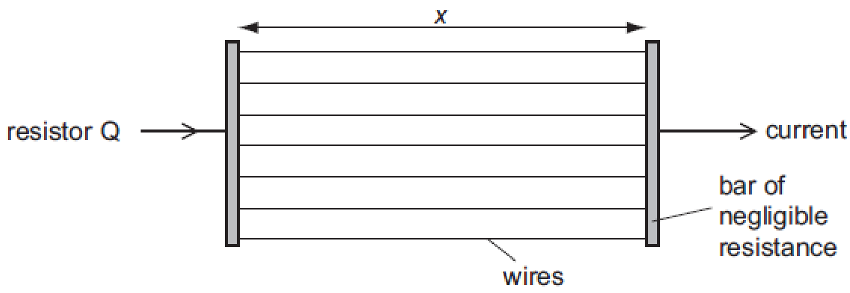
	V/V	P/W
A	1.0	0.50
B	1.0	1.5
C	2.0	1.0
D	2.0	1.5

*****22 June 07 P1 Q37**

37 A researcher has two pieces of copper of the same volume. All of the first piece is made into a cylindrical resistor P of length x.



All of the second piece is made into uniform wires each of the same length x which he connects between two bars of negligible resistance to form a resistor Q.



How do the electrical resistances of P and Q compare?

A P has a larger resistance than Q.

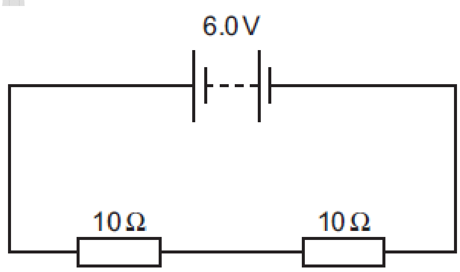
B Q has a larger resistance than P.

C P and Q have equal resistance.

D Q may have a larger or smaller resistance than P, depending on the number of wires made.

****23 Nov 07 P1 Q30**

30 A battery of negligible internal resistance is connected to two 10 Ω resistors in series.

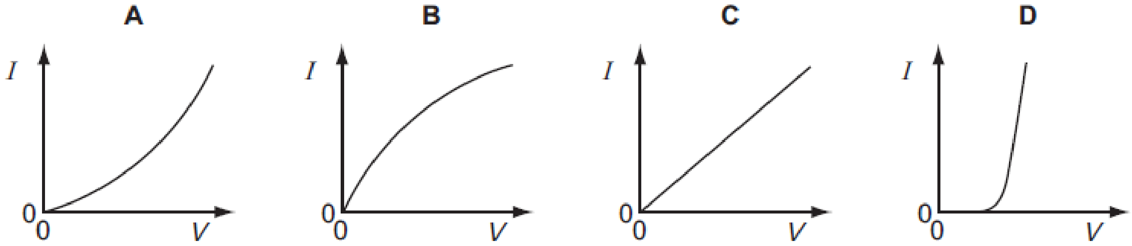


What charge flows through each of the 10 Ω resistors in 1 minute?

A 0.30 C **B** 0.60 C **C** 3.0 C **D** 18 C

***24 Nov 08 P1 Q33**

33 Which graph best represents the way the current I through a filament lamp varies with the potential difference V across it?



****25 June 09 P1 Q31**

31 A 12 V battery is charged for 20 minutes by connecting it to a source of electromotive force (e.m.f.). The battery is supplied with 7.2×10^4 J of energy in this time.

How much charge flows into the battery?

A 5.0 C **B** 60 C **C** 100 C **D** 6000 C

***26 June 09 P1Q32**

32 What is meant by the electromotive force (e.m.f.) of a cell?

A The e.m.f. of a cell is the energy converted into electrical energy when unit charge passes through the cell.

B The e.m.f. of a cell is the energy transferred by the cell in driving unit charge through the external resistance.

C The e.m.f. of a cell is the energy transferred by the cell in driving unit charge through the internal resistance of the cell.

D The e.m.f. of a cell is the amount of energy needed to bring a unit positive charge from infinity to its positive pole.

Section B

1 June 03 P2 Q5

5 A filament lamp operates normally at a potential difference (p.d.) of 6.0 V. The variation with p.d. V of the current I in the lamp is shown in Fig. 5.1.

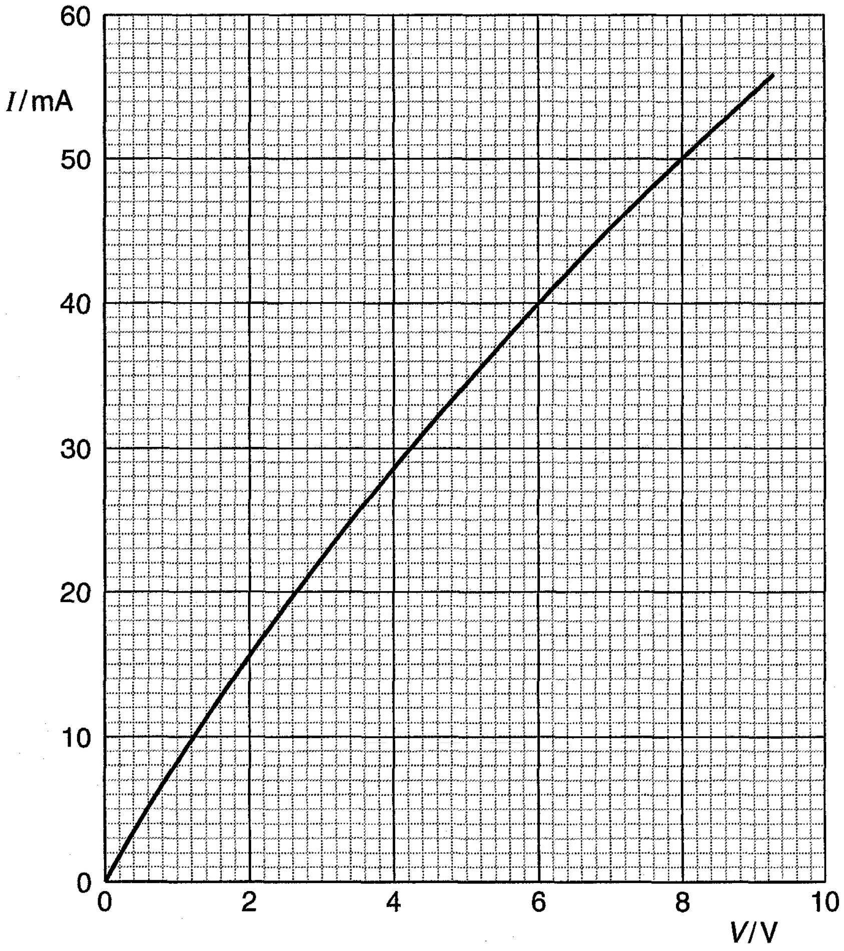


Fig. 5.1

(a) Use Fig. 5.1 to determine, for this lamp,

(i) the resistance when it is operating at a p.d. of 6.0 V,

resistance = ... Ω

(ii) the change in resistance when the p.d. increases from 6.0 V to 8.0 V.

change in resistance = ... Ω
[4]

(b) The lamp is connected into the circuit of Fig. 5.2.

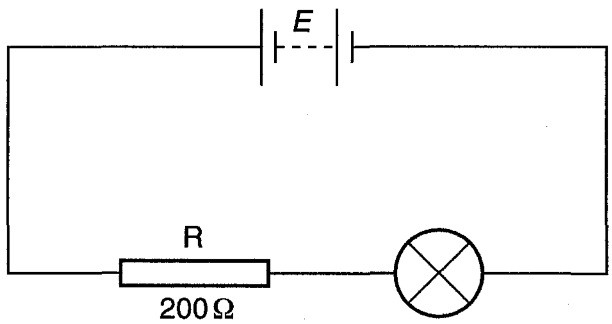


Fig. 5.2

R is a fixed resistor of resistance 200 Ω. The battery has e.m.f. *E* and negligible internal resistance.

(i) On Fig. 5.1, draw a line to show the variation with p.d. *V* of the current *I* in the resistor R.

(ii) Determine the e.m.f. of the battery for the lamp to operate normally.

e.m.f. = ... V
[4]

2 Nov 03 P2 Q7

7 An electric heater is rated as 240 V, 1.2 kW and has constant resistance.

(a) For the heater operating at 240 V,

(i) show that the current in the heater is 5.0 A,

(ii) calculate its resistance.

resistance = ... Ω
[4]

(b) The heater in **(a)** is connected to a mains supply by means of two long cables, as illustrated in Fig. 7.1.

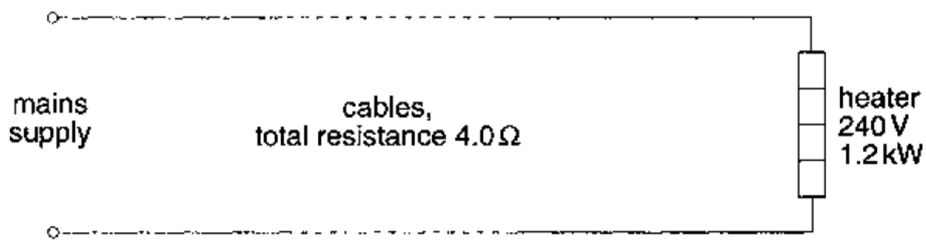


Fig. 7.1

The cables have a total resistance of 4.0 Ω. The voltage of the mains supply is adjusted so that the heater operates normally at 240 V. Using your answers in **(a)**, where appropriate, calculate

(i) the potential difference across the cables,

potential difference = ... V

(ii) the voltage of the mains supply,

voltage = ... V

(iii) the power dissipated in the cables.

power dissipated = ... W
[3]

(c) Using information from **(b)**, determine the efficiency ε at which power is transferred from the supply to the heater. That is, calculate

$$\varepsilon = \frac{\text{power dissipated in heater}}{\text{power input from supply}}.$$

efficiency = ...[2]

3 June 04 P2 Q7

7 A household electric lamp is rated as 240 V, 60 W. The filament of the lamp is made from tungsten and is a wire of constant radius 6.0×10^{-6} m. The resistivity of tungsten at the normal operating temperature of the lamp is $7.9 \times 10^{-7}\ \Omega$ m.

(a) For the lamp at its normal operating temperature,

(i) calculate the current in the lamp,

current = ... A

(ii) show that the resistance of the filament is 960 Ω.

[3]

(b) Calculate the length of the filament.

length = ... m [3]

(c) Comment on your answer to **(b)**.

....

.... [1]

4 Nov 04 P2 Q6

6 Fig. 6.1 shows the variation with applied potential difference V of the current I in an electrical component C.

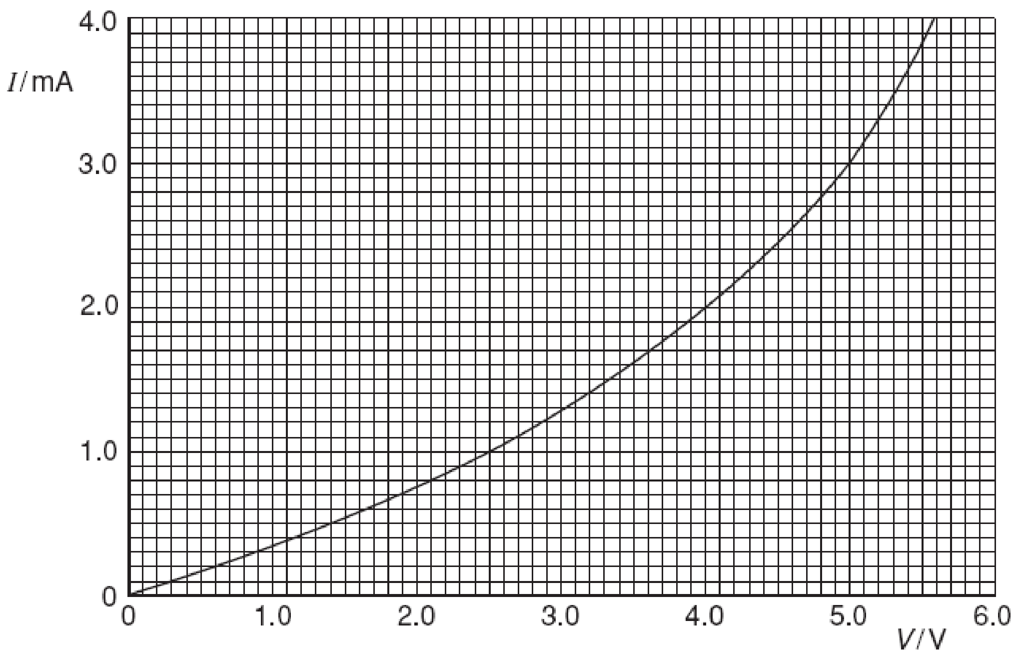


Fig. 6.1

(a) (i) State, with a reason, whether the resistance of component C increases or decreases with increasing potential difference.

....

.... [2]

(ii) Determine the resistance of component C at a potential difference of 4.0 V.

resistance = ... Ω [2]

(b) Component C is connected in parallel with a resistor R of resistance 1500 Ω and a battery of e.m.f. E and negligible internal resistance, as shown in Fig. 6.2.

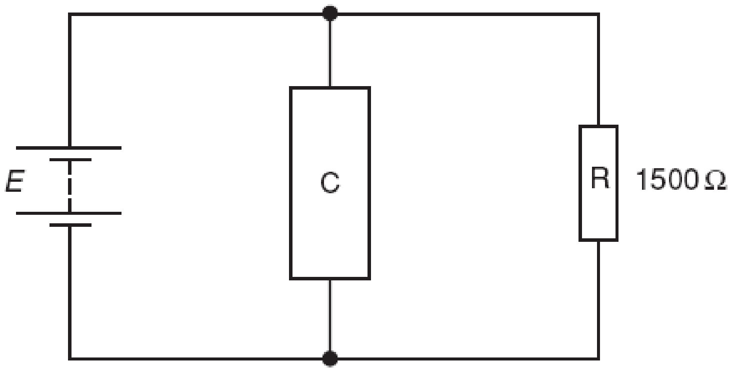


Fig. 6.2

(i) On Fig. 6.1, draw a line to show the variation with potential difference V of the current I in resistor R. [2]

(ii) Hence, or otherwise, use Fig. 6.1 to determine the current in the battery for an e.m.f. of 2.0 V.

current = ……………………….. A [2]

(c) The resistor R of resistance 1500 Ω and the component C are now connected in series across a supply of e.m.f. 7.0 V and negligible internal resistance.

Using information from Fig. 6.1, state and explain which component, R or C, will dissipate thermal energy at a greater rate.

....

....

....

.... [3]

5 June 07 P2 Q7

7 **(a)** Define the *resistance* of a resistor.

....

....[1]

(b) In the circuit of Fig. 7.1, the battery has an e.m.f. of 3.00 V and an internal resistance *r*. R is a variable resistor. The resistance of the ammeter is negligible and the voltmeter has an infinite resistance.

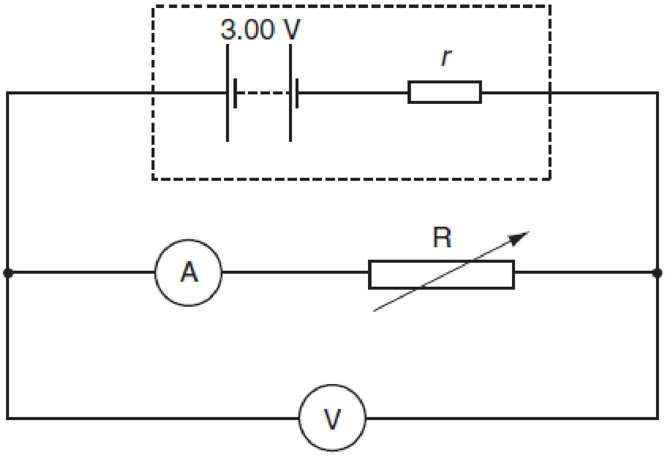


Fig. 7.1

The resistance of R is varied. Fig. 7.2 shows the variation of the power *P* dissipated in R with the potential difference *V* across R.

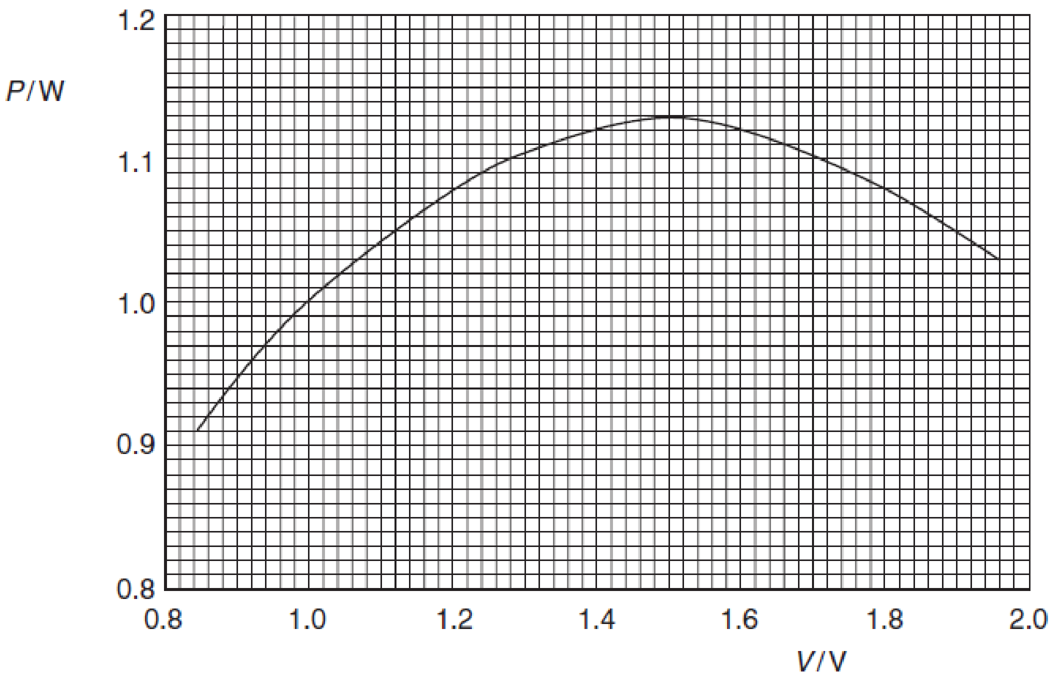


Fig. 7.2

(i) Use Fig. 7.2 to determine

1. the maximum power dissipation in R,

maximum power = ... W

2. the potential difference across R when the maximum power is dissipated.

potential difference = ... V
[1]

(ii) Hence calculate the resistance of R when the maximum power is dissipated.

resistance = ... Ω [2]

(iii) Use your answers in **(i)** and **(ii)** to determine the internal resistance *r* of the battery.

r = ... Ω [3]

(c) By reference to Fig. 7.2, it can be seen that there are two values of potential difference *V* for which the power dissipation is 1.05 W.
State, with a reason, which value of *V* will result in less power being dissipated in the internal resistance.

....

....

....

....[3]

6 Nov 06 P2 Q6

6 A straight wire of unstretched length L has an electrical resistance R. When it is stretched by a force F, the wire extends by an amount ΔL and the resistance increases by ΔR. The area of cross-section A of the wire may be assumed to remain constant.

(a) **(i)** State the relation between R, L, A and the resistivity ρ of the material of the wire.

....

.... [1]

(ii) Show that the fractional change in resistance $\frac{\Delta R}{R}$ is equal to the strain in the wire.

[2]

(b) A steel wire has area of cross-section $1.20 \times 10^{-7}\,\text{m}^2$ and a resistance of $4.17\,\Omega$.

The Young modulus of steel is $2.10 \times 10^{11}\,\text{Pa}$.

The tension in the wire is increased from zero to 72.0 N. The wire obeys Hooke's law at these values of tension.

Determine the strain in the wire and hence its change in resistance. Express your answer to an appropriate number of significant figures.

change = ... Ω [5]

7 June 07 P2 Q6

6 A car battery has an internal resistance of 0.060 Ω. It is re-charged using a battery charger having an e.m.f. of 14 V and an internal resistance of 0.10 Ω, as shown in Fig. 6.1.

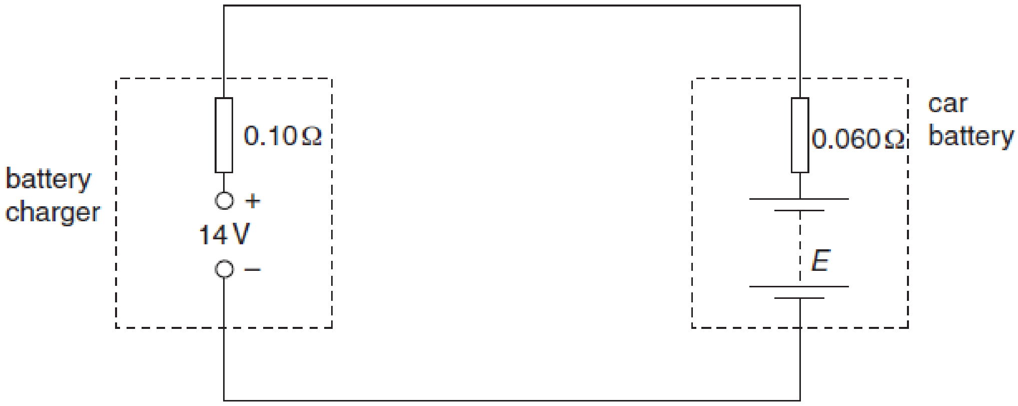


Fig. 6.1

(a) At the beginning of the re-charging process, the current in the circuit is 42 A and the e.m.f. of the battery is *E* (measured in volts).

(i) For the circuit of Fig. 6.1, state

1. the magnitude of the total resistance,

resistance = ... Ω

2. the total e.m.f. in the circuit. Give your answer in terms of *E*.

e.m.f. = ... V
[2]

(ii) Use your answers to (i) and data from the question to determine the e.m.f. of the car battery at the beginning of the re-charging process.

e.m.f. = ... V [2]

(b) For the majority of the charging time of the car battery, the e.m.f. of the car battery is 12 V and the charging current is 12.5 A. The battery is charged at this current for 4.0 hours. Calculate, for this charging time,

(i) the charge that passes through the battery,

charge = ... C [2]

(ii) the energy supplied from the battery charger,

energy = ... J [2]

(iii) the total energy dissipated in the internal resistance of the battery charger and the car battery.

energy = ... J [2]

(c) Use your answers in **(b)** to calculate the percentage efficiency of transfer of energy from the battery charger to stored energy in the car battery.

efficiency = ... % [2]