Higher Electricity

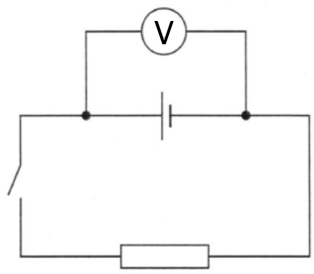
Past Paper Questions

Book 2

Contents

Internal Resistance

1. A student sets up the following circuit.



When the switch is open, the student notes that the reading on the voltmeter is 1·5 V. The switch is then closed and the reading falls to 1·3 V.

The decrease of 0·2 V is referred to as the

A e.m.f.

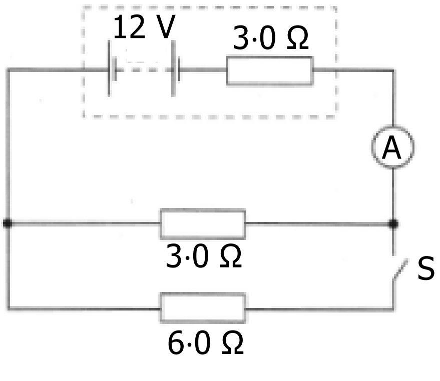
B lost volts

C peak voltage

D r.m.s. voltage

E terminal potential difference.

2. A battery of e.m.f. 12 V and internal resistance 3·0 Ω is connected in a circuit as shown.



When switch S is closed the ammeter reading changes from

A 2·0 A to 1·0 A

B 2·0 A to 2·4 A

C 2·0 A to 10 A

D 4·0 A to 1·3 A

E 4·0 A to 6·0 A.

3. The e.m.f. of a battery is

A the total energy supplied by the battery

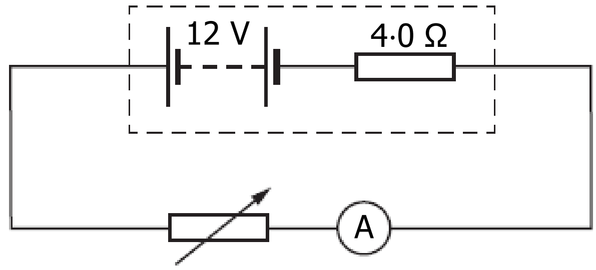
B the voltage lost due to the internal resistance of the battery

C the total charge which passes through the battery

D the number of coulombs of charge passing through the battery per second

E the energy supplied to each coulomb of charge passing through the battery.

4. A circuit is set up as shown.



The resistance of the variable resistor is increased and corresponding readings on the ammeter are recorded.

Resistance (Ω)	2·0	4·0	6·0	8·0
Current (A)	2·0	1·5	1·2	1·0

These results show that as the resistance of the variable resistor increases the power dissipated in the variable resistor

A increases

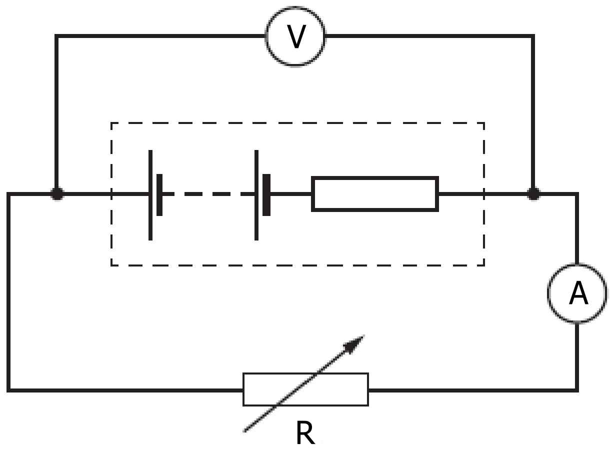
B decreases

C remains constant

D decreases and then increases

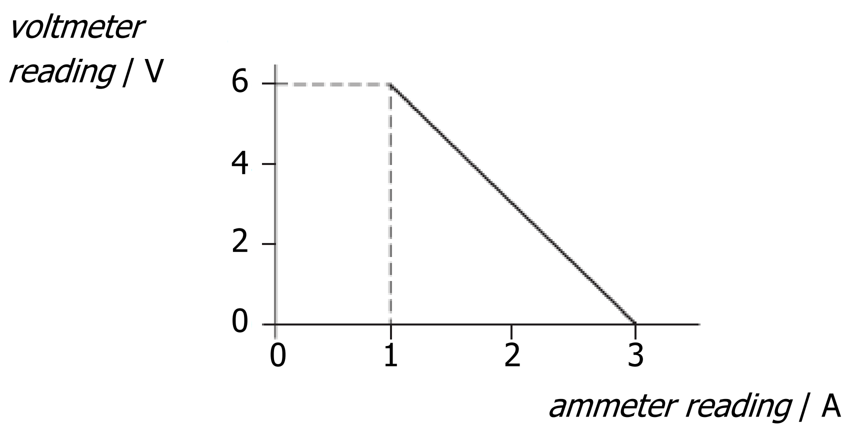
E increases and then decreases.

5. A circuit is set up as shown.



The variable resistor R is adjusted and a series of readings taken from the voltmeter and ammeter.

The graph shows how the voltmeter reading varies with the ammeter reading.

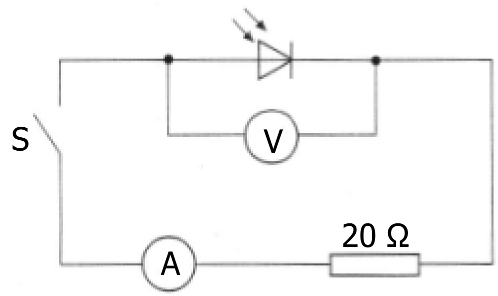


Which row in the table shows the values for the e.m.f. and internal resistance of the battery in the circuit?

	e.m.f. / V	*internal resistance* / Ω
A	6	2
B	6	3
C	9	2
D	9	3
E	9	6

Internal Resistance

6. A photodiode is connected in a circuit as shown below.



(a) Light of constant intensity is shone on to the photodiode.

The following measurements are obtained with S open and then with S closed.

	S open	S closed
reading on voltmeter / V	0·508	0·040
reading on ammeter / mA	0·00	2·00

(i) State the value of the e.m.f. produced by the photodiode for this light intensity. 1

(ii) Calculate the internal resistance of the photodiode for this light intensity. 3

(b) In the circuit above, the 20 Ω resistor is now replaced with a 10 Ω resistor.

The intensity of the light is unchanged.

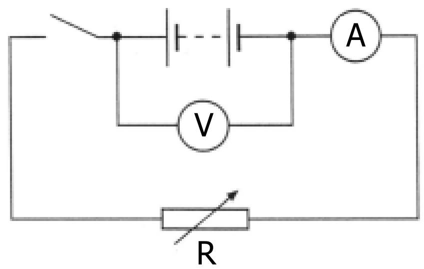
The following measurements are obtained.

	S open	S closed
reading on voltmeter / V	0·508	0·021

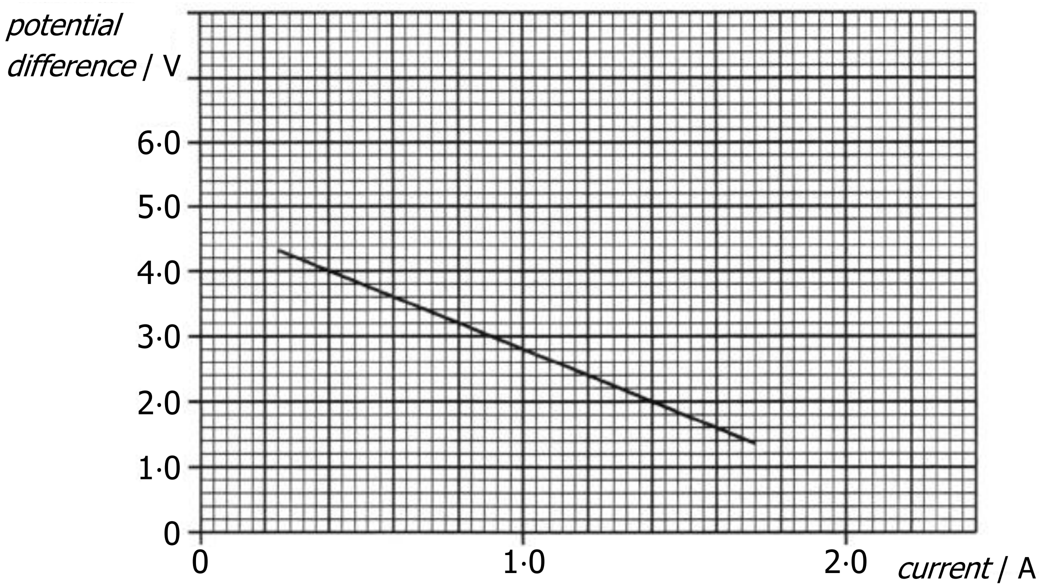
Explain why the reading on the voltmeter, when S is closed, is smaller than the corresponding reading in part (b). 2

Internal Resistance

7. (a) The following circuit is used to measure the e.m.f. and the internal resistance of a battery.



Readings of current and potential difference from this circuit are used to produce the following graph.



Use information from the graph to find:

(i) the e.m.f. of the battery, in volts; 1

(ii) the internal resistance of the battery. 3

(b) A car battery has an e.m.f of 12 V and an internal resistance of 0·050 Ω.

(i) Calculate the short circuit current for this battery. 3

(ii) The battery is now connected in series with a lamp. The resistance of the lamp is 2·5 Ω.

Calculate the power dissipated in the lamp. 4

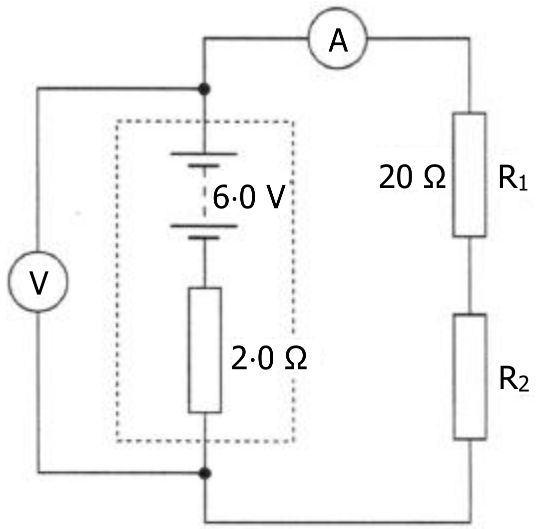
Internal Resistance

8. A battery has an e.m.f. of 6·0 V and internal resistance 2·0 Ω.

(a) State what is meant by an *e.m.f. of 6·0 V.* 1

(b) The battery is connected in series with two resistors, R_1 and R_2. Resistor R_1 has a resistance of 20 Ω.

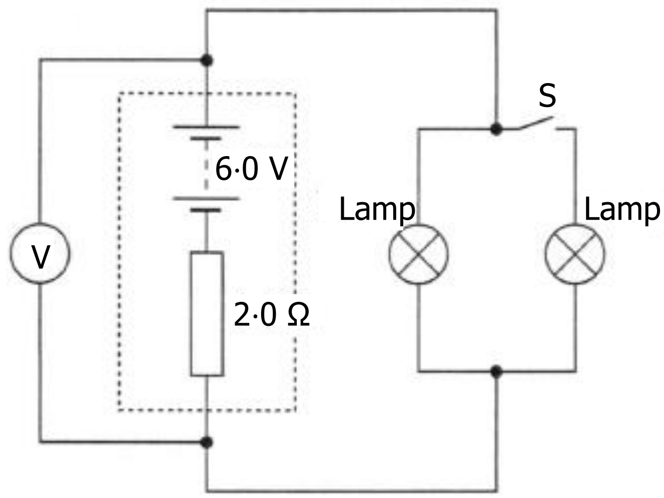
The reading on the ammeter is 200 mA.



(i) Show by calculation that R_2 has a resistance of 8·0 Ω. 3

(ii) Calculate the reading on the voltmeter. 3

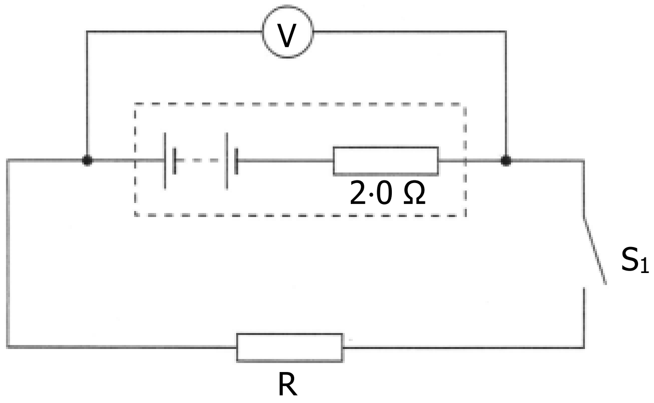
(c) The battery is now connected to two identical lamps as shown below.



State and explain what happens to the reading on the voltmeter when switch S is closed. 2

Internal Resistance

9. A student sets up the circuit shown.



The internal resistance of the battery is 2·0 Ω.

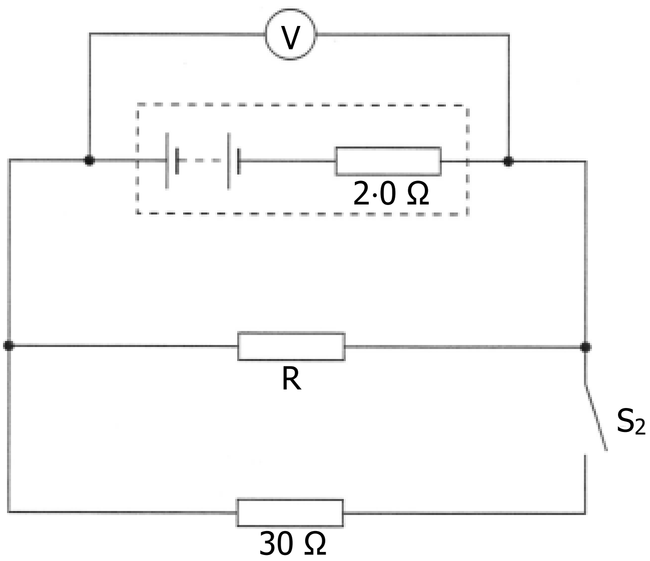
With S_1 open, the student notes that the voltmeter reading is 9·0 V.

The student closes S_1 and notes that the voltmeter reading is now 7·8 V.

(a) (i) Calculate the resistance of resistor R. 4

(ii) Explain why the reading on the voltmeter decreases when S_1 is closed. 1

(b) The student adds a 30 Ω resistor and a switch S_2 to the circuit as shown.

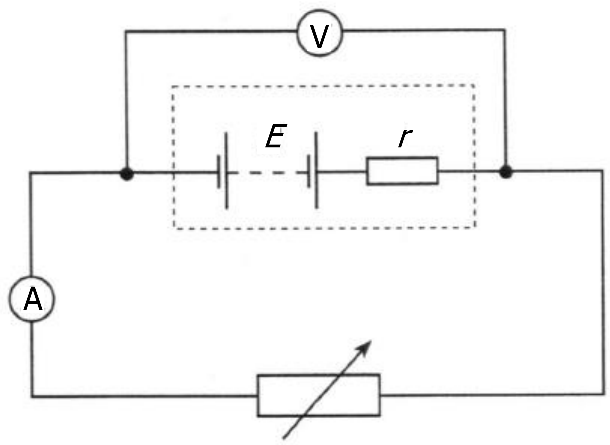


The student now closes S_2.

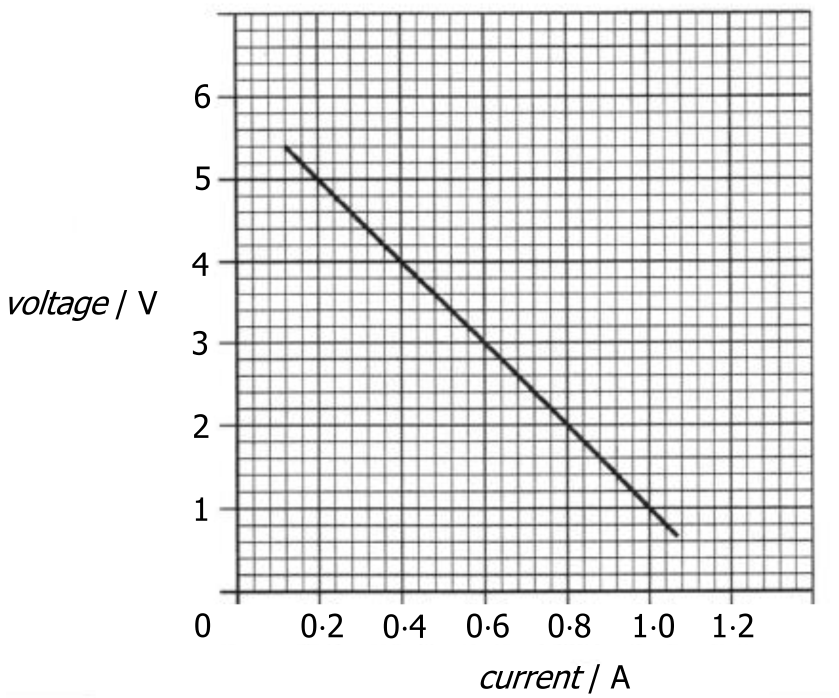
State and explain what happens to the reading on the voltmeter. 2

Internal Resistance

10. A student sets up the following circuit to find the e.m.f. E and the internal resistance r of a battery.



Readings from the voltmeter and ammeter are used to plot the following graph.



(a) State what is meant by the term *e.m.f.* 1

(b) (i) Use the graph to determine:

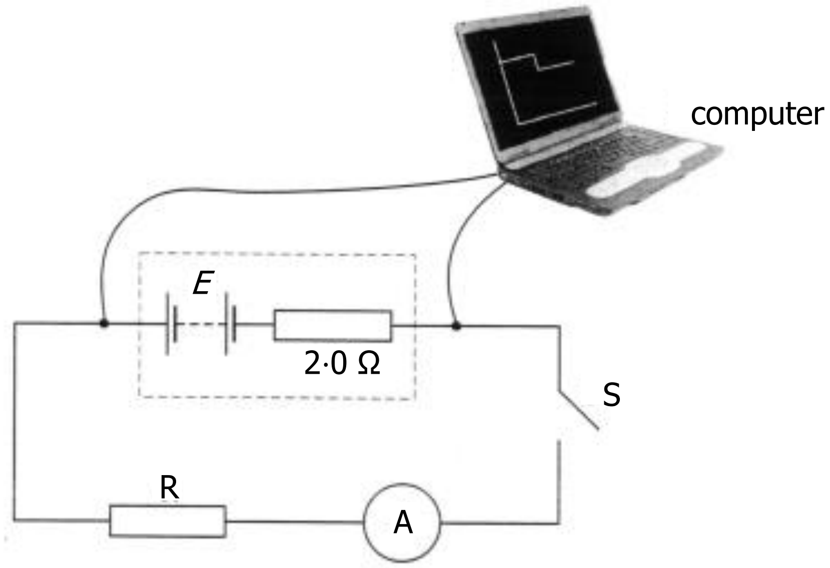
(A) the e.m.f.; 1

(B) the internal resistance of the battery. 3

(ii) Show that the variable resistor has a value of 15 Ω when the current is 0·30 A. 2

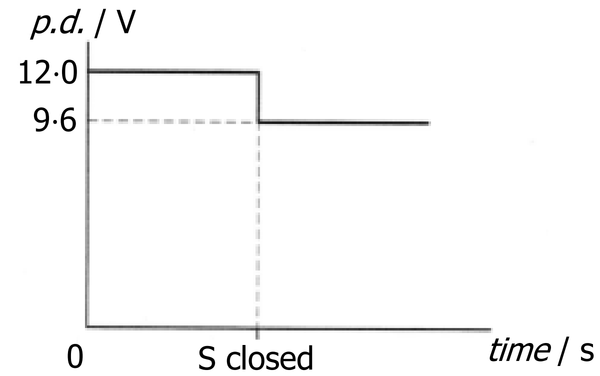
Internal Resistance

11. A power supply of e.m.f. E and internal resistance 2·0 Ω is connected as shown.



The computer connected to the apparatus displays a graph of potential difference against time.

The graph shows the potential difference (*p.d.*) across the terminals of the power supply for a short time before and after switch S is closed.



(a) State the e.m.f. of the power supply. 1

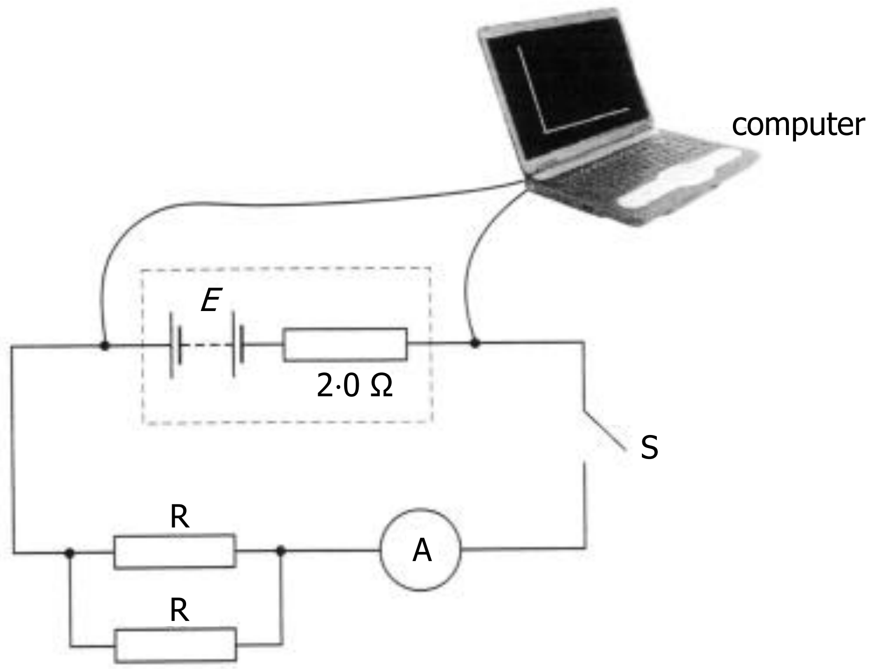
(b) Calculate:

(i) the reading on the ammeter after switch S is closed; 3

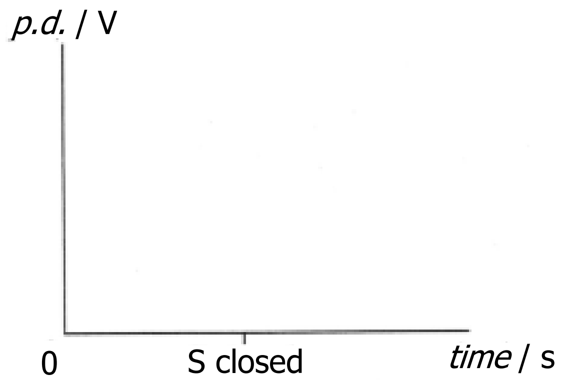
(ii) the resistance of resistor R. 3

11. **(continued)**

(c) Switch S is opened. A second identical resistor is now connected in parallel with R as shown.



The computer is again connected in order to display a graph of potential difference against time.



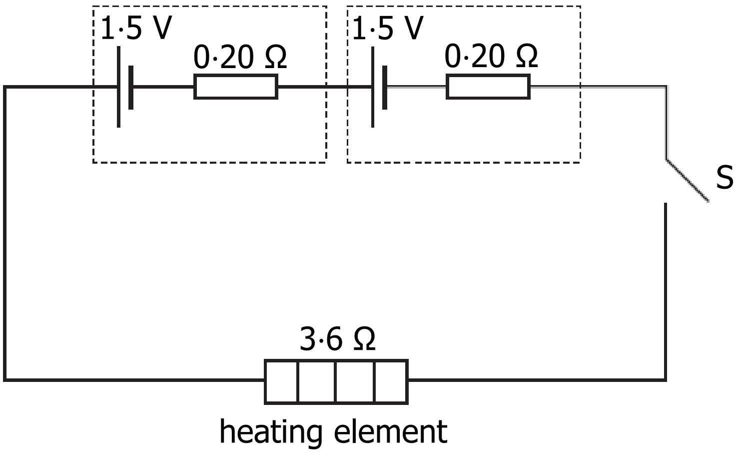
Copy and complete the new graph of potential difference against time. Numerical values are required on the potential difference axis. 2

Internal Resistance; Practical Circuits

12. Electrically heated gloves are used by skiers and climbers to provide extra warmth.

(a) Each glove has a heating element of resistance 3·6 Ω.

Two cells, each of e.m.f. 1·5 V and internal resistance 0·20 Ω, are used to operate the heating element.



Switch S is closed.

(i) Determine the value of the total circuit resistance. 1

(ii) Calculate the current in the heating element. 3

(iii) Calculate the power output of the heating element. 3

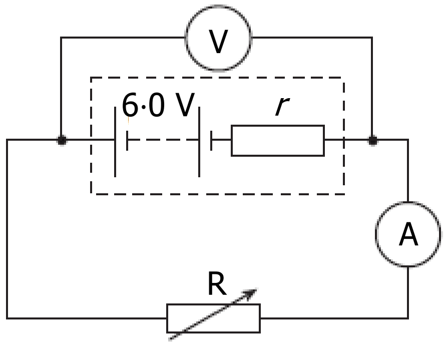
(b) When in use, the internal resistance of each cell gradually increases.

State the effect, if any, that this has on the power output of the heating element.

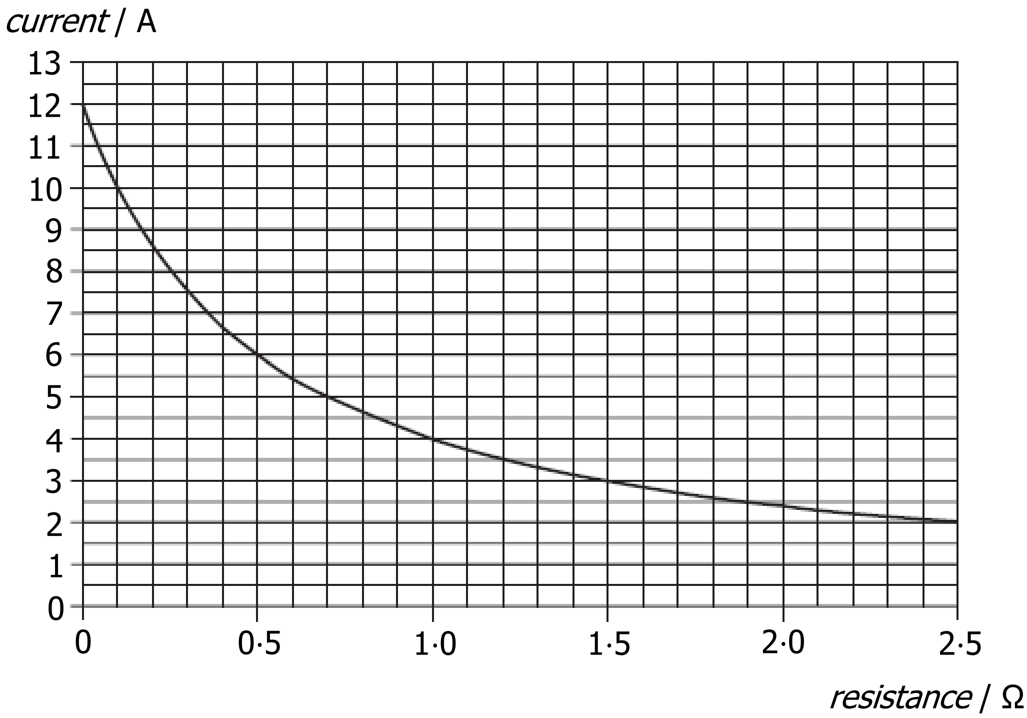
Justify your answer. 2

Internal Resistance

13. A battery of e.m.f. 6·0 V and internal resistance *r* is connected to a variable resistor R as shown.



The graph shows how the current in the circuit changes as the resistance of R increases.



(a) Use information from the graph to calculate:

(i) the lost volts in the circuit when R has a resistance of 1·5 Ω; 4

(ii) the internal resistance, *r*, of the battery. 3

(b) The resistance of R is now increased.

State the effect, if any, this has on the lost volts.

You must justify you answer. 2

Internal Resistance

14. (a) A supply of e.m.f. 10·0 V and internal resistance *r* is connected in a circuit as shown in Figure 1.

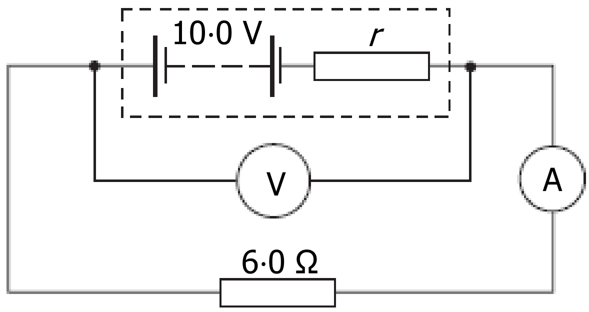


Figure 1

The meters displace the following readings.

Reading on ammeter = 1·25 A

Reading on voltmeter = 7·50 V

(i) State what is meant by an *e.m.f. of 10·0 V*. 1

(ii) Show that the internal resistance *r* of the supply is 2·0 Ω. 2

(b) A resistor R is connected to the circuit as shown in Figure 2.

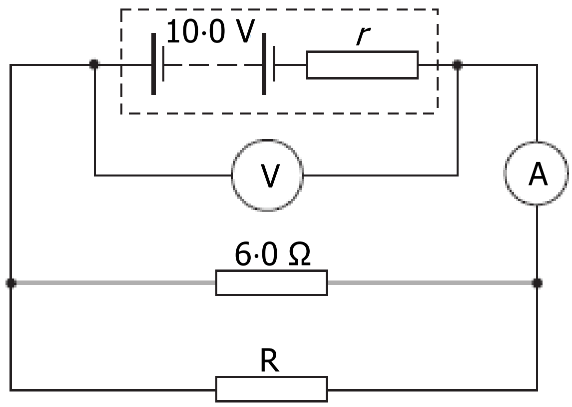


Figure 2

The meters now display the following readings.

Reading on ammeter = 2·0 A

Reading on voltmeter = 6·0 V

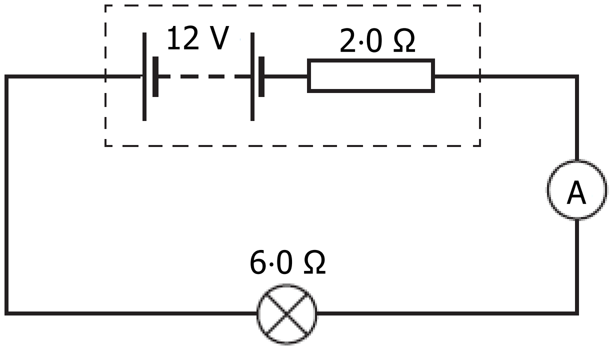
(i) Explain why the reading on the voltmeter has decreased. 2

(ii) Calculate the resistance of R. 4

Internal Resistance; Practical Circuits

15. A student carries out two experiments using different power supplies connected to a lamp of resistance 6·0 Ω.

(a) In the first experiment the lamp is connected to a power supply of e.m.f. 12 V and internal resistance 2·0 Ω as shown.



Calculate:

(i) the reading on the ammeter; 3

(ii) the lost volts; 1

(iii) the output power of the lamp. 3

(b) In the second experiment the lamp is connected to a different power supply. This supply has the same e.m.f. as the supply in part (a) but a different value of internal resistance.

The output power of the lamp is now greater.

Assuming the resistance of the lamp has not changed, state whether the internal resistance of the new power supply is less than, equal to, or greater than the internal resistance of the original supply.

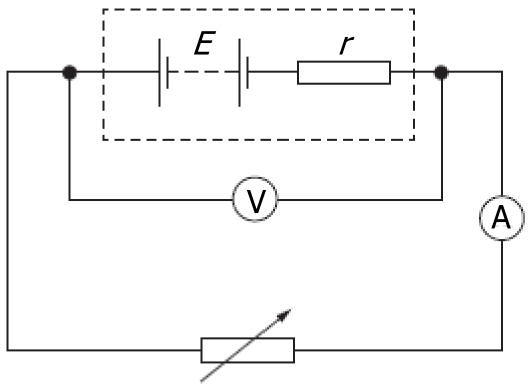
You must justify your answer. 2

Internal Resistance

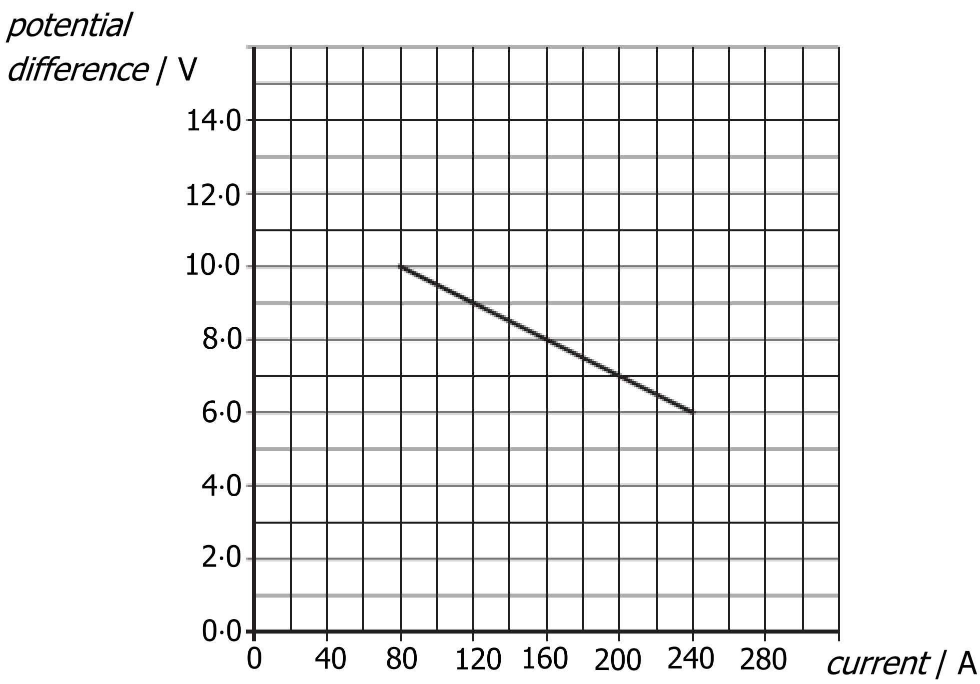
16. A technician is testing a new design of car battery.

The battery has an e.m.f. *E* and internal resistance *r*.

(a) In one test, the technician uses this battery in the following circuit.



Readings from the voltmeter and ammeter are used to plot the following graph.



(i) Use information from the graph to determine the e.m.f. of the car battery. 1

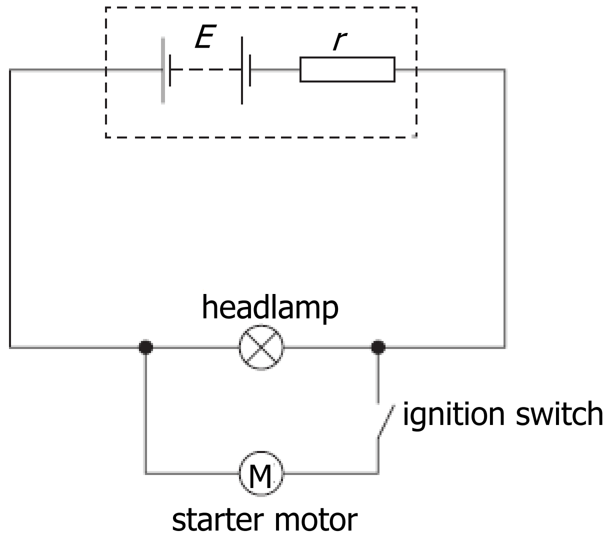
(ii) Calculate the internal resistance of the car battery. 3

(iii) The technician accidentally drops a metal spanner across the terminals of the battery. This causes a short circuit.

Calculate the short circuit current. 3

16. **(continued)**

(b) In a second test, the technician connects the battery to a headlamp in parallel with a starter motor as shown.

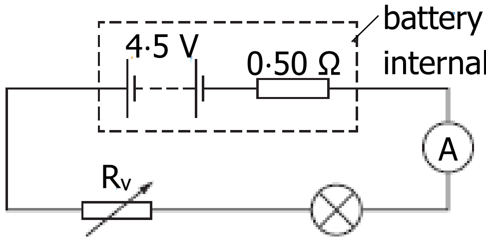


The technician notices that the headlamp becomes dimmer when the ignition switch is closed and the starter motor operates.

Explain why this happens. 2

17. A technician investigates the use of different light sources for torches.

The following circuit is set up.



battery of e.m.f. 4·5 V and internal resistance 0·50 Ω

(a) The resistance of variable resistor R_v is set to 2·5 Ω. The reading on the ammeter is 0·30 A.

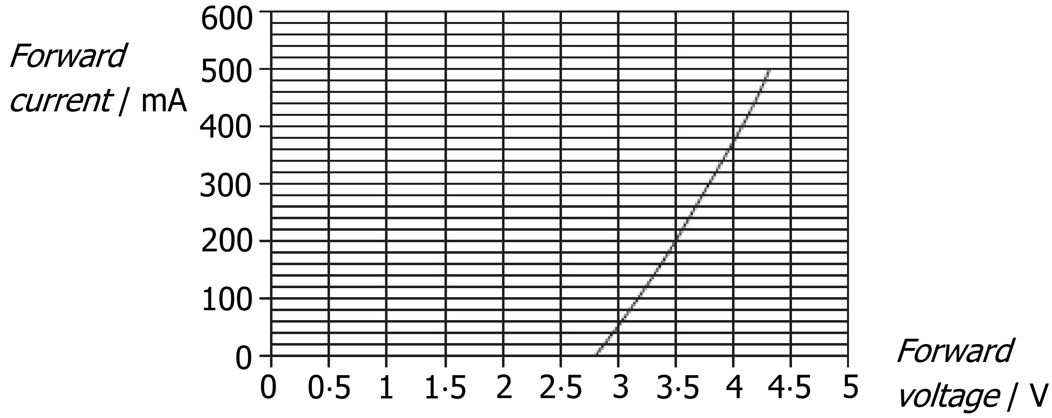
(i) Show that the resistance of the lamp is 12 Ω at this current. 3

(ii) Calculate the power output of the lamp at this current. 3

(b) To increase the life of the battery, the lamp is replaced by an LED. The LED emits bright light.

An extract from the manufacturer's data sheet for the LED is shown.

Forward current / mA	*Relative luminosity*
0	0
100	0·6
200	1·0
300	1·5
400	1·8



The variable resistor is adjusted until the relative luminosity of the LED is 1·0.

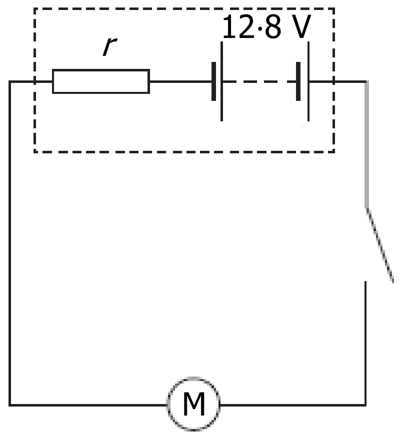
(i) Determine the forward voltage across the LED. 1

(ii) Calculate the potential difference across the variable resistor. 4

(c) Describe how an LED operates. 2

Internal Resistance

18. A car battery is connected to an electric motor as shown.



The electric motor requires a large current to operate.

(a) The car battery has an e.m.f. of 12·8 V and an internal resistance *r* of $6{\cdot}0 \times 10^{-3}$ Ω. The motor has a resistance of 0·050 Ω.

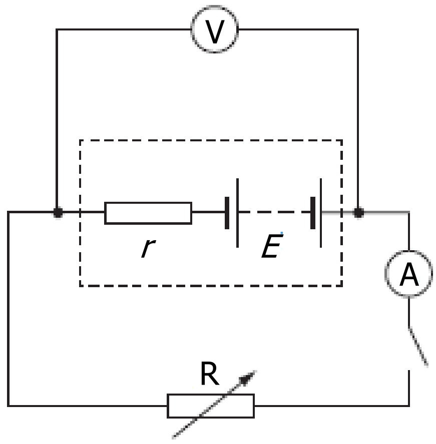
(i) State what is meant by an *e.m.f. of 12·8 V*. 1

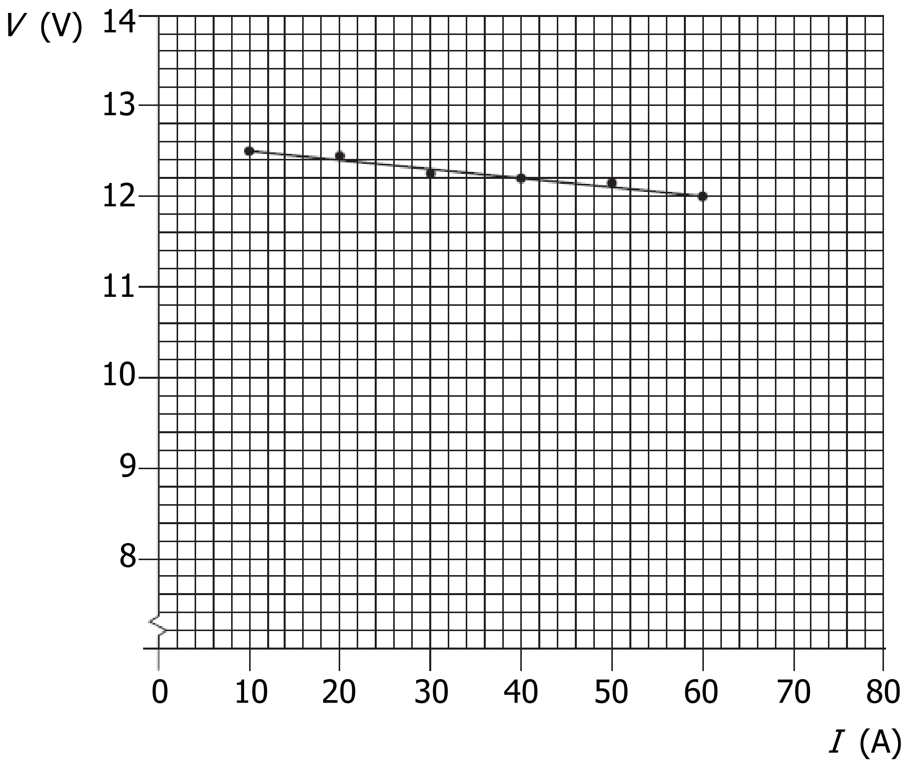
(ii) Calculate the current in the circuit when the motor is operating. 3

(iii) Suggest why the connecting wires used in this circuit have a large diameter. 1

18. **(continued)**

(b) A technician sets up the following circuit with a different car battery connected to a variable resistor R.





Use information from the graph to determine:

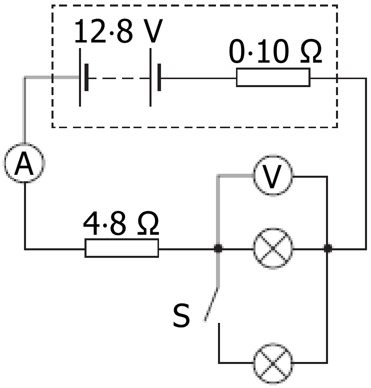
(i) the e.m.f. of the battery; 1

(ii) the internal resistance of the battery. 3

Internal Resistance; Band Theory and Conductivity

19. A technician sets up a circuit as shown, using a car battery and two identical lamps.

The battery has an e.m.f of 12·8 V and an internal resistance of 0·10 Ω.



(a) Switch S is open. The reading on the ammeter is 1·80 A.

(i) Determine the reading on the voltmeter. 4

(ii) Switch S is now closed.

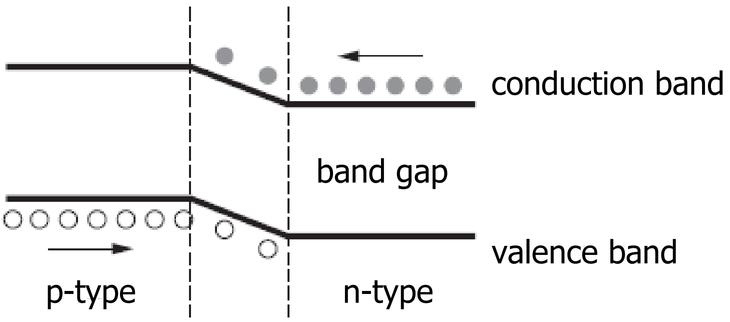
State the effect this has on the reading on the voltmeter.

Justify your answer. 3

(b) Some cars use LEDs in place of filament lamps.

An LED is made from semiconductor material that has been doped with impurities to create a p-n junction.

The diagram represents the band structure of an LED.



(i) A voltage is applied across an LED so that it is forward biased and emits light.

Using band theory, explain how the LED emits light. 3

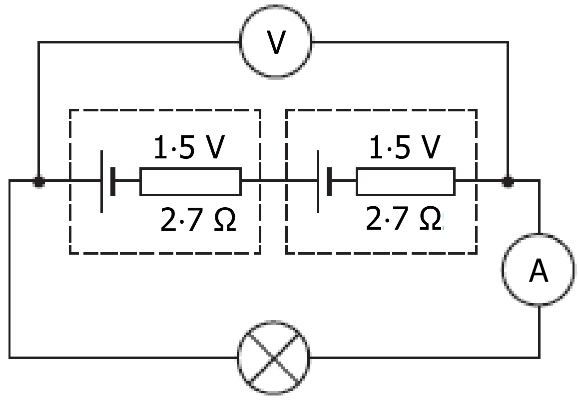
(ii) The energy gap between the valence band and conduction band is known as the band gap.

The band gap for the LED is $3{\cdot}03 \times 10^{-19}$ J.

Calculate the wavelength of the light emitted by the LED. 4

<u>Internal Resistance</u>

20. A lamp is connected to a battery containing two cells as shown.



The e.m.f. of each cell is 1·5 V and the internal resistance of each cell is 2·7 Ω. The reading on the ammeter is 64 mA.

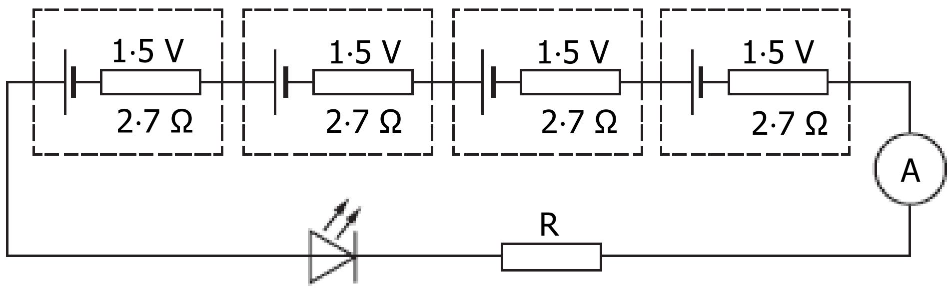
(a) State what is meant by *an e.m.f. of 1·5 V*. 1

(b) (i) Show that the lost volts in the battery is 0·35 V. 2

(ii) Determine the reading on the voltmeter. 1

(iii) Calculate the power dissipated by the lamp. 3

(c) In a different circuit, an LED is connected to a battery containing four cells.

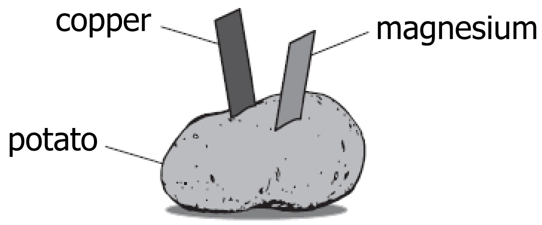


The potential difference across the LED is 3·6 V when the current is 26 mA.

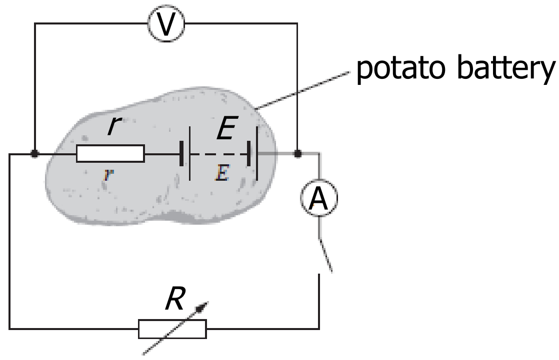
Determine the resistance of R. 4

Internal Resistance

21. A student constructs a battery using a potato, a strip of copper and a strip of magnesium.

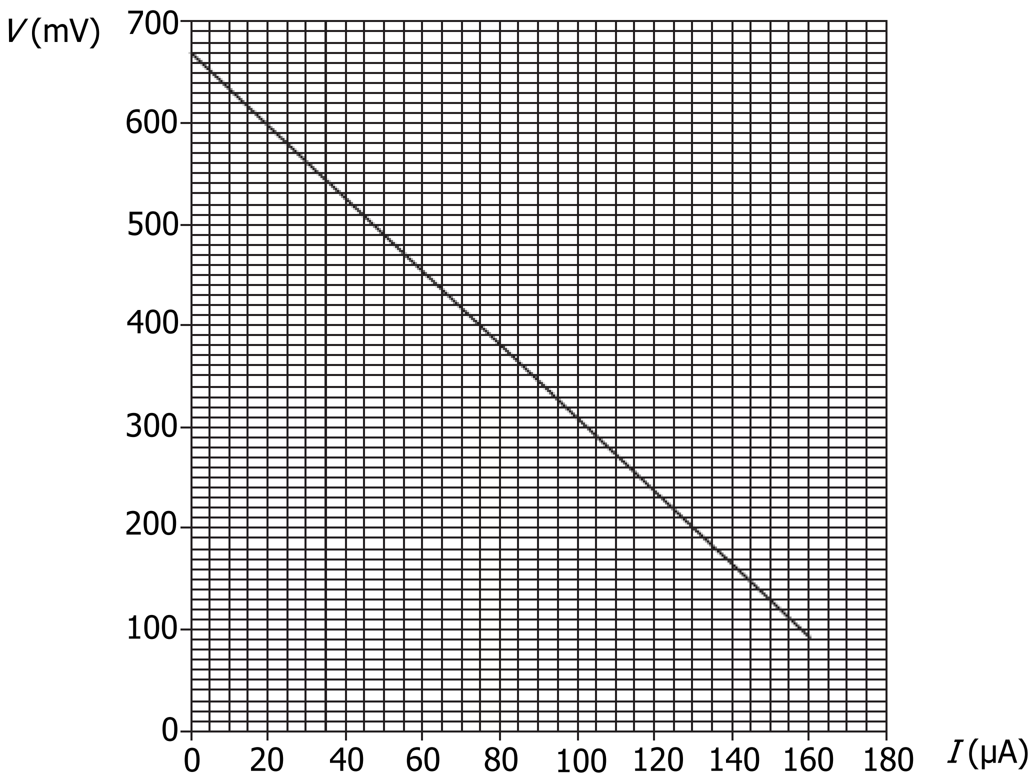


The student then sets up the following circuit with the potato battery connected to a variable resistor R, in order that the electromotive force (e.m.f.) and internal resistance of the battery may be determined.



(a) State what is meant by the term *electromotive force* (*e.m.f.*). 1

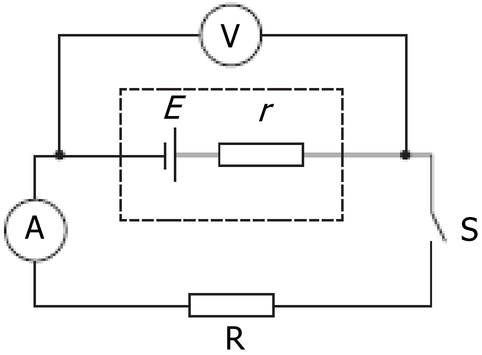
(b) The student uses readings of current I and terminal potential difference V from this circuit to produce the graph shown.



Determine the internal resistance of the potato battery. 3

Internal Resistance; Practical Circuits

22. (a) A student sets up the circuit shown.



When switch S is open the reading on the voltmeter is 1·5 V.

Switch S is now closed.

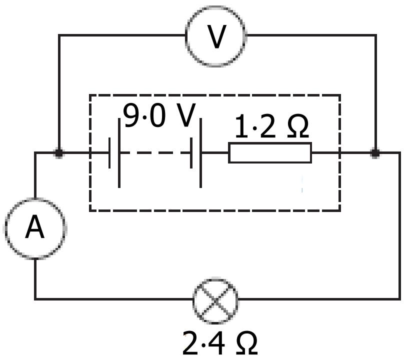
The reading on the voltmeter is now 1·3 V and the reading on the ammeter is 0·88 A.

(i) State the EMF E of the cell. 1

(ii) Calculate the internal resistance r of the cell. 3

(iii) Explain why the reading on the voltmeter decreases when the switch is closed. 2

(b) A battery of EMF 9·0 V and internal resistance 1·2 Ω is connected in series with a lamp. The lamp has a resistance of 2·4 Ω.

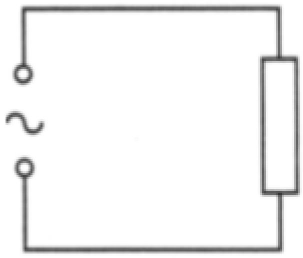


(i) Determine the current in the lamp. 3

(ii) Calculate the power dissipated in the lamp. 3

Oscilloscopes and A.C. Supplies

1. A supply with a sinusoidally alternating output of 6·0 V r.m.s. is connected to a 3·0 Ω resistor.



Which row in the following table shows the peak voltage across the resistor and the peak current in the circuit?

	Peak voltage / V	*Peak Current* / A
A	$6\sqrt{2}$	$6\sqrt{2}$
B	$6\sqrt{2}$	2
C	6	2
D	$6\sqrt{2}$	$\frac{1}{2\sqrt{2}}$
E	6	$6\sqrt{2}$

2. The element of an electric kettle has a resistance of 30 Ω. The kettle is connected to a mains supply. The r.m.s. voltage of this supply is 230 V. The peak value of the current in the kettle is

A 0·13 A

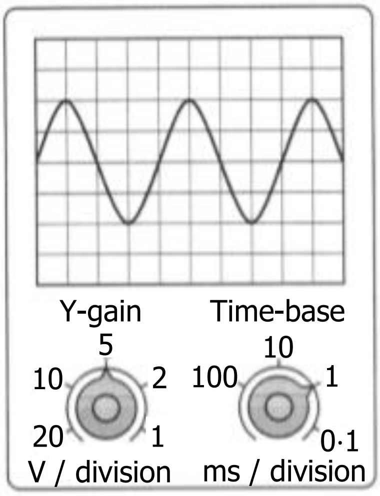
B 0·18 A

C 5·4 A

D 7·7 A

E 10·8 A.

3. The output from a signal generator is connected to the input terminals of an oscilloscope. The trace observed on the oscilloscope screen, the Y-gain setting and the time-base setting are shown in the diagram.



The frequency of the signal shown is calculated using the

A Y-gain setting and the vertical height of the trace

B Y-gain setting and the horizontal distance between the peaks of the trace.

C Y-gain setting and time-base setting

D time-base setting and the vertical height of the trace

E time-base setting and the horizontal distance between the peaks of the trace.

4. An a.c. signal is displayed on an oscilloscope screen. The Y-gain and time-base controls are set as shown.

The frequency of the signal is

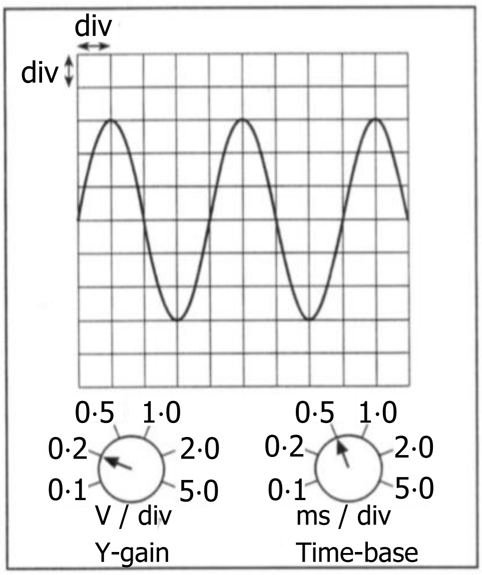
A 0·50 Hz

B 1·25 Hz

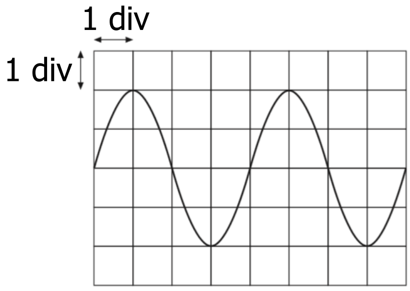
C 2·00 Hz

D 200 Hz

E 500 Hz



5. The diagram shows the trace on an oscilloscope when an alternating voltage is applied to its input.

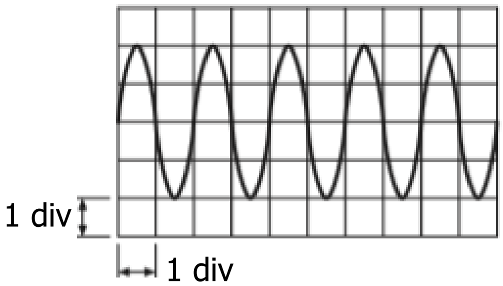


The timebase is set at 5 ms/div and the Y-gain is set at 10 V/div.

Which row in the table gives the peak voltage and the frequency of the signal?

	Peak voltage / V	*Frequency* / Hz
A	7·1	20
B	14	50
C	20	20
D	20	50
E	40	50

6. The output of a 50 Hz a.c. supply is connected to the input of an oscilloscope. The trace produced on the oscilloscope's screen is shown.



The time-base control of the oscilloscope is set at

A 1 ms/div

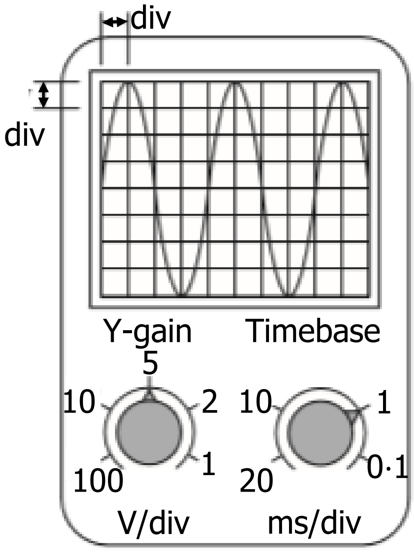
B 10 ms/div

C 20 ms/div

D 100 ms/div

E 200 ms/div

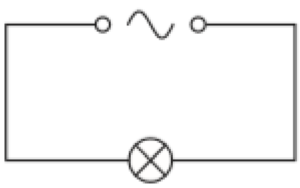
7. An alternating voltage is displayed on an oscilloscope screen. The Y-gain and the timebase settings are shown.



Which row in the table gives the values for the peak voltage and frequency of the signal?

	Peak voltage / V	*Frequency* / Hz
A	10	100
B	10	250
C	20	250
D	10	500
E	20	1000

8. A circuit is set up as shown.



The r.m.s. voltage across the lamp is 12 V. The power produced by the lamp is 24 W. The peak current in the lamp is.

A 0·71 A

B 1·4 A

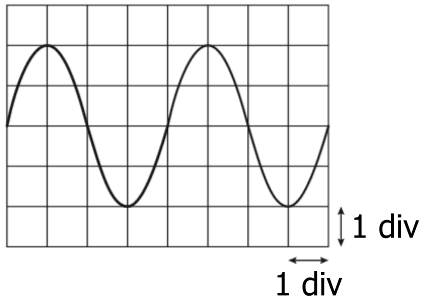
C 2·0 A

D 2·8 A

E 17 A.

9. An oscilloscope is connected to the output terminals of a signal generator.

The trace displayed on the screen is shown.



The timebase of the oscilloscope is set at 30 ms/div.

The frequency of the output signal from the signal generator is.

A $4{\cdot}2 \times 10^{-3}$ Hz

B $8{\cdot}3 \times 10^{-3}$ Hz

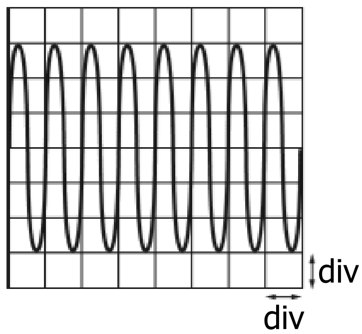
C 0·28 Hz

D 4·2 Hz

E 8·3 Hz.

10. The output of a signal generator is connected to an oscilloscope.

The trace produced on the screen of the oscilloscope is shown.



The timebase control of the oscilloscope is set at 2ms/div.

The Y-gain control of the oscilloscope is set at 4 mV/div.

Which row in the table shows the frequency and peak voltage of the output of the signal generator?

	Frequency (Hz)	*Peak Voltage* (mV)
A	1·5	12
B	0·5	6
C	250	6
D	500	12
E	500	24

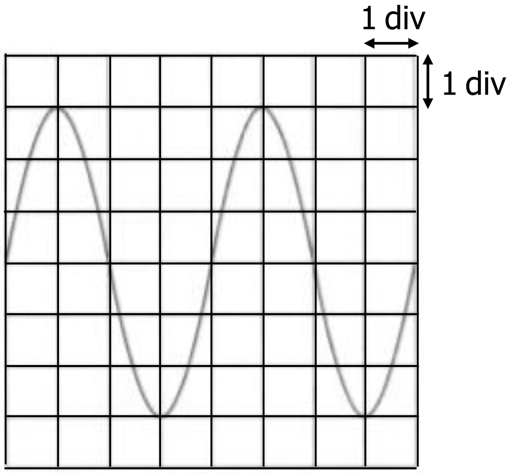
11. A signal from a power supply is displayed on an oscilloscope.

The trace on the oscilloscope is shown below to the right.

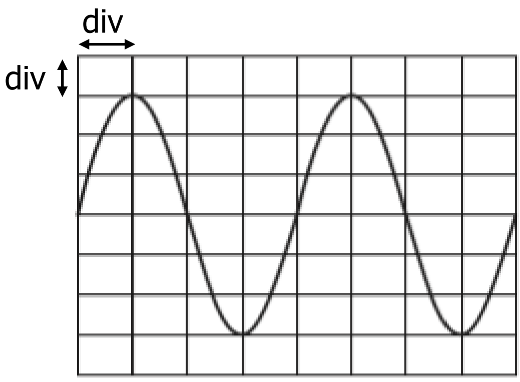
The time-base is set at 0·01 s/div and the Y-gain is set at 4·0 V/div.

Which row in the table to the left shows the r.m.s. voltage and the frequency of the signal?

	r.m.s. voltage (V)	*frequency* (Hz)
A	8·5	25
B	12	25
C	24	25
D	8·5	50
E	12	50



12. The output from an AC power supply is connected to an oscilloscope. The trace seen on the oscilloscope screen is shown.



The Y-gain setting on the oscilloscope is 1·0 V/div.

The r.m.s. voltage of the power supply is

A 2·1 V

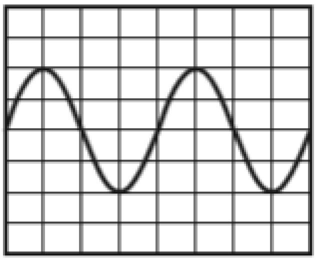
B 3·0 V

C 4·0 V

D 4·2 V

E 6·0 V.

13. The output from a signal generator is connected to an oscilloscope. The trace observed on the oscilloscope screen is as shown in the diagram.



The frequency of the signal from the signal generator is doubled.

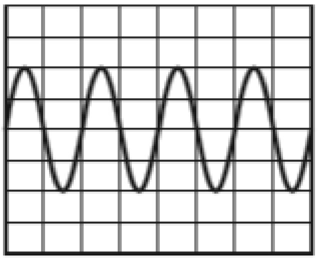
The amplitude of the signal is unchanged.

The Y-gain setting on the oscilloscope is unchanged.

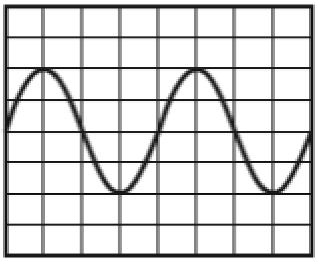
The timebase setting on the oscilloscope is changed from 1·0 ms/division to 0·5 ms/division.

Which of the following diagrams shows the trace that is now observed on the oscilloscope screen?

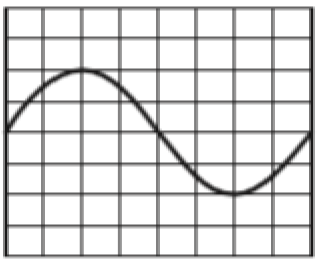
A



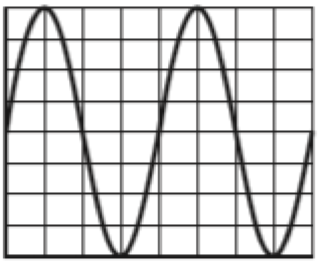
B



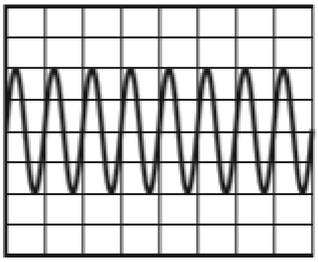
C



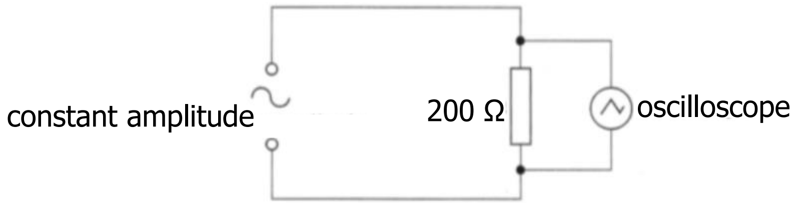
D



E



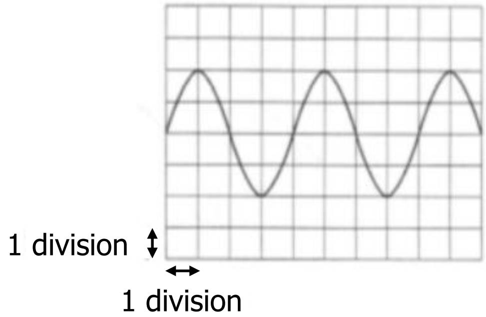
14. A circuit is set up as shown below. The amplitude of the output voltage of the a.c. supply is kept constant.



The settings of the controls on the oscilloscope are as follows:

y-gain setting = 5 V/division
time-base setting = 2·5 ms/division

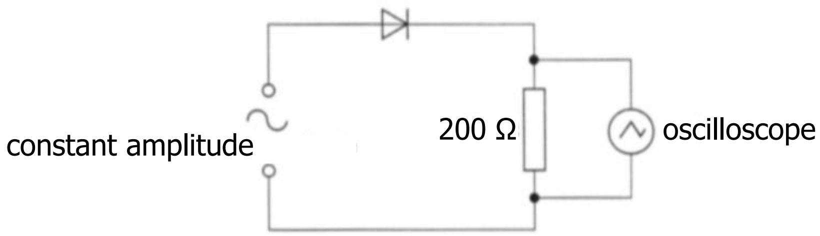
The following trace is displayed on the oscilloscope screen.



(a) (i) Calculate the frequency of the output from the a.c. supply. 3

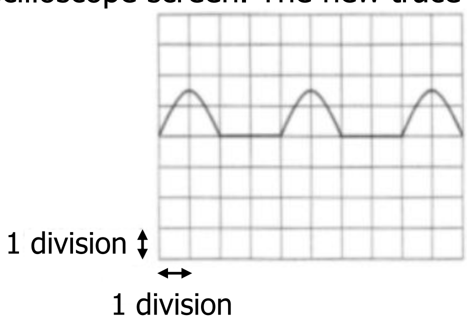
(ii) Calculate the **r.m.s. current** in the 200 Ω resistor. 4

(b) A diode is now connected in the circuit as shown below.



The settings on the controls of the oscilloscope remain unchanged.

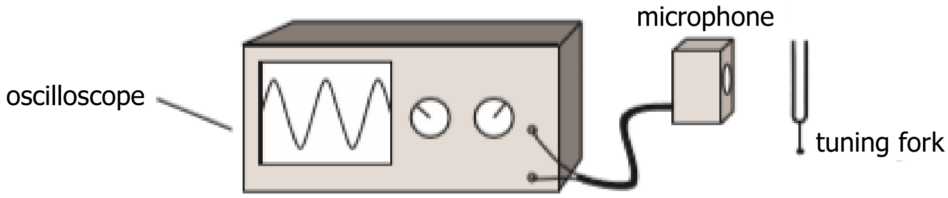
Connecting the diode in the circuit causes changes to the original trace displayed on the oscilloscope screen. The new trace is shown below.



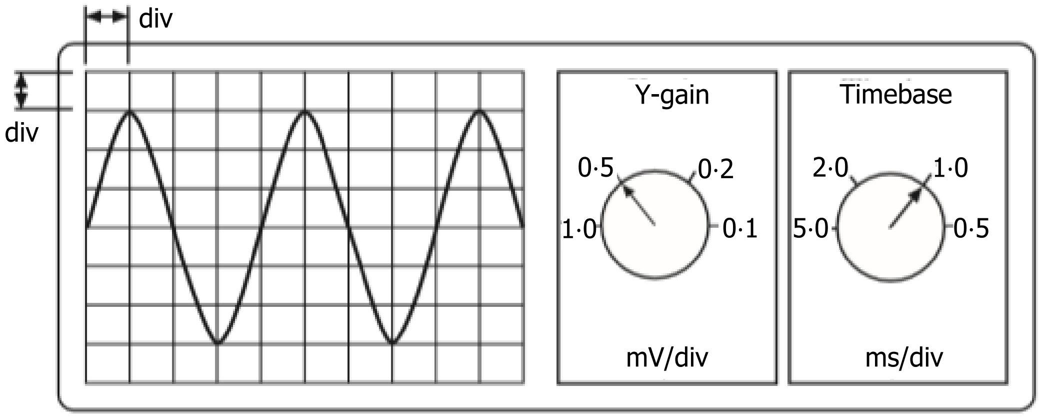
Decribe and explain the changes to the original trace. 2

Oscilloscopes and A.C. Supplies

15. A microphone is connected to the input terminals of an oscilloscope. A tuning fork is made to vibrate and held close to the microphone as shown.



The following diagram shows the trace obtained and the settings on the oscilloscope.

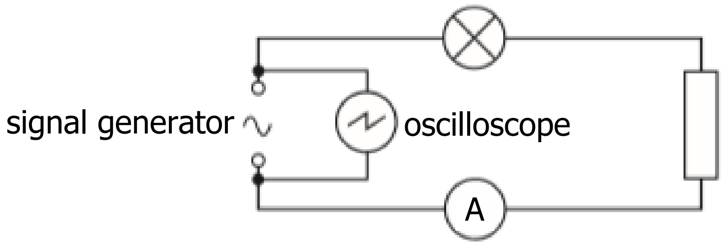


(a) Determine the peak voltage of the signal. 1

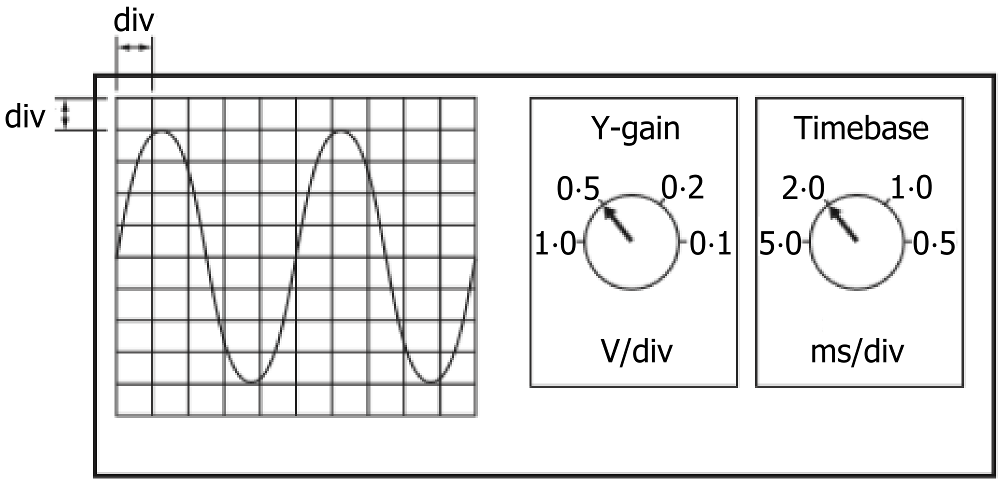
(b) Determine the frequency of the signal. 3

<u>Oscilloscopes and A.C. Supplies</u>

16. A signal generator is connected to a lamp, a resistor and an ammeter in series. An oscilloscope is connected across the output terminals of the signal generator.



The oscilloscope control settings and the trace displayed on its screen are shown.



(a) For this signal determine:

(i) the peak voltage; 1

(ii) the frequency. 3

(b) The frequency is now doubled. The peak voltage of the signal is kept constant.

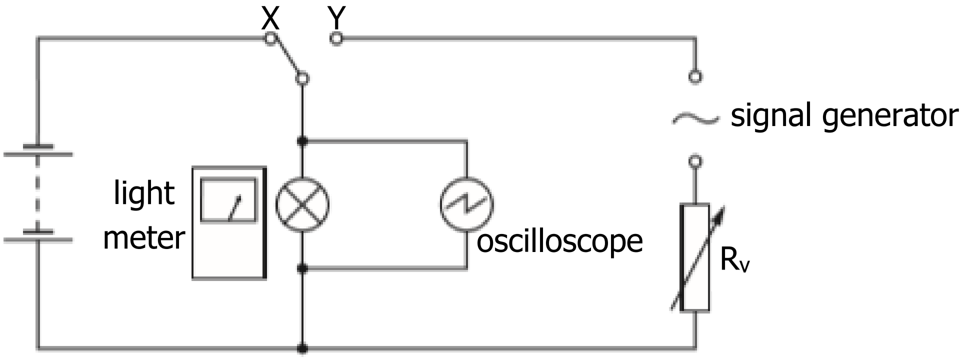
State what happens to the reading on the ammeter. 1

(c) The Y-gain setting on the oscilloscope is changed from 0·5 V/div to 1·0 V/div.

Describe how this affects the trace displayed on the oscilloscope. 1

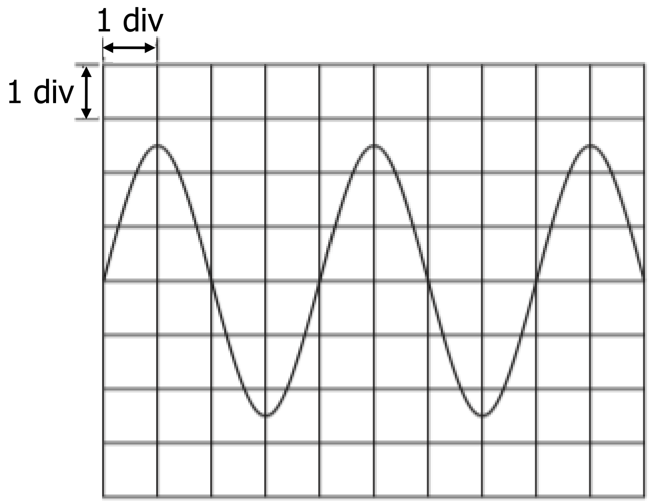
Oscilloscopes and A.C. Supplies

17. The circuit shown is used to compare the voltage from a battery and the voltage produced by a signal generator.



The switch is connected to X and the voltage across the lamp is 2·30 V. The reading on the light meter is recorded.

The switch is now connected to Y. The resistance of R_v is adjusted until the light meter reading is the same as before. The trace on the oscilloscope screen is shown.



(a) The timebase setting is 0·01 s/div.

Determine the frequency of the output voltage of the signal generator. 3

(b) Calculate the peak value of the voltage displayed on the oscilloscope. 3

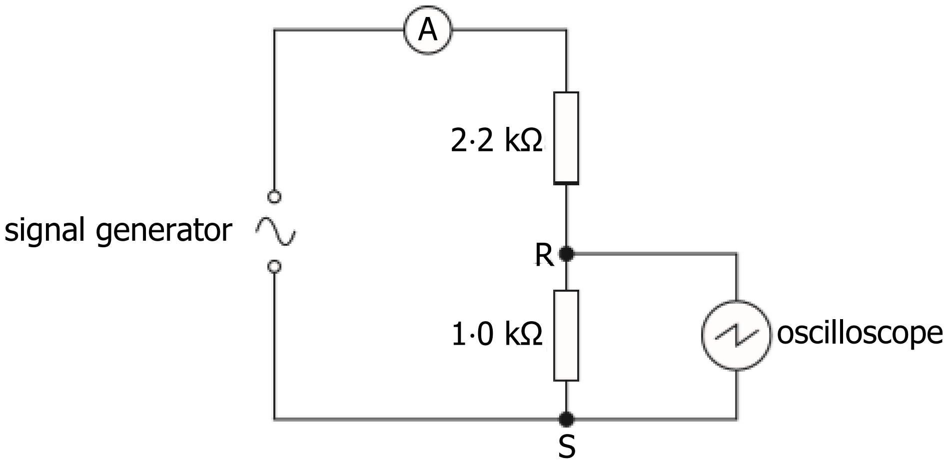
(c) With the switch still connected to Y, the signal generator frequency is now doubled without altering the output voltage.

(i) Describe how this affects the trace observed on the oscilloscope screen. 1

(ii) State and explain what happens to the reading on the light meter. 2

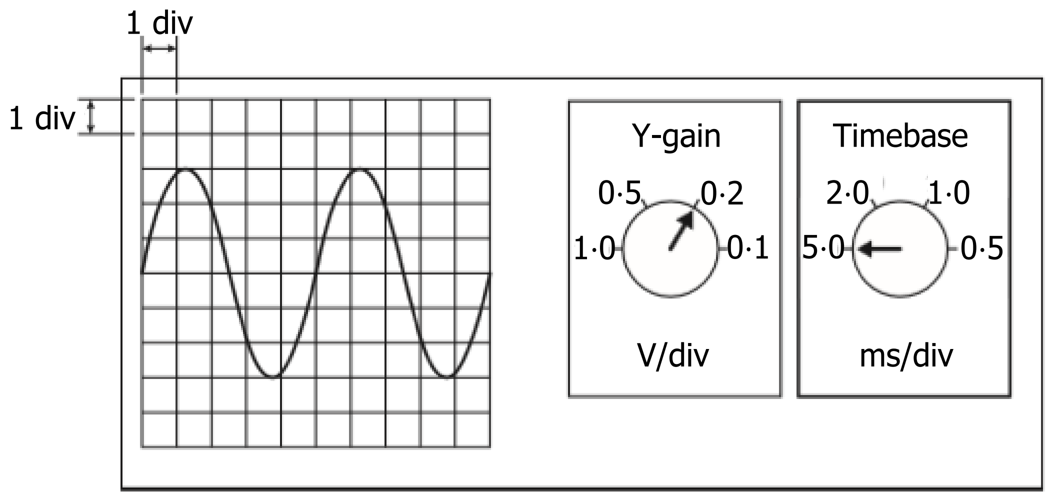
Oscilloscopes and A.C. Supplies

18. A student sets up the following circuit to investigate alternating current.



(a) An oscilloscope is connected across the 1·0 kΩ resistor.

The oscilloscope control settings and the trace displayed on its screen are shown.



(i) Determine the peak voltage across the 1·0 kΩ resistor. 1

(ii) Calculate the r.m.s. current in the 1·0 kΩ resistor. 4

(iii) Calculate the r.m.s output voltage of the signal generator. 3

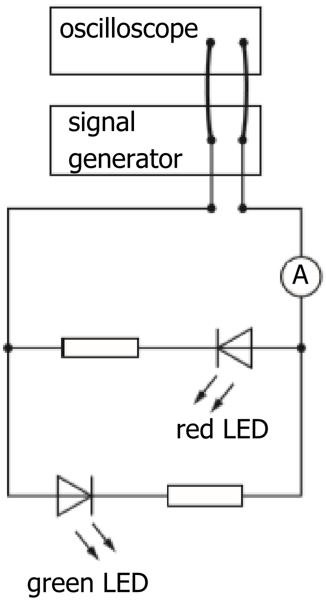
(b) The oscilloscope is now added in parallel with the 2·2 kΩ resistor. The timebase setting and the Y-gain setting are unchanged.

State whether the amplitude of the trace displayed on the screen now would be greater than, less than or the same as the original trace.

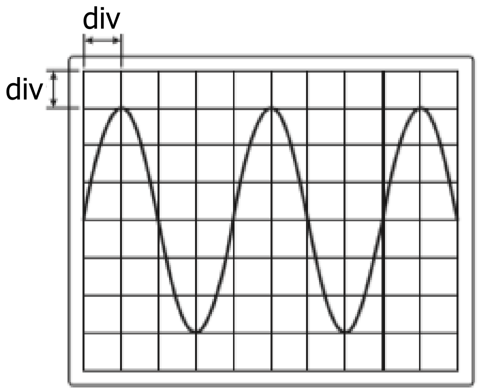
You must justify your answer. 2

19. A student carries out a series of experiments to investigate alternating current.

(a) A signal generator is connected to an oscilloscope and a circuit as shown.



The output of the signal generator is displayed on the oscilloscope.



The Y-gain setting on the oscilloscope is 1·0 V/div.

The timebase setting on the oscilloscope is 0·5 s/div.

(i) Determine the peak voltage of the output of the signal generator. 1

(ii) Determine the frequency of the output of the signal generator. 3

(iii) The student observes that the red LED is only lit when the ammeter gives a positive reading and the green LED is only lit when the ammeter gives a negative reading.

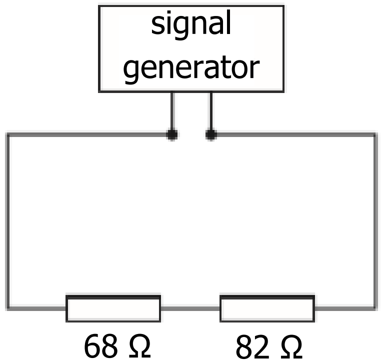
Explain these observations. 2

19. **(continued)**

(b) The signal generator is now connected in a circuit as shown.

The settings on the signal generator are unchanged.

The signal generator has negligible internal resistance.



Determine the r.m.s. voltage across the 82 Ω resistor. 5