Cumbernauld Academy

Higher Physics

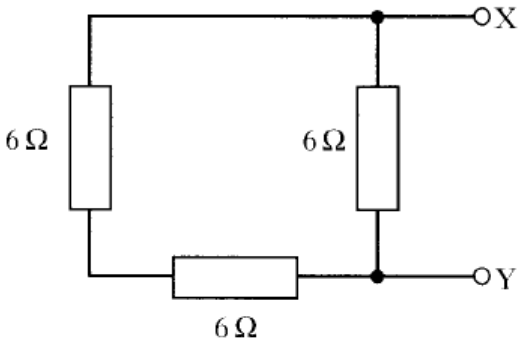
Electricity

Homework

Exercise 13 – AC, Current , Voltage, Power and Resistance

Past Paper Homework Exercise

1. Three resistors are connected as shown.



The total resistance between X and Y is

A 2 Ω

B 4 Ω

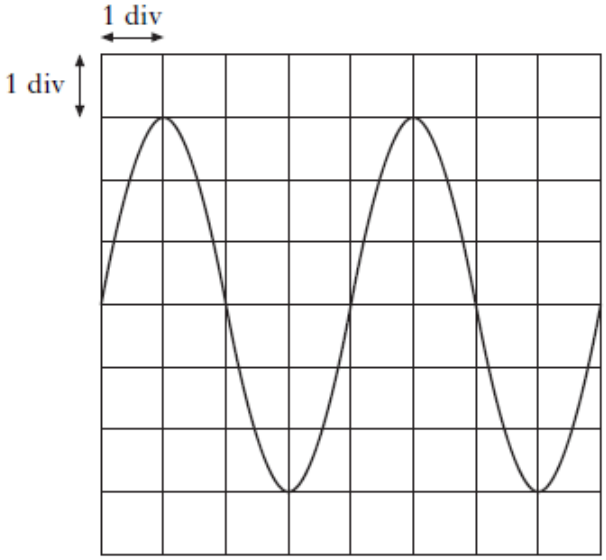
C 6 Ω

D 9 Ω

E 18 Ω.

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

The trace on the oscilloscope is shown.

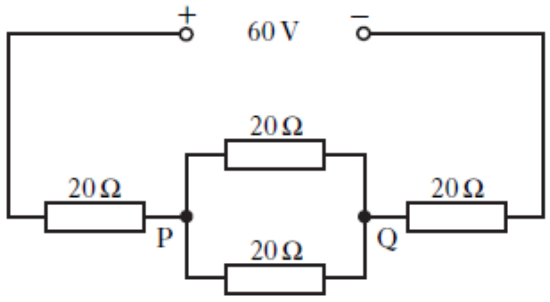


The time-base is set at 0·01 s/div and the Y-gain is set at 4·0 V/div.

Which row in the table 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

2. Four resistors, each of resistance 20 Ω, are connected to a 60 V supply of negligible internal resistance, as shown.



The potential difference across PQ is

A 12 V

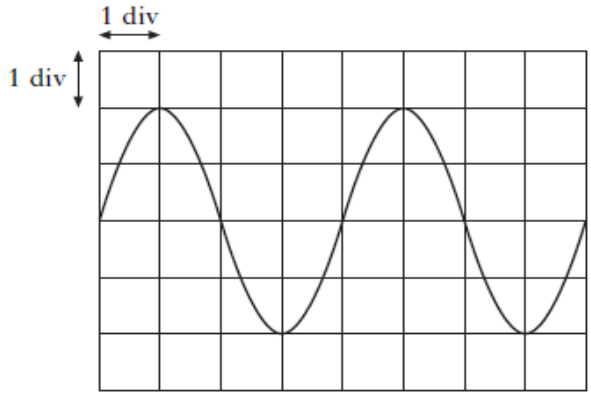
B 15 V

C 20 V

D 24 V

E 30 V.

10. 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

5. The potential difference between two points is

A the work done in moving one electron between the two points

B the voltage between the two points when there is a current of one ampere

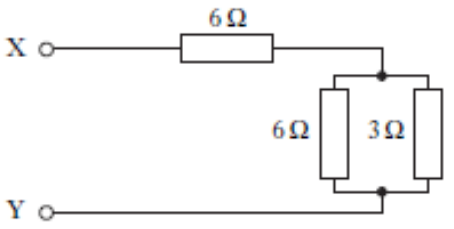
C the work done in moving one coulomb of charge between the two points

D the kinetic energy gained by an electron as it moves between the two points

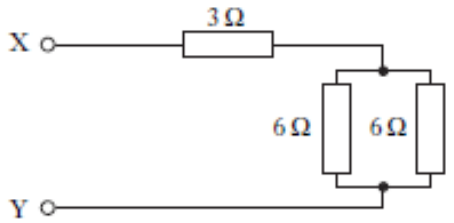
E the work done in moving any charge between the two points.

9. Which of the following combinations of resistors has the greatest resistance between X and Y?

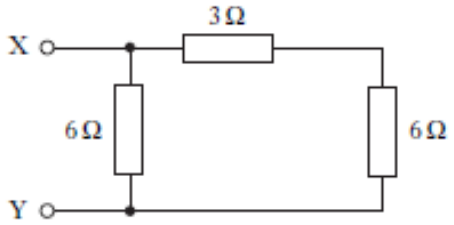
A



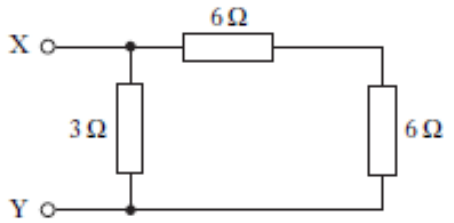
B



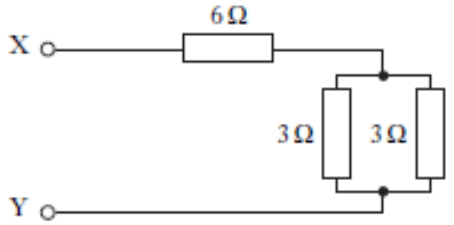
C



D



E



8. One v 9. equivalent to one

A farad per coulomb

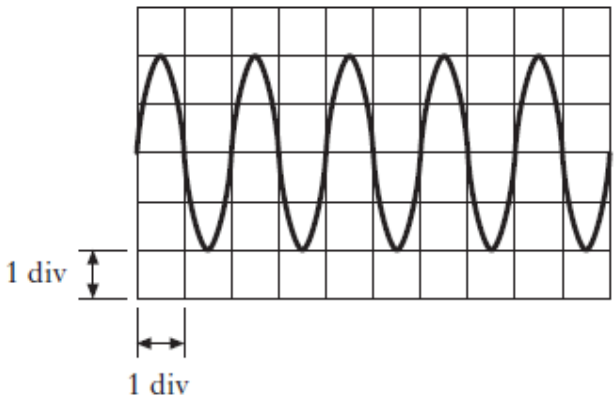
B ampere per ohm

C joule per ampere

D joule per ohm

E joule per coulomb.

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



The time-base control of the oscilloscope is set at

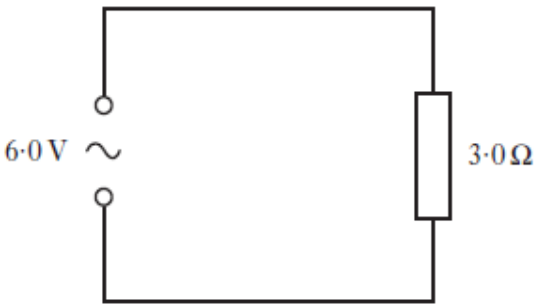
A 1 ms/div

B 10 ms/div

C 20 ms/div

D 100 ms/div

12. An a.c. supply with an output voltage of 6·0 V r.m.s. is connected to a 3·0 Ω resistor.

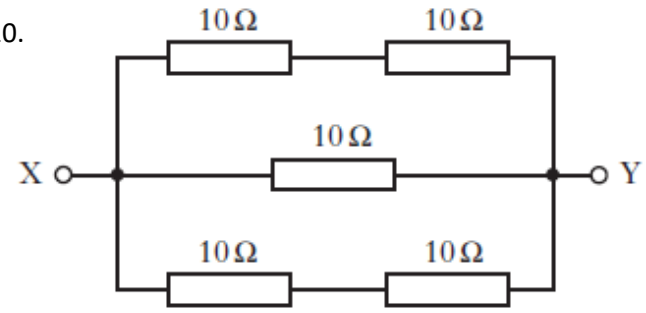


Which row in the across the resistor circuit?

	Peak volta
A	$6\sqrt{2}$
B	$6\sqrt{2}$
C	6
D	$\frac{6}{\sqrt{2}}$
E	6

9. The diagram shows part of an electrical circuit.

10.



What is the resistance between X and Y?

A 0·2 Ω

B 5 Ω

C 10 Ω

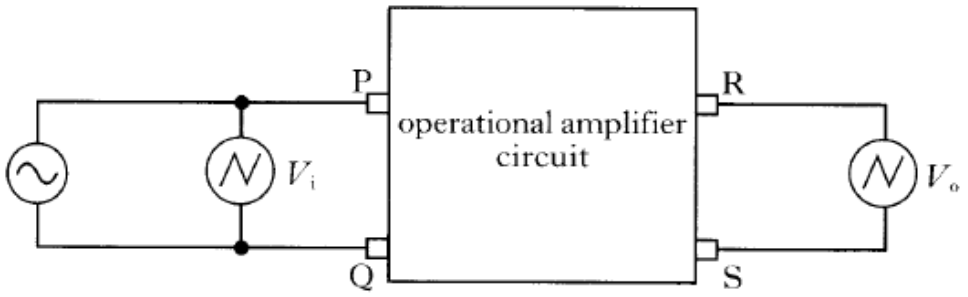
D 20 Ω

E 50 Ω

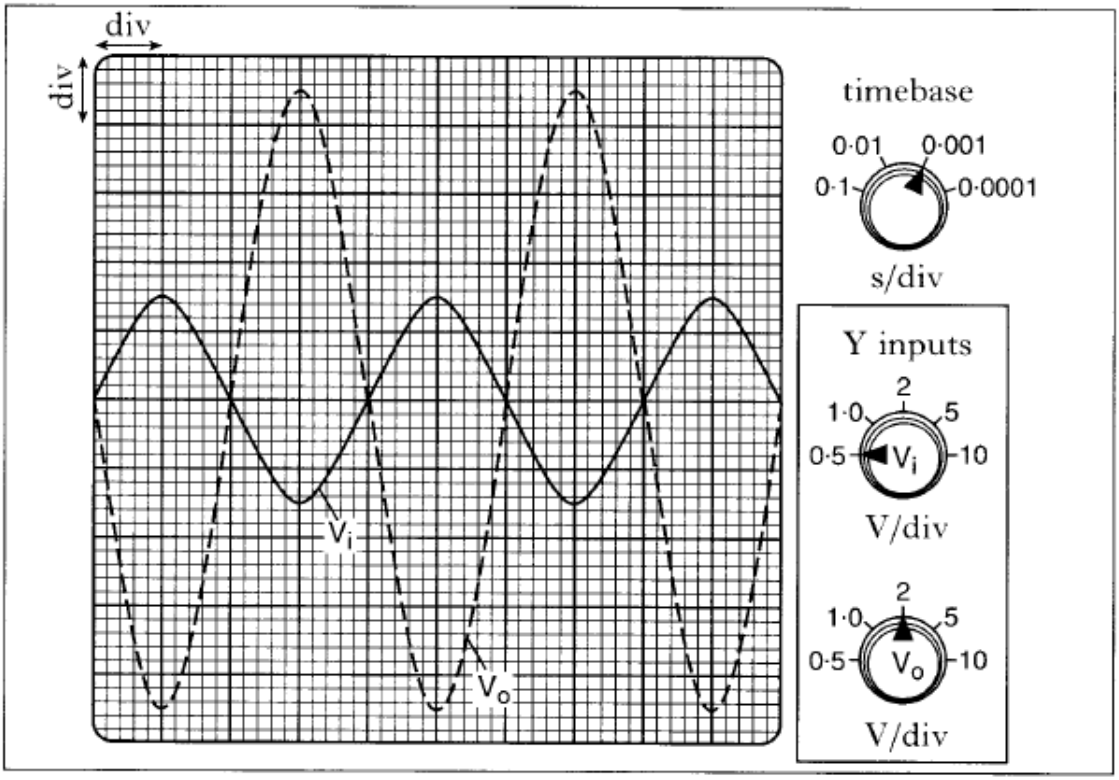
26. A double beam oscilloscope has two inputs which allows two signals to be viewed on the screen at the same time.

A double beam oscilloscope is connected to the input terminals **P** and **Q** and the output terminals **R** and **S** of a box containing an operational amplifier circuit.

The operational amplifier is operating in the inverting mode.



(*a*) The oscilloscope control settings and the two traces displayed on its screen are shown in the diagram.

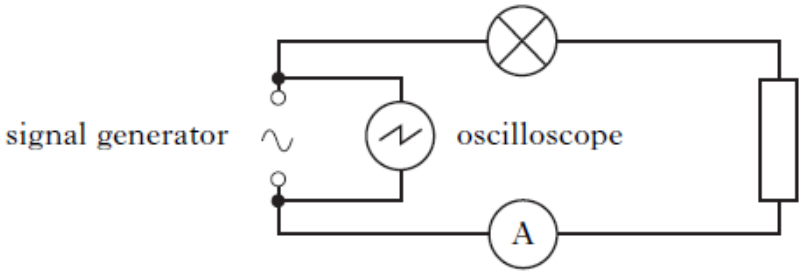


(i) Calculate the frequency of the a.c. supply. **2**

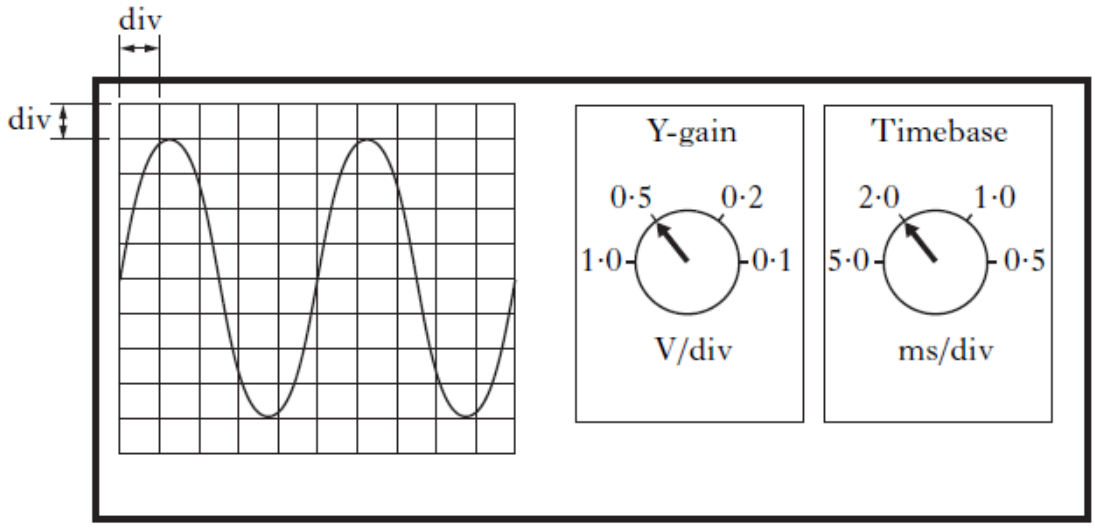
(ii) Calculate the voltage gain of the amplifier circuit. **2**

(iii) Calculate the r.m.s. value of the output voltage of the amplifier circuit. **2**

12. 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.

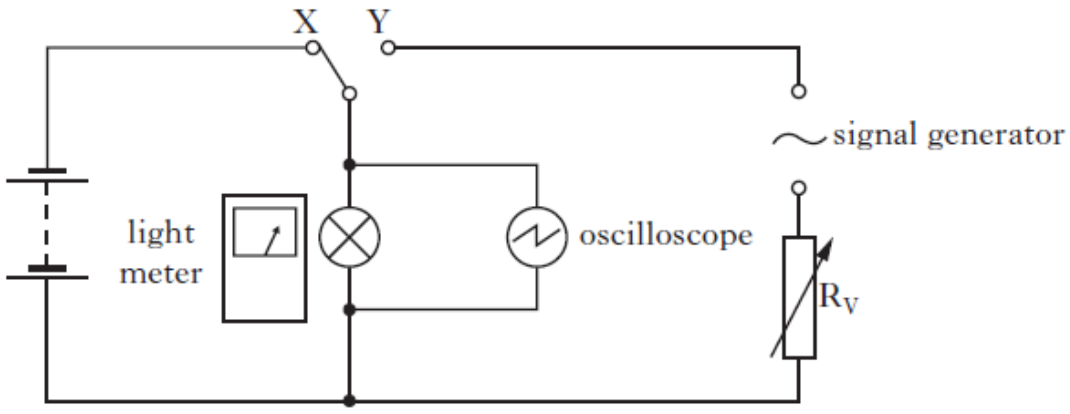


(*a*) For this signal calculate:

(i) the peak voltage;

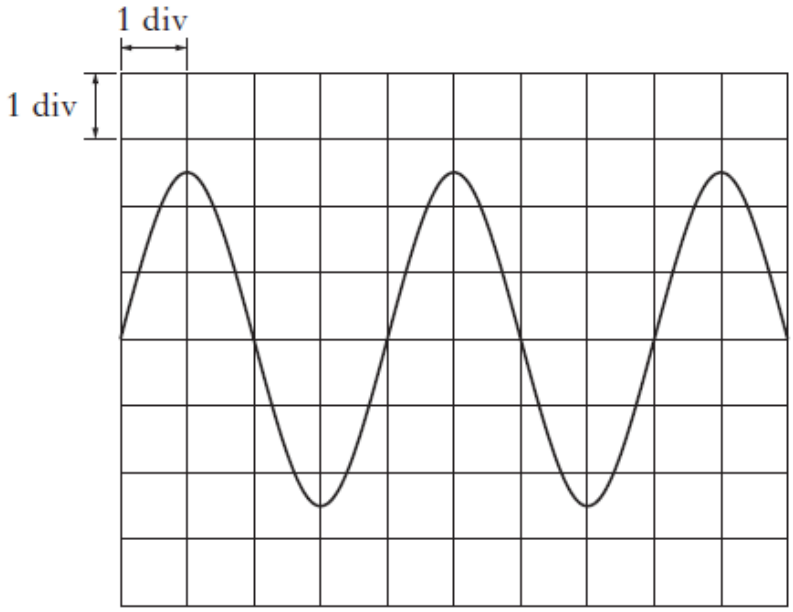
(ii) the frequency.

26. 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.

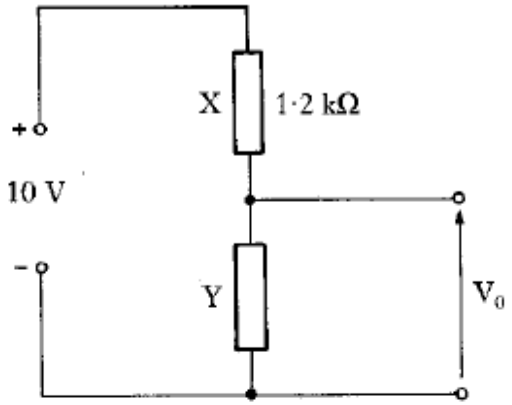


(*a*) The timebase setting is 0·01 s/div.

Calculate the frequency of the output voltage of the signal generator. **2**

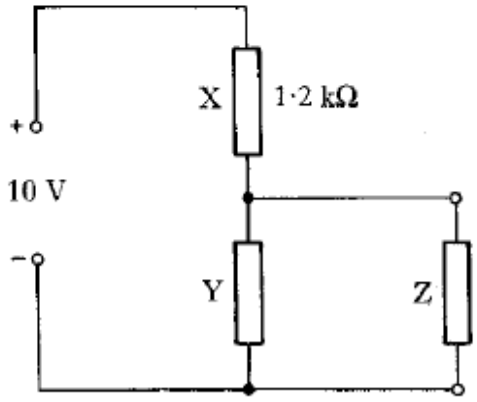
(*b*) Calculate the peak value of the voltage displayed on the oscilloscope. **2**

5. (*a*) A potential divider is used to provide an output voltage V_0 from a 10 V supply as shown below. The supply has negligible internal resistance.



(i) The resistance of resistor X is 1·2 kΩ and the output voltage required is 6·0 V. Calculate the resistance of resistor Y.

(ii) A load resistor Z is now connected across the output as shown below.



Explain why the voltage across Z is less than 6·0 V.

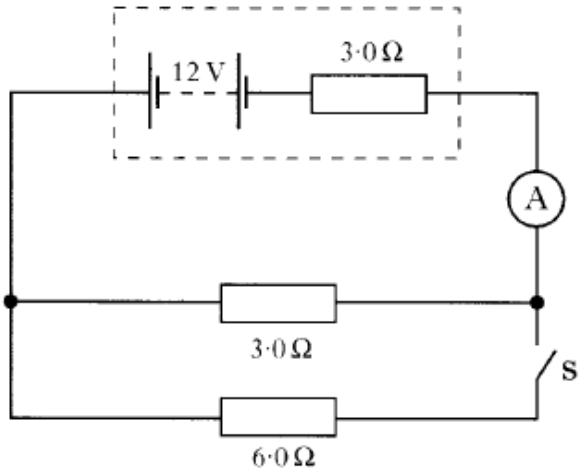
(iii) Calculate the voltage across resistor Z when its resistance is 4·7 kΩ. **6**

30 marks

Exercise 14 - Emf and Internal Resistance

Past Paper Homework Questions

1. 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

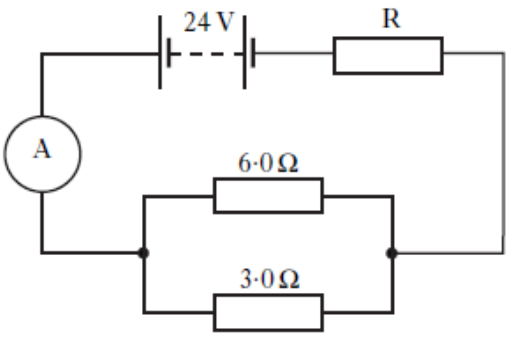
B 2·0 A to 2·4 A

C 2·0 A to 10 A

D 4·0 A to 1·3 A

E 4·0 A to 6·0 A.

2. A battery of e.m.f. 24 V and negligible internal resistance is connected as shown.



The reading on the ammeter is 2·0 A.

The resistance of R is

A 3·0 Ω

B 4·0 Ω

C 10 Ω

D 12 Ω

E 18 Ω.

3. The e

A th

B th
re

C th
b

D th
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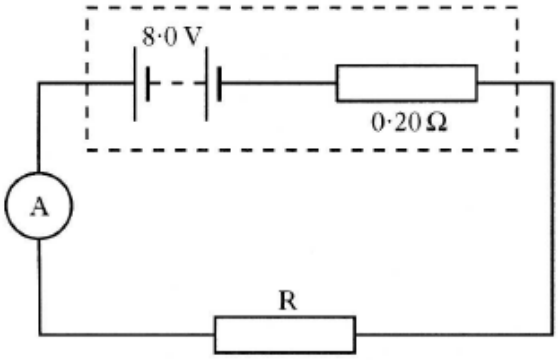
cl

4. In the following circuit, the battery has an e.m.f. of 8·0 V and an internal resistance of 0·20 Ω.



The reading on the ammeter is 4·0 A.

The resistance of R is

A 0·5 Ω

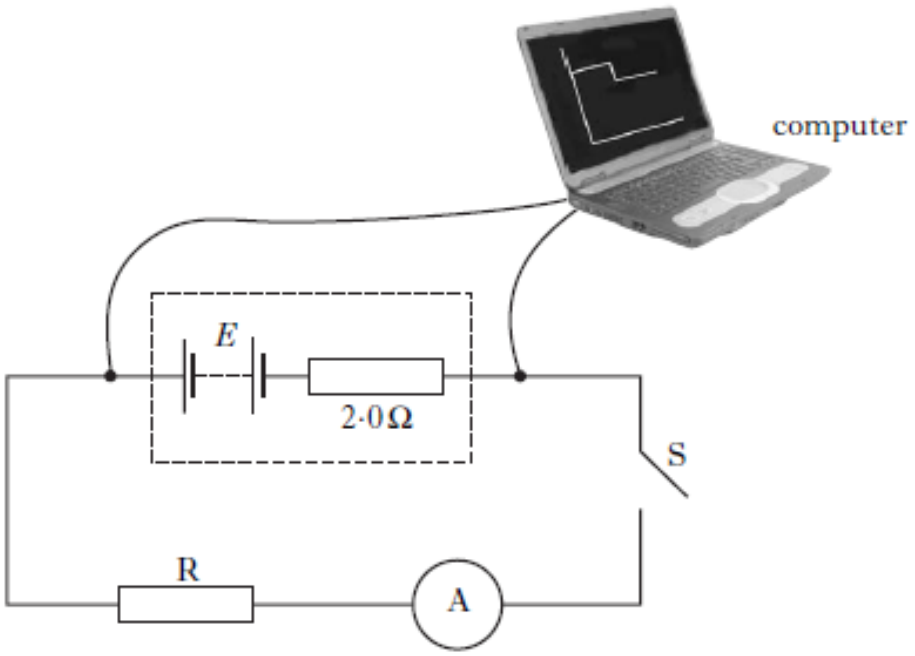
B 1·8 Ω

C 2·0 Ω

D 2·2 Ω

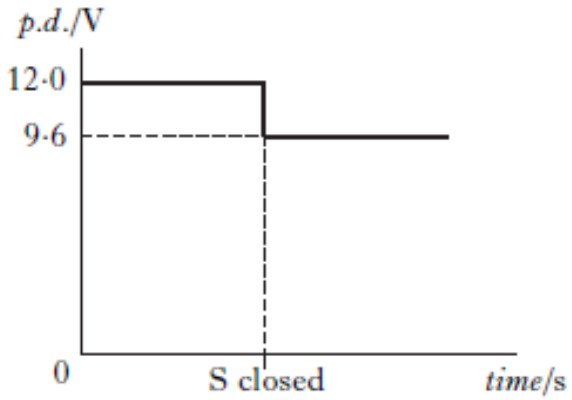
E 6·4 Ω.

25. A power supply of e.m.f. E and internal resistance $2{\cdot}0\,\Omega$ is connected as shown.



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

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



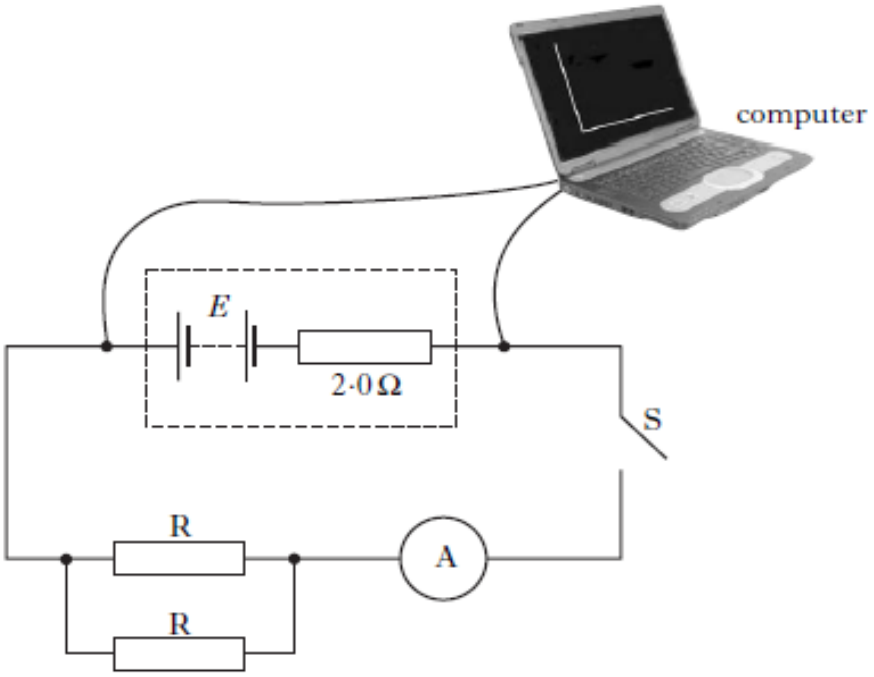
(*a*) State the e.m.f. of the power supply. **1**

(*b*) Calculate:

(i) the reading on the ammeter after switch S is closed; **2**

(ii) the resistance of resistor R. **1**

(*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.

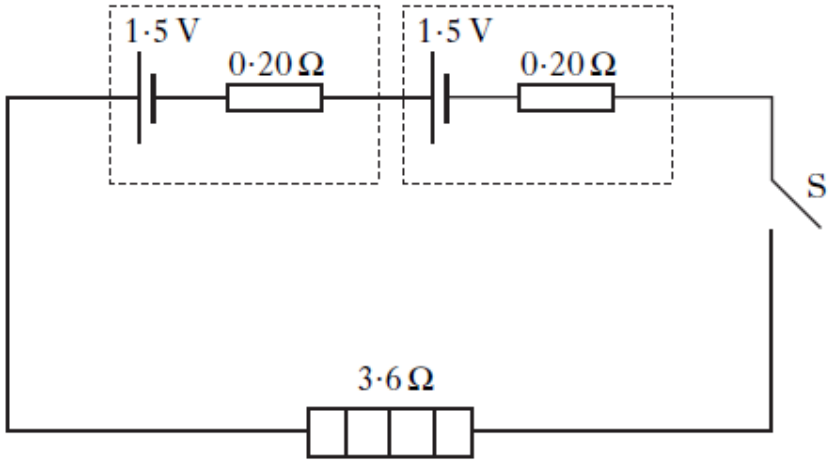
Copy and complete the new graph of potential difference against time showing the values of potential difference before and after switch S is closed. **2**

(6)

24. 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.



heating element

Switch S is closed.

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

(ii) Calculate the current in the heating element. **2**

(iii) Calculate the power output of the heating element. **2**

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

What effect, if any, does this have on the power output of the heating element?

Justify your answer. **2**

(7)

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

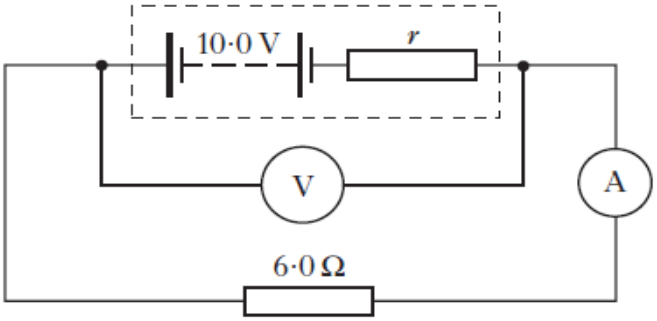


Figure 1

The meters display the following readings.

Reading on ammeter = 1·25 A

Reading on voltmeter = 7·50 V

(i) 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. **1**

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

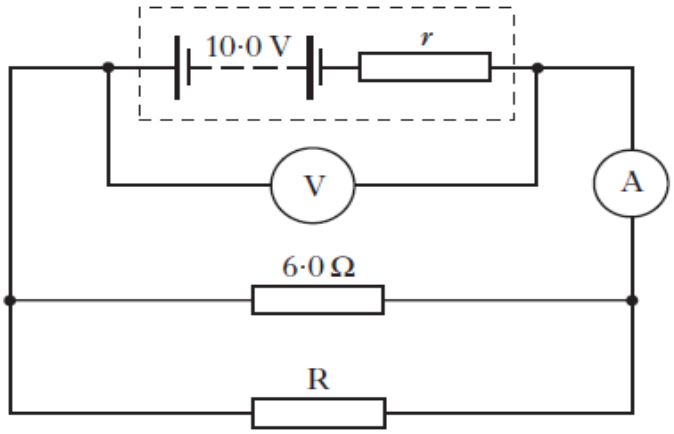


Figure 2

The meters now display the following readings.

Reading on ammeter = 2·0 A

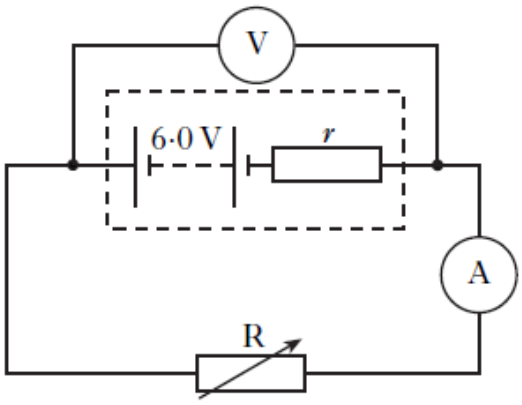
Reading on voltmeter = 6·0 V

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

(ii) Calculate the resistance of resistor R. **3**

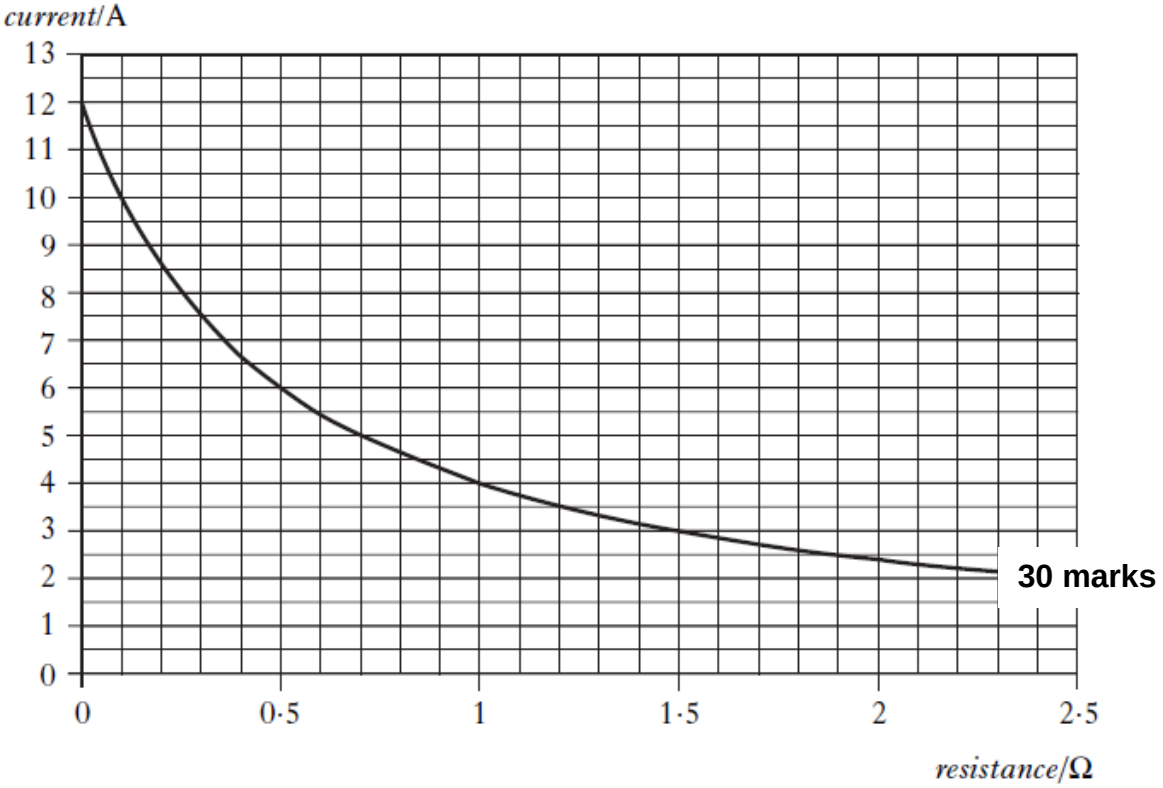
(7)

24. 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.

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



30 marks

(*a*) Use information from the graph to calculate:

(i) the lost volts in the circuit when the resistance of R is 1·5 Ω; **2**

(ii) the internal resistance, r, of the battery. **2**

(*b*) The resistance of R is now increased.

What effect, if any, does this have on the lost volts?

You must justify your answer. **2**

Exercise 15 - Capacitance

Past Paper Homework Questions

11. The uni 4. ıpacitance can be written as

A VC^{-1}

B CV^{-1}

C Js^{-1}

D CJ^{-1}

E JC^{-1}.

12. Which of the following statements about capacitors is/are true?

I Capacitors are used to block a.c. signals.

II Capacitors are used to block d.c. signals.

III Capacitors can store energy.

IV Capacitors can store electric charge.

A I only

B I

C I

D I

E I

11. A student about capa

I Capac

II Capac

III Capac

Which of t

A I only

B I and

C I and

D II anc

E I, II a

5. **13.** In an experiment to find the capacitance of a capacitor, a student makes the following measurements.

potential difference across capacitor $= (10{\cdot}0 \pm 0{\cdot}1)\,V$

charge stored by capacitor $= (500 \pm 25)\,\mu C$

Which row in the table gives the capacitance of the capacitor and the percentage uncertainty in the capacitance?

	Capacitance/μF	*Percentage uncertainty*
A	0·02	1
B	0·02	5
C	50	1
D	50	5
E	5000	6

11. A 25·0 μF capacitor is charged until the potential difference across it is 500 V.
The charge stored in the capacitor is

A $5{\cdot}00 \times 10^{-8}\,C$

B $2{\cdot}00 \times 10^{-5}\,C$

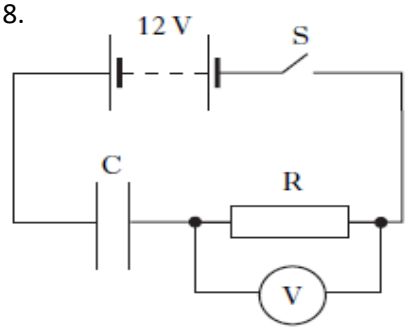
C $1{\cdot}25 \times 10^{-2}\,C$

D $1{\cdot}25 \times 10^{4}\,C$

E $2{\cdot}00 \times 10^{7}\,C$.

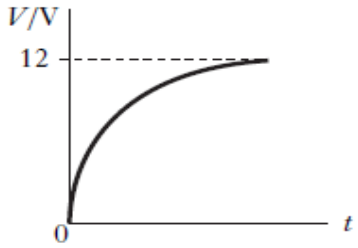
12. A circuit is set up as shown.

8.

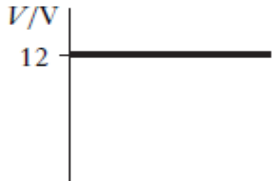


The capacitor is initially uncharged. Switch S is now closed. Which graph shows how the potential difference, V, across R, varies with time, t?

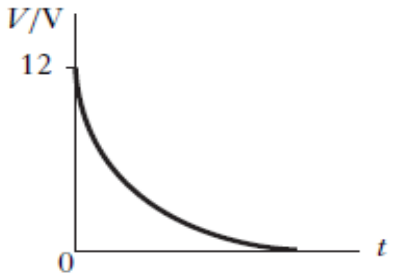
A



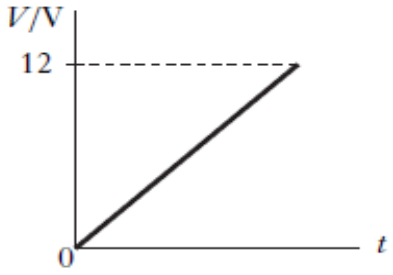
B



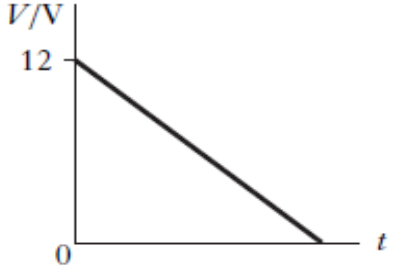
C



D



E



11. A student carries out an experiment to find the capacitance of a capacitor. The charge on the capacitor is measured for different values of p.d. across the capacitor. The results are shown.

charge on capacitor/μC	*p.d. across capacitor*/V
1·9	1·0
4·6	2·0
9·6	4·0

The best estimate of the capacitance is

A 1·9 μF

B 2·2 μF

C 2·3 μF

D 2·4 μF

E 2·6 μF.

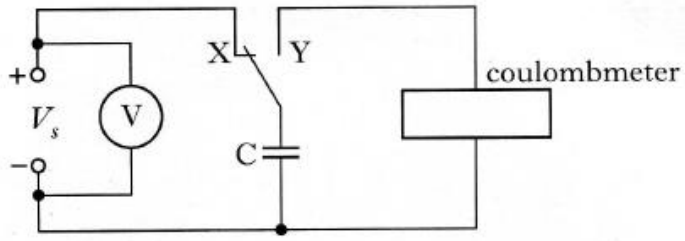
10. The capacitance of a capacitor is 1000 μF. The potential difference (p.d.) across the capacitor is 100 V. The charge stored by the capacitor is 0·10 C.

The charge on the capacitor is now reduced to half its original value.

Which row in the table shows the capacitance of the capacitor and the p.d. across the capacitor, for this new value of charge?

	Capacitance/μF	*p.d.*/V
A	1000	200
B	500	100
C	1000	100
D	500	50
E	1000	50

9. (*a*) In an experiment to measure the capacitance of a capacitor, a student sets up the following circuit.



When the switch is in position X, the capacitor charges up to the supply voltage, V_s. When the switch is in position Y, the coulombmeter indicates the charge stored by the capacitor.

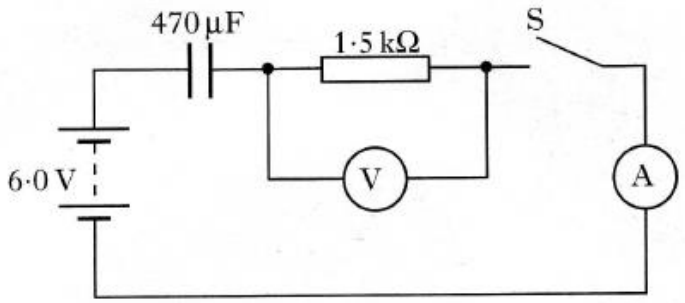
The student records the following measurements and uncertainties.

Reading on voltmeter = $(2{\cdot}56 \pm 0{\cdot}01)$ V
Reading on coulombmeter = $(32 \pm 1)\,\mu$C

Calculate the value of the capacitance and the percentage uncertainty in this value. You must give the answer in the form

value ± percentage uncertainty. **3**

25. (*a*) The following diagram shows a circuit that is used to investigate the charging of a capacitor.



The capacitor is initially uncharged.

The capacitor has a capacitance of 470 μF and the resistor has a resistance of 1·5 kΩ.

The battery has an e.m.f. of 6·0 V and negligible internal resistance.

(i) Switch S is now closed. What is the initial current in the circuit?

(ii) How much energy is stored in the capacitor when it is fully charged?

(iii) What change could be made to this circuit to ensure that the **same** capacitor stores **more** energy? **5**

(*b*) A capacitor is used to provide the energy for an electronic flash in a camera.

When the flash is fired, $6{\cdot}35 \times 10^{-3}$ J of the stored energy is emitted as light.

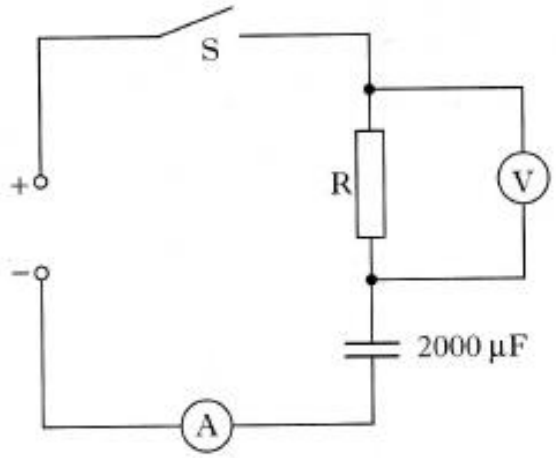
The mean value of the frequency of photons of light from the flash is $5{\cdot}80 \times 10^{14}$ Hz.

Calculate the number of photons emitted in each flash of light. **3**

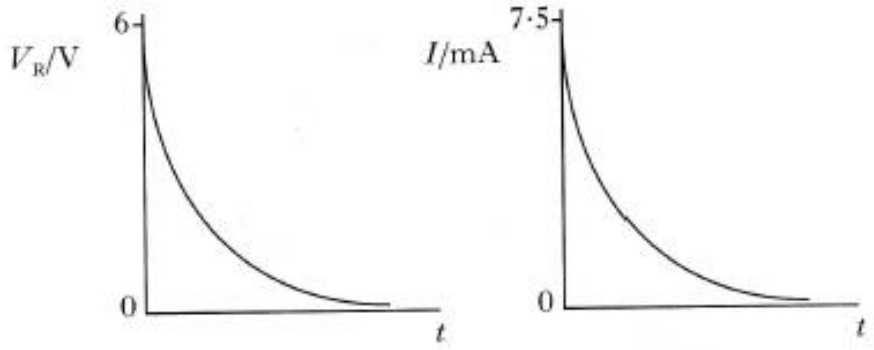
(8)

25. (*a*) The circuit below is used to investigate the charging of a 2000 μF capacitor. The d.c. supply has negligible internal resistance.

30 marks



The graphs below show how the potential difference V_R across the **resistor** and the current I in the circuit vary with time from the instant switch S is closed.



(i) What is the potential difference across the capacitor when it is fully charged?

(ii) Calculate the energy stored in the capacitor when it is fully charged.

(iii) Calculate the resistance of R in the circuit above. **5**

Exercise 16 – Electrons at Work

Past Paper Homework Questions

1. A student writes the following statements about n-type semiconductor material.

   I Most charge carriers are negative.

   II The n-type material has a negative charge.

   III Impurity atoms in the material have 5 outer electrons.

   Which of these statements is/are true?

   A I only

   B II only

   C III only

   D I and II only

   E I and III only

3. Materials are "doped" to produce n-type semiconductor material.

   In n-type semiconductor material

   A the majority charge carriers are electrons

   B the majority charge carriers are neutrons

   C the majority charge carriers are protons

   D there are more protons than neutrons

   E there are more electrons than neutrons.

2. A student writes the following statements about p-type semiconductor material.

I Most charge carriers are positive.

II The p-type material has a positive charge.

III Impurity atoms in the material have 3 outer electrons.

Which of these statements is/are true?

A I only

B II only

C I and II only

D I and III only

E I, II and III

18. A p-n junction diode is forward biased.

Positive and negative charge carriers recombine in the junction region. This causes the emission of

A a hole

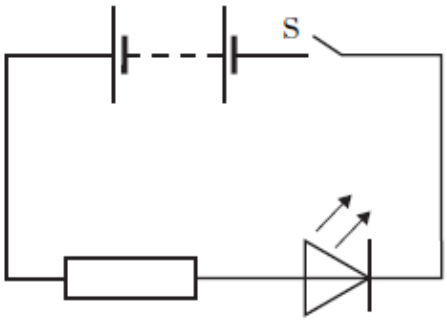
B an electron

C an electron-hole pair

D a proton

E a photon.

4. The letters **X**, **Y** and **Z** represent three missing
An LED is connected as shown.



When switch S is closed

A the p-n junction is reverse biased and free charge carriers are produced which may recombine to give quanta of radiation

B the p-n junction is forward biased and positive and negative charge carriers are produced by the action of light

C the p-n junction is reverse biased and positive and negative charge carriers are produced by the action of light

D the p-n junction is forward biased and positive and negative charge carriers may recombine to give quanta of radiation

E the p-n junction is reverse biased and positive and negative charge carriers may recombine to give quanta of radiation.

10.

9. A student reads the following passage in a physics dictionary.

"*. . . is a solid state device in which positive and negative charge carriers are produced by the action of light on a p-n junction.*"

The passage describes

A a thermistor

B a MOSFET

C a photodiode

D a laser

E an LED.

7. In an n-type semiconductor

A the majority charge carriers are electrons

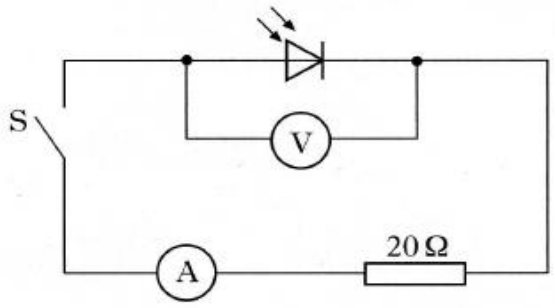
B the majority charge carriers are holes

C the majority charge carriers are protons

D there are more protons than electrons

E there are more electrons than protons.

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



Switch S is open.
Light is shone on to the photodiode.
A reading is obtained on the voltmeter.

(*a*) (i) State the mode in which the photodiode is operating.

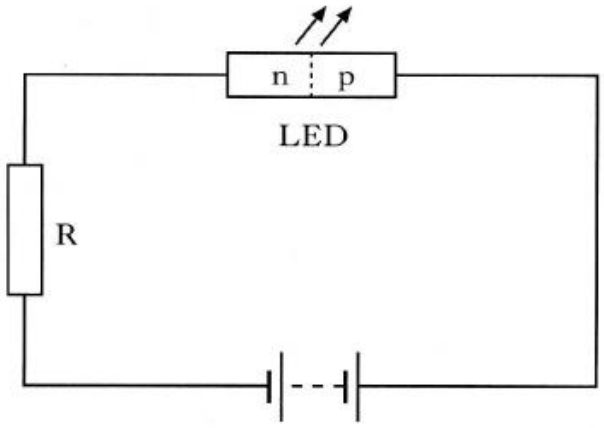
(ii) Describe the effect of light on the material of which the photodiode is made.

(iii) The intensity of the light on the photodiode is increased.
What happens to the reading on the voltmeter? **3**

11. (*a*) A sample of pure semiconducting material is doped by adding impurity atoms.

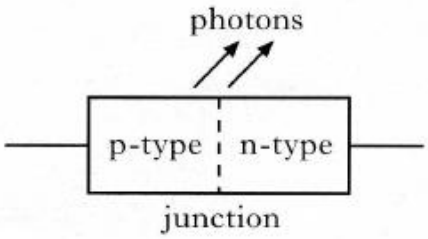
How does this addition affect the resistance of the semiconducting material? **1**

(*b*) The circuit below shows a p-n junction diode used as a light emitting diode (LED).



(i) Explain in terms of the charge carriers how the LED emits light.

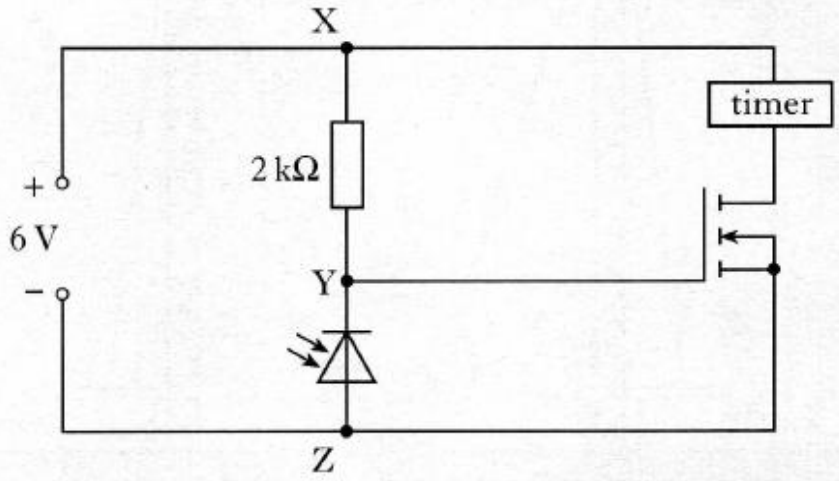
13. An LED consists of a p-n junction as shown.



(*a*) Copy the diagram and add a battery so that the p-n junction is forward-biased. **1**

(*b*) Using the terms *electrons, holes* and *photons*, explain how light is produced at the p-n junction of the LED. **1**

14. The light gate consists of a lamp shining onto a photodiode.
The photodiode forms part of the circuit shown.

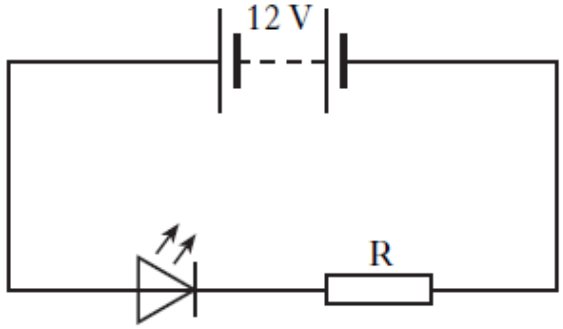


(i) In which mode is the photodiode operating? **1**

(ii) Explain why the timer only operates while the light beam is broken. **2**

(*c*) The brake lights of the car consist of a number of very bright LEDs.

16. An LED from the brake lights is forward biased by connecting it to a 12 V car battery as shown.



The battery has negligible internal resistance.

(i) Explain, in terms of charge carriers, how the LED emits light. **1**

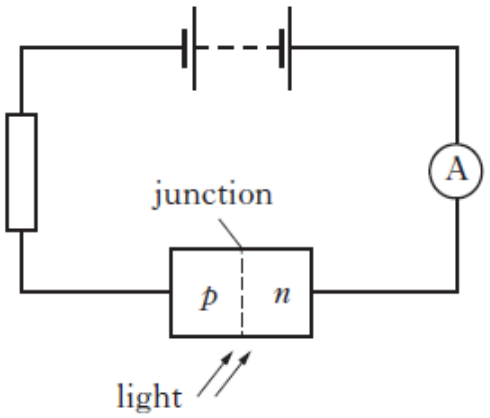
(ii) The LED is operating at its rated values of 5·0 V and 2·2 W.

Calculate the value of resistor R. **3**

30. (*a*) An n-type semiconductor is formed by adding impurity atoms to a sample of pure semiconductor material.

State the effect that the addition of the impurity atoms has on the resistance of the material. **1**

(*b*) A p-n junction is used as a photodiode as shown.



(i) In which mode is the photodiode operating? **1**

(ii) The irradiance of the light on the junction of the photodiode is now increased.

Explain what happens to the current in the circuit. **2**

17. A sample of pure semiconductor material has a small amount of impurity atoms added to form a p-type semiconductor.

a) What is this process called?
b) How does the addition of the impurity atoms affect the resistance of the material?

2

30 marks