Wallace Hall Academy

Physics Department

Higher

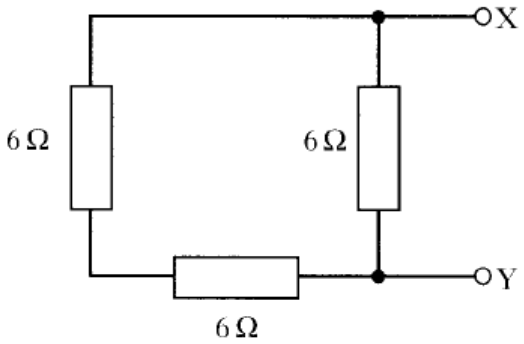
Electricity

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

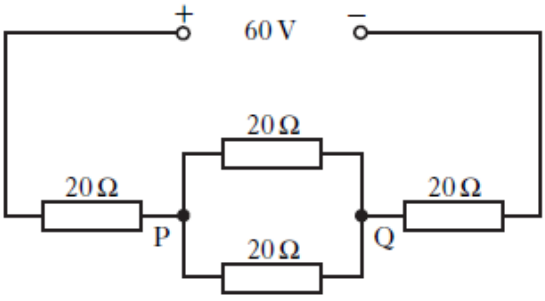
B 4 Ω

C 6 Ω

D 9 Ω

E 18 Ω.

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

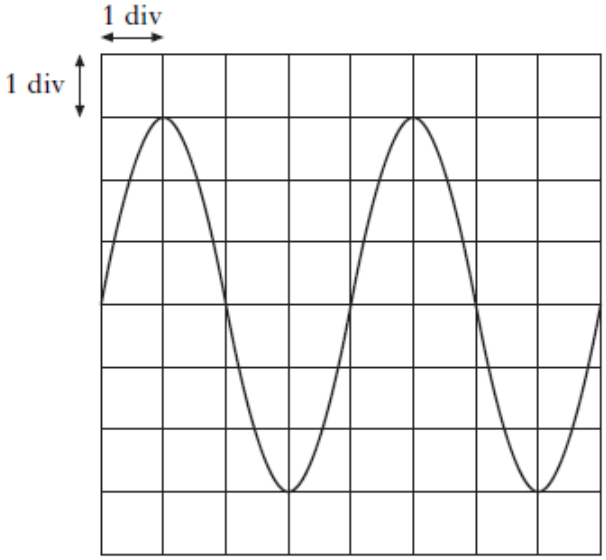
C 20 V

D 24 V

E 30 V.

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

The trace on the oscilloscope is shown.

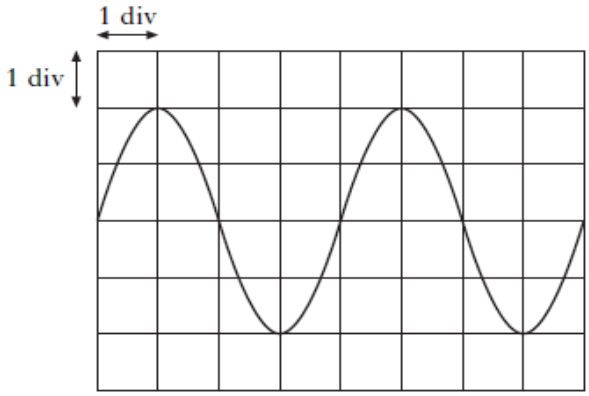


The time-base is set at 0·01 s/div and the Y-gain is set at 4·0 V/div.

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

4. 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

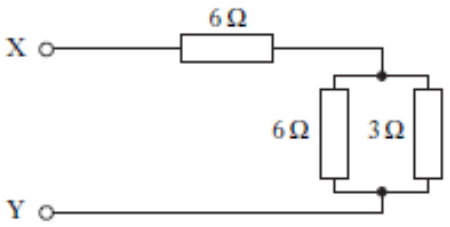
C the work done in moving one coulomb of charge between the two points

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

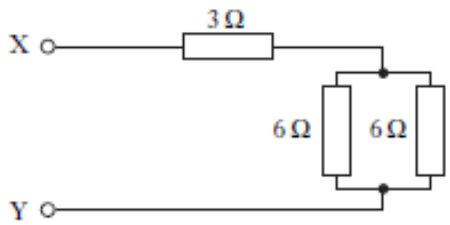
E the work done in moving any charge between the two points.

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

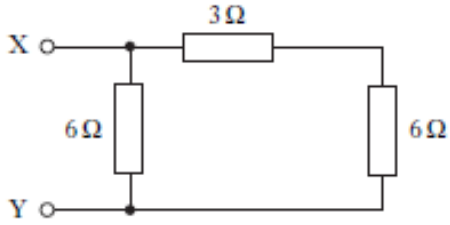
A



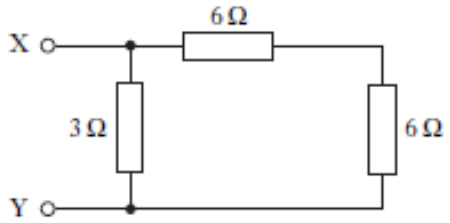
B



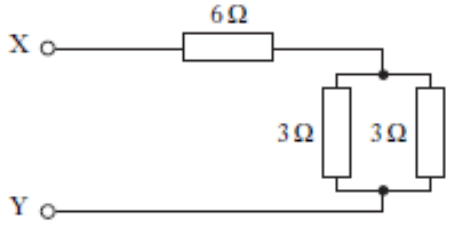
C



D



E



7. One volt is equivalent to one

A farad per coulomb

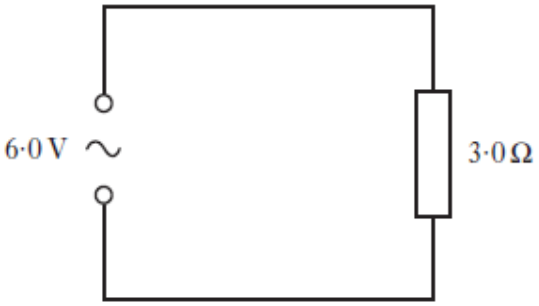
B ampere per ohm

C joule per ampere

D joule per ohm

E joule per coulomb.

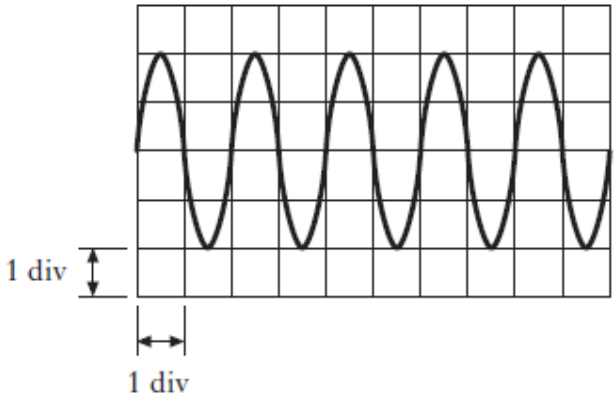
8. An a.c. supply with an output voltage of 6·0 V r.m.s. is connected to a 3·0 Ω resistor.



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

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

9. 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

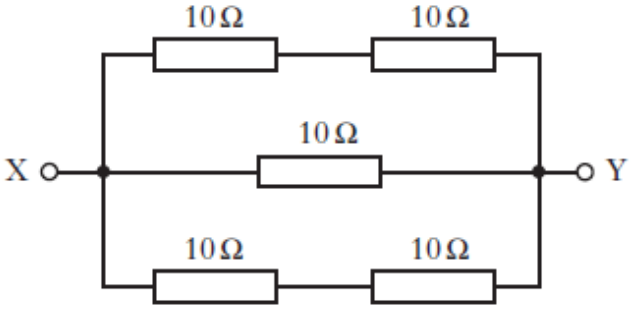
B 10 ms/div

C 20 ms/div

D 100 ms/div

E 200 ms/div.

10. The diagram shows part of an electrical circuit.



What is the resistance between X and Y?

A 0·2 Ω

B 5 Ω

C 10 Ω

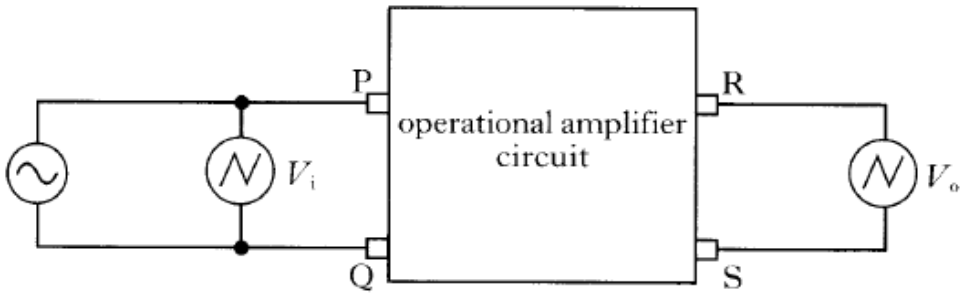
D 20 Ω

E 50 Ω

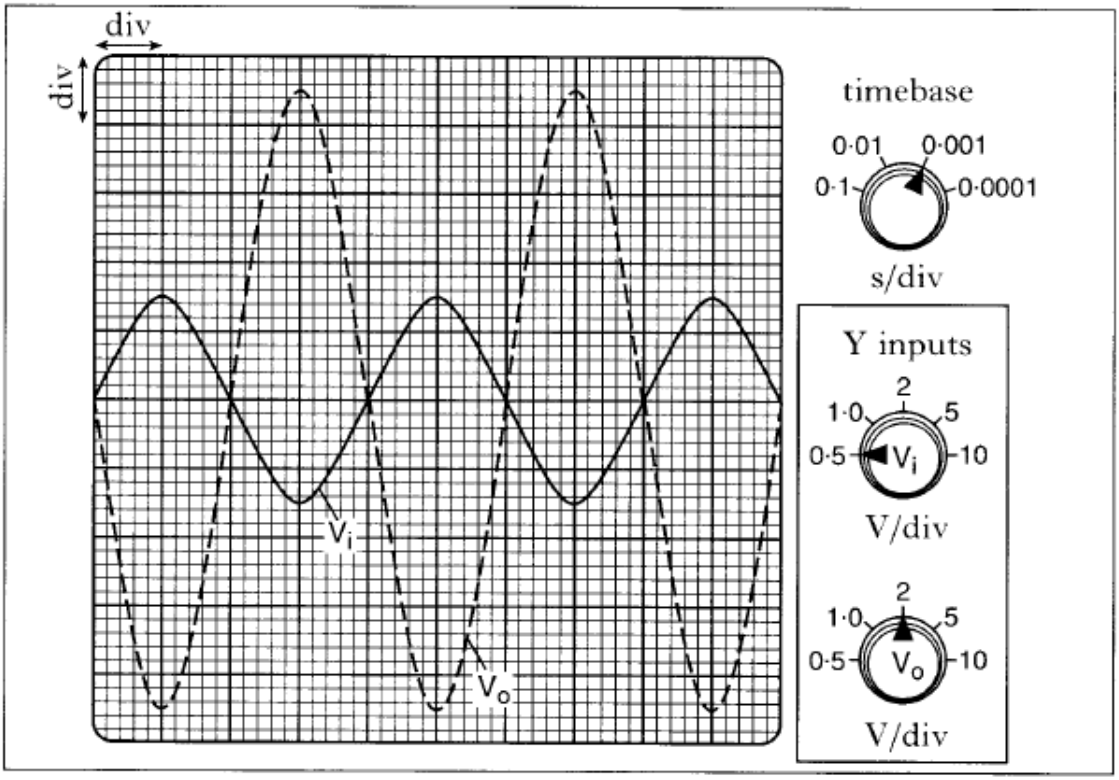
11. A double beam oscilloscope has two inputs which allows two signals to be viewed on the screen at the same time.

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.

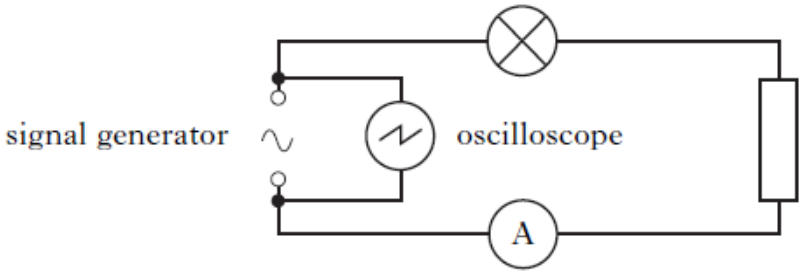


(i) Calculate the frequency of the a.c. supply. **2**

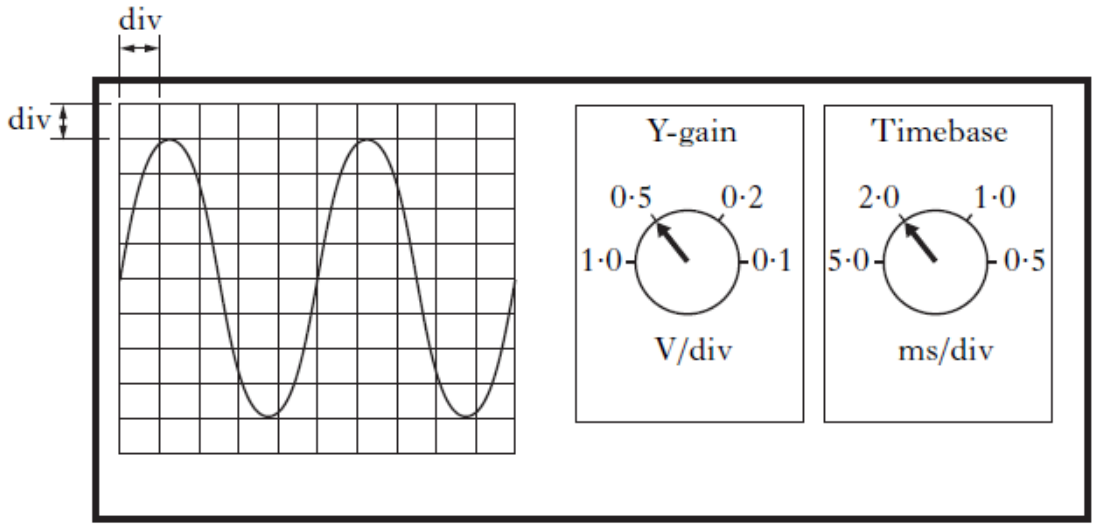
(ii) Calculate the voltage gain of the amplifier circuit. **2**

(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.



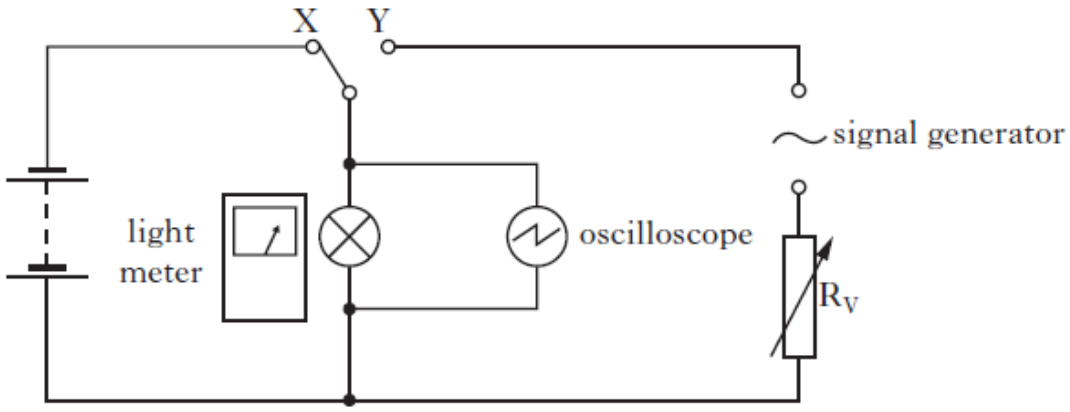
(*a*) For this signal calculate:

(i) the peak voltage;

(ii) the frequency.

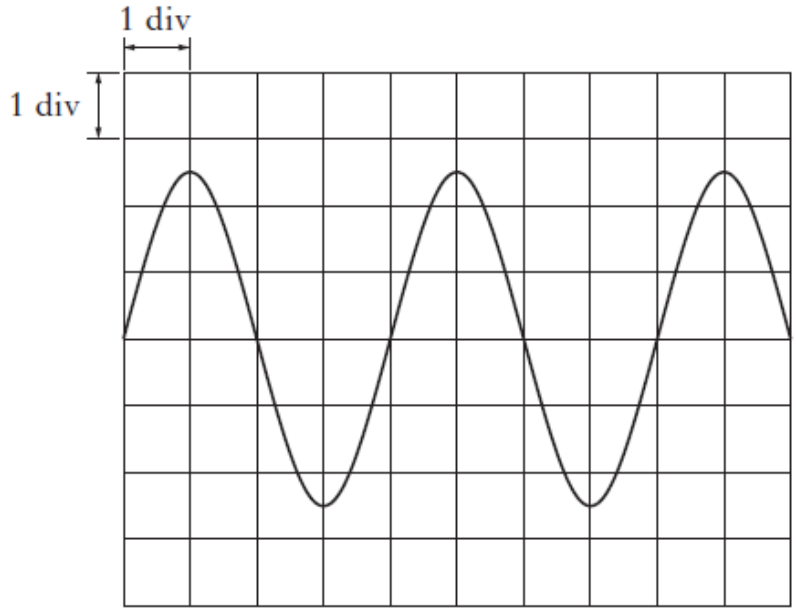
4

13. 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.

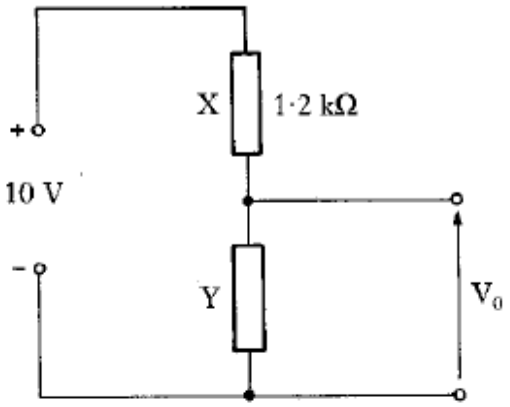


(*a*) The timebase setting is 0·01 s/div.

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

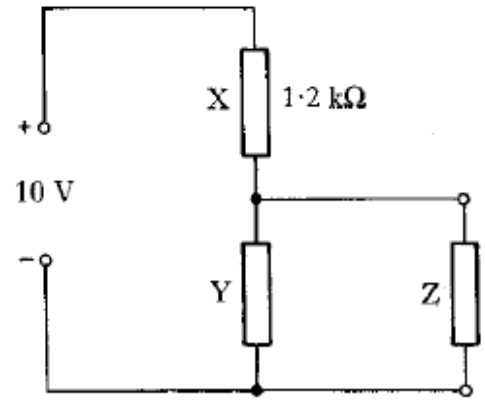
(*b*) Calculate the peak value of the voltage displayed on the oscilloscope. **2**

14. (*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.

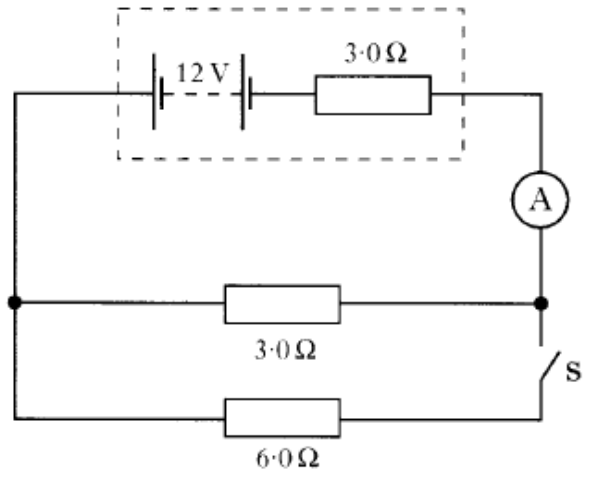
(iii) Calculate the voltage across resistor Z when its resistance is 4·7 kΩ. **6**

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

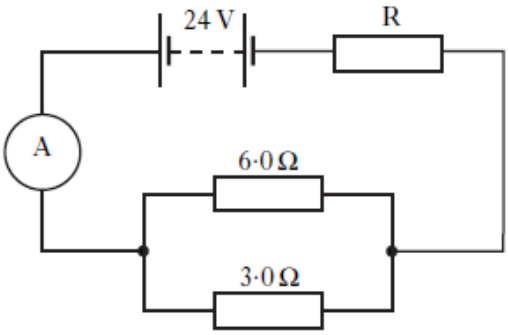
B 2·0 A to 2·4 A

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.m.f. of a battery is

A the total energy supplied by the battery

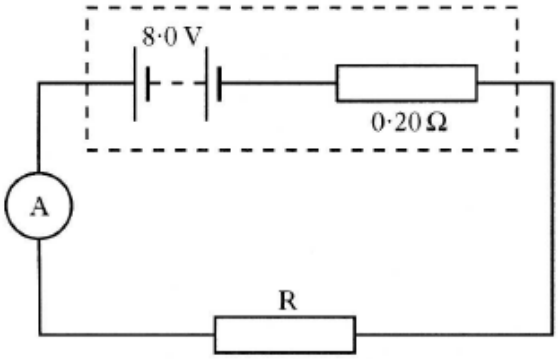
B the voltage lost due to the internal resistance of the battery

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. 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

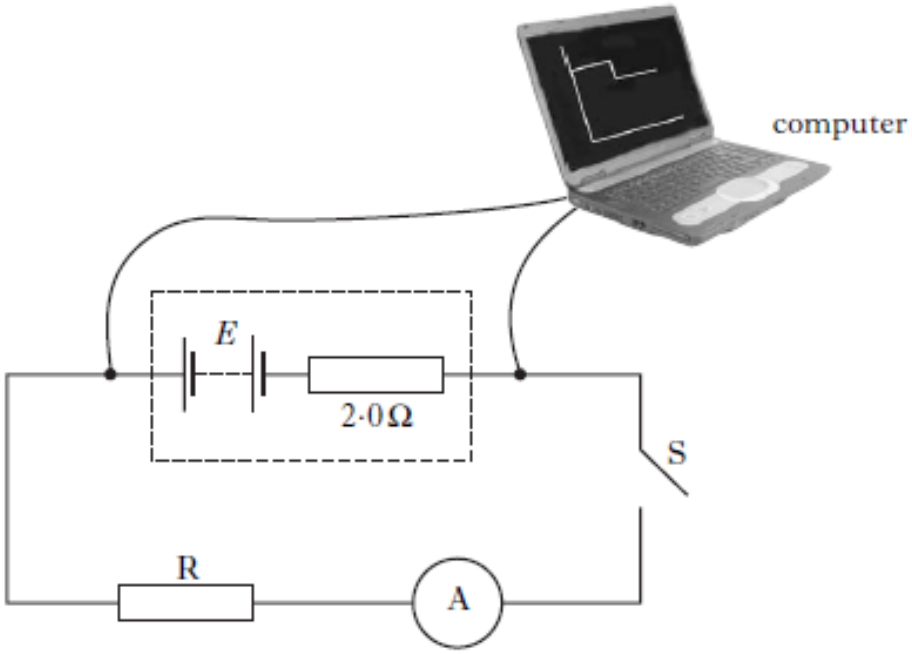
B 1·8 Ω

C 2·0 Ω

D 2·2 Ω

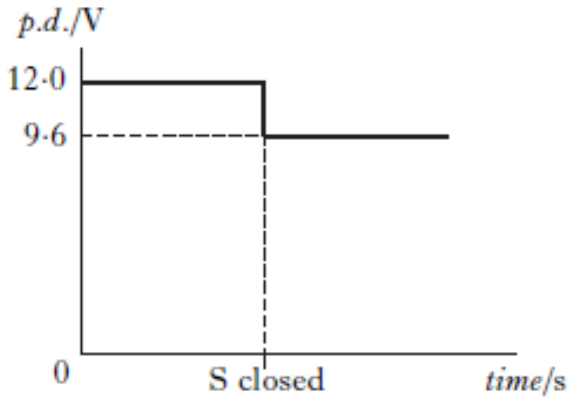
E 6·4 Ω.

5. 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.



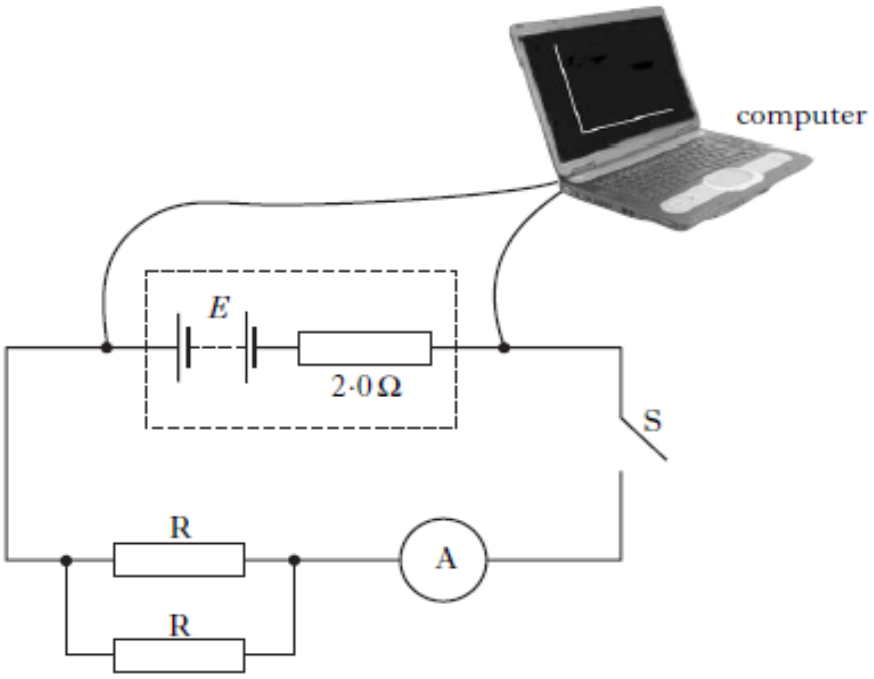
(*a*) State the e.m.f. of the power supply. **1**

(*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.

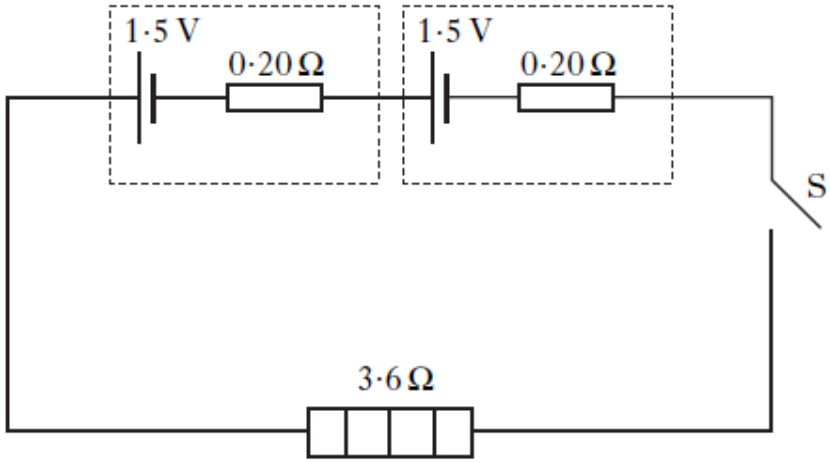
Copy and complete the new graph of potential difference against time showing the values of potential difference before and after switch S is closed. **2**

(6)

6. 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)

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

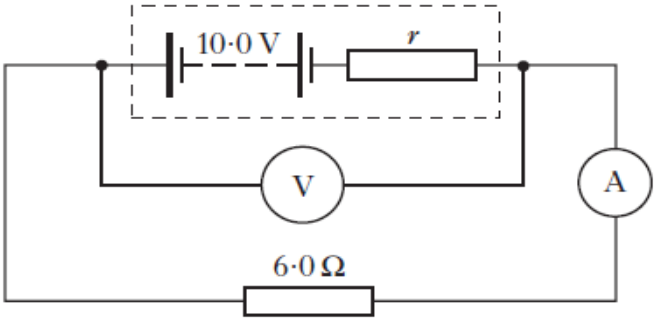


Figure 1

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.

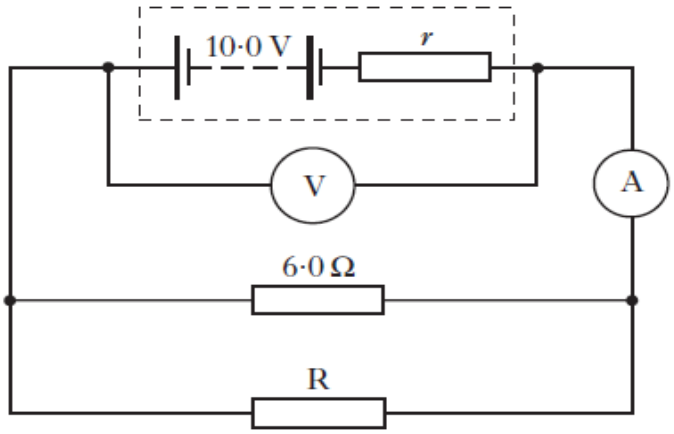


Figure 2

The meters now display the following readings.

Reading on ammeter = 2·0 A

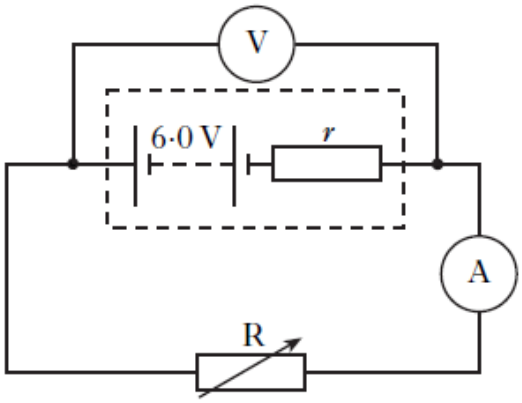
Reading on voltmeter = 6·0 V

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

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

(7)

8. 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.

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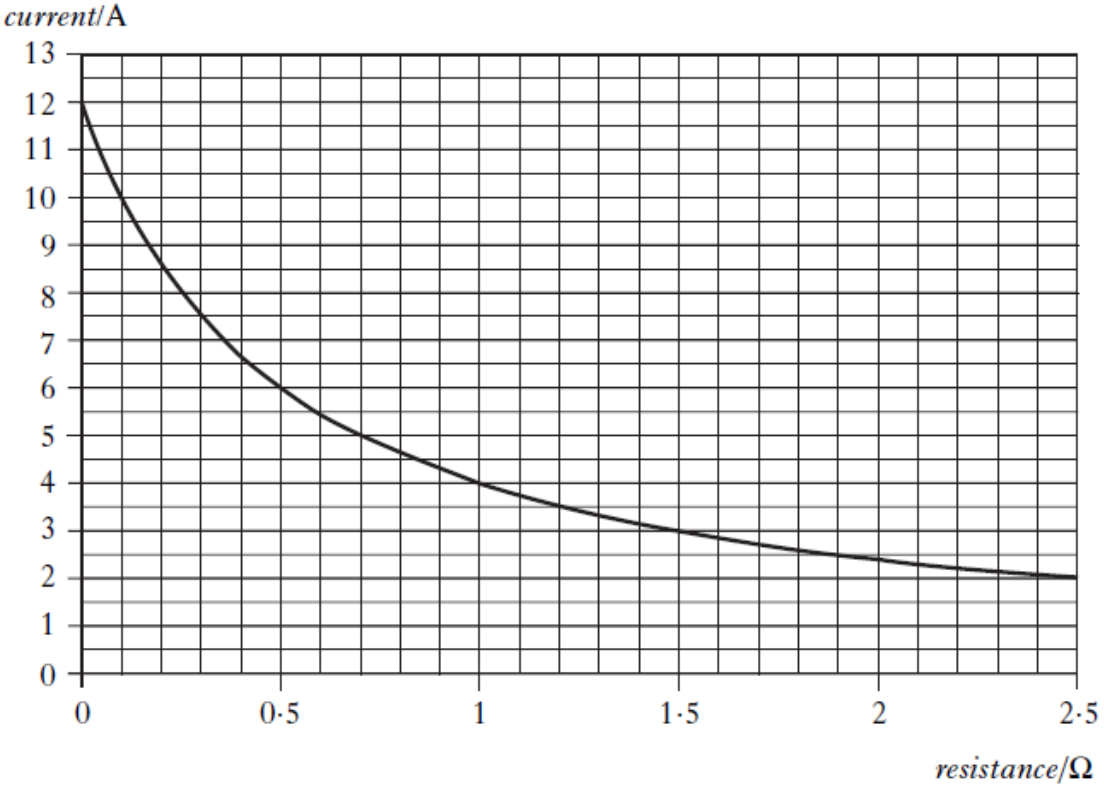


(*a*) Use information from the graph to calculate:

(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**

30 marks

Exercise 15 - Capacitance

Past Paper Homework Questions

1. The unit for capacitance can be written as

A $V C^{-1}$

B $C V^{-1}$

C $J s^{-1}$

D $C J^{-1}$

E $J C^{-1}$.

2. 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 and III only

C II and III only

D II, III and IV only

E III and IV only

3. A student makes the following statements about capacitors.

I Capacitors block a.c. signals.

II Capacitors store energy.

III Capacitors store charge.

Which of these statements is/are true?

A I only

B I and II only

C I and III only

D II and III only

E I, II and III

4. A $25{\cdot}0\,\mu F$ 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 $2{\cdot}00 \times 10^{7}\,C$.

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

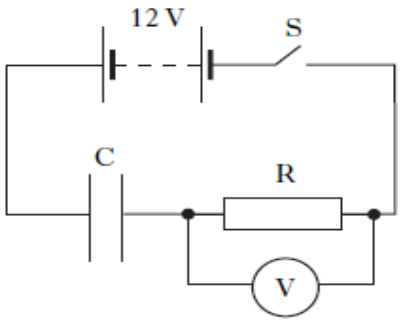
potential difference across capacitor $= (10{\cdot}0 \pm 0{\cdot}1)\,V$

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?

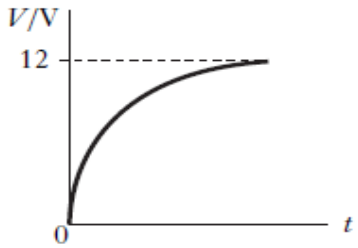
	Capacitance/μF	*Percentage uncertainty*
A	0·02	1
B	0·02	5
C	50	1
D	50	5
E	5000	6

6. A circuit is set up as shown.

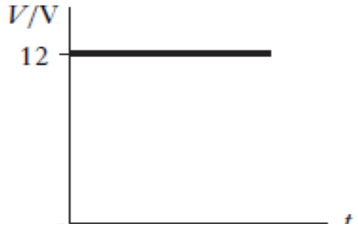


The capacitor is initially uncharged. Switch S is now closed. Which graph shows how the potential difference, V, across R, varies with time, t?

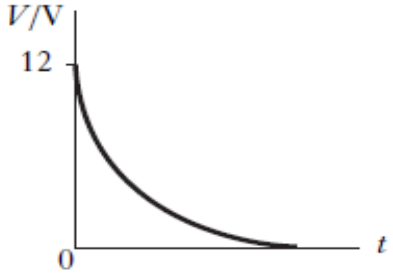
A



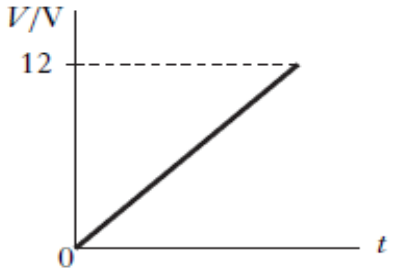
B



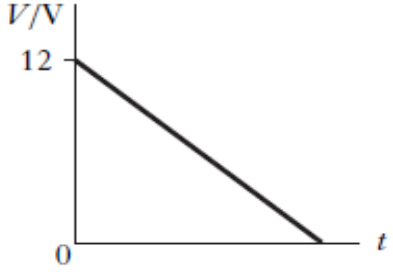
C



D



E



7. 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.

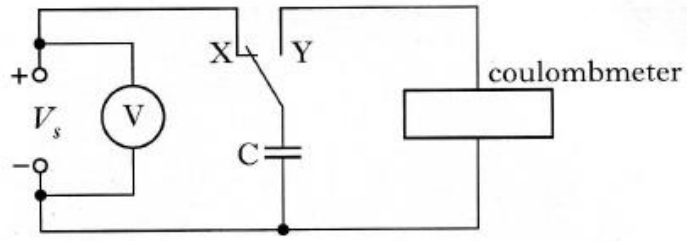
8. The capacitance of a capacitor is 1000 μF. The potential difference (p.d.) across the capacitor is 100 V. The charge stored by the capacitor is 0·10 C.

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.

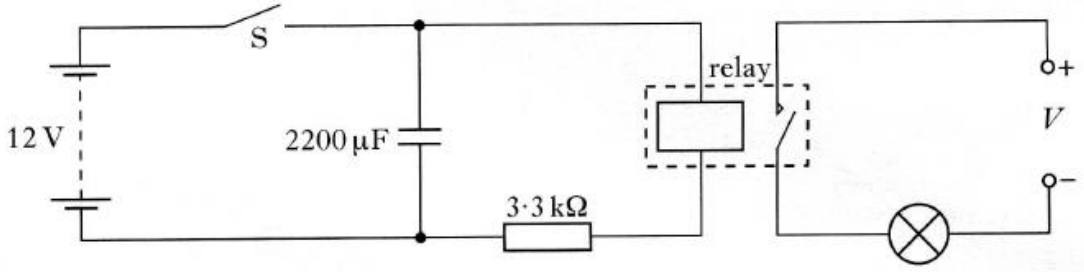
The student records the following measurements and uncertainties.

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**

(*b*) The student designs the circuit shown below to switch off a lamp after a certain time.



The 12 V battery has negligible internal resistance.

The relay contacts are normally open. When there is a current in the relay coil the contacts close and complete the lamp circuit.

Switch S is initially closed and the lamp is on.

(i) What is the maximum energy stored in the capacitor?

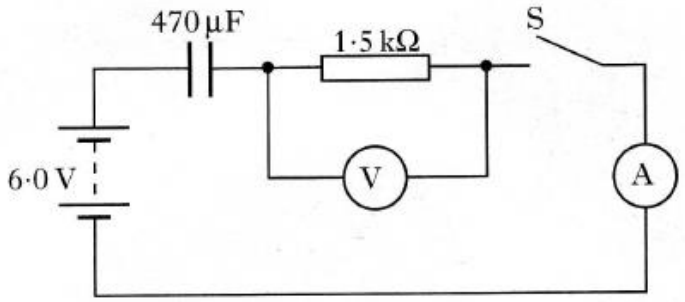
(ii) (A) Switch S is now opened. Explain why the lamp stays lit for a few seconds.

(B) The 2200 μF capacitor is replaced with a 1000 μF capacitor.

Describe and explain the effect of this change on the operation of the circuit. **6**

(9)

10. (*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.

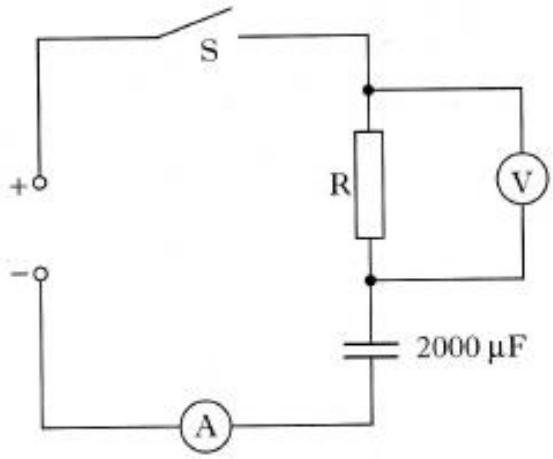
When the flash is fired, $6{\cdot}35 \times 10^{-3}$ J of the stored energy is emitted as light.

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

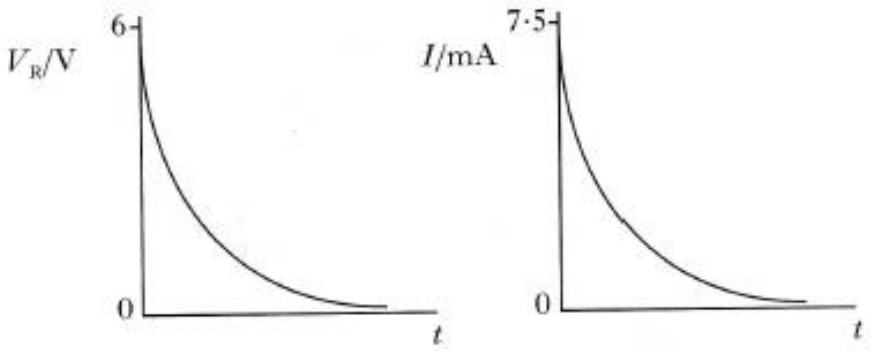
Calculate the number of photons emitted in each flash of light. **3**

(8)

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



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**

30 marks

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

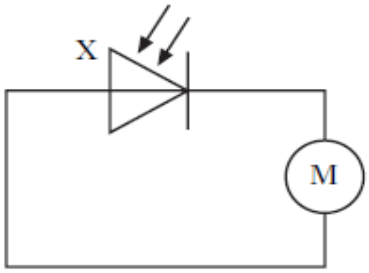
B II only

C III only

D I and II only

E I and III only

2. In the following circuit, component X is used to drive a motor.



Which of the following gives the name of component X and its mode of operation?

	Name of component X	*Mode of operation*
A	light-emitting diode	photoconductive
B	light-emitting diode	photovoltaic
C	photodiode	photoconductive
D	photodiode	photovoltaic
E	op-amp	inverting

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.

4. The letters **X**, **Y** and **Z** represent three missing words from the following passage.

Materials can be divided into three broad categories according to their electrical resistance.

*.....**X**..... have a very high resistance.*

*.....**Y**..... have a high resistance in their pure form but when small amounts of certain impurities are added, the resistance decreases.*

*.....**Z**..... have a low resistance.*

Which row in the table shows the missing words?

	X	**Y**	**Z**
A	conductors	insulators	semi-conductors
B	semi-conductors	insulators	conductors
C	insulators	semi-conductors	conductors
D	conductors	semi-conductors	insulators
E	insulators	conductors	semi-conductors

5. 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

6. 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.

7. In an n-type semiconductor

A the majority charge carriers are electrons

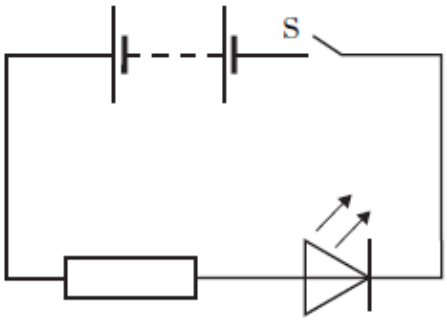
B the majority charge carriers are holes

C the majority charge carriers are protons

D there are more protons than electrons

E there are more electrons than protons.

8. 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.

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

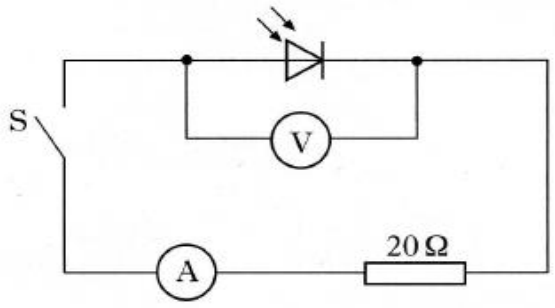
B a MOSFET

C a photodiode

D a laser

E an LED.

10. 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.

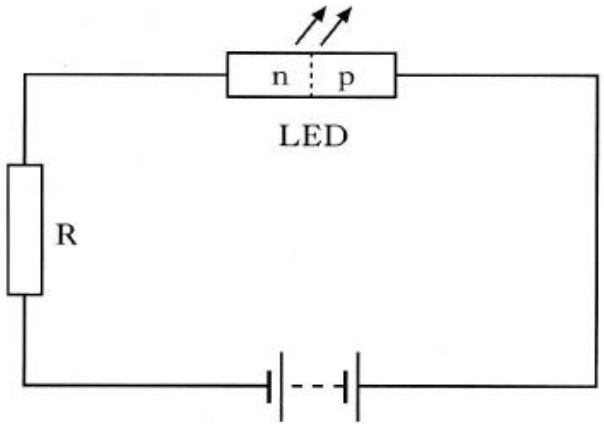
(ii) Describe the effect of light on the material of which the photodiode is made.

(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.

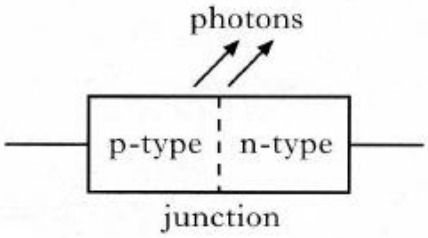
How does this addition affect the resistance of the semiconducting material? **1**

(*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. 2

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

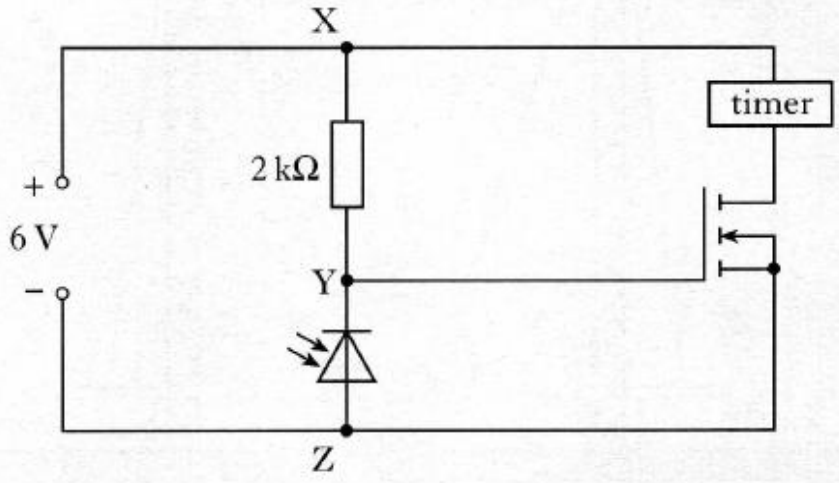


(*a*) Copy the diagram and add a battery so that the p-n junction is forward-biased. **1**

(*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.

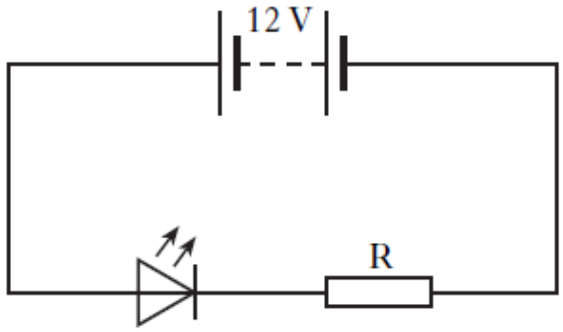


(i) In which mode is the photodiode operating? **1**

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

15. The brake lights of the car consist of a number of very bright LEDs.

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**

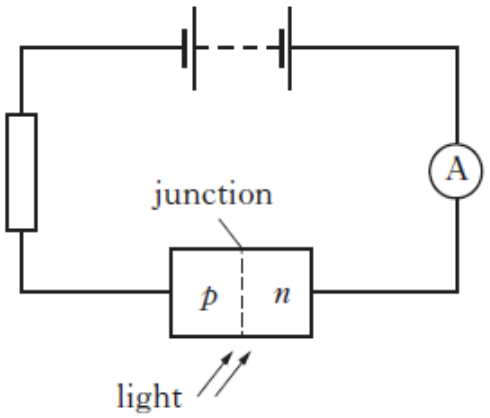
(ii) The LED is operating at its rated values of 5·0 V and 2·2 W.

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

16. (*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?

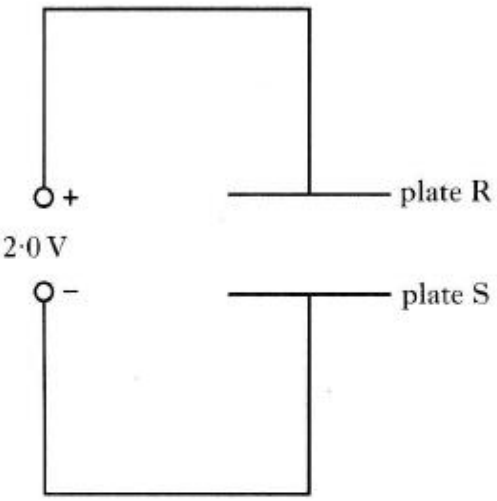
2

30 marks

Exercise 11- Standard Model and Forces on Charged Particles

Past Paper Homework Questions

1. Two parallel metal plates, R and S, are connected to a 2·0 V d.c. supply as shown.



An electron is moved from plate R to plate S.

The gain in electrical potential energy of the electron is

A $8{\cdot}0 \times 10^{-20}$ J

B $1{\cdot}6 \times 10^{-19}$ J

C $3{\cdot}2 \times 10^{-19}$ J

D $6{\cdot}4 \times 10^{-19}$ J

E $1{\cdot}3 \times 10^{-19}$ J.

2. An electron is accelerated from rest through a potential difference of 2·0 kV.

The kinetic energy gained by the electron is

A $8{\cdot}0 \times 10^{-23}$ J

B $8{\cdot}0 \times 10^{-20}$ J

C $3{\cdot}2 \times 10^{-19}$ J

D $1{\cdot}6 \times 10^{-16}$ J

E $3{\cdot}2 \times 10^{-16}$ J.

3. A student writes the following statements about electric fields.

I There is a force on a charge in an electric field.

II When an electric field is applied to a conductor, the free electric charges in the conductor move.

III Work is done when a charge is moved in an electric field.

Which of the above statements is/are correct?

A I only

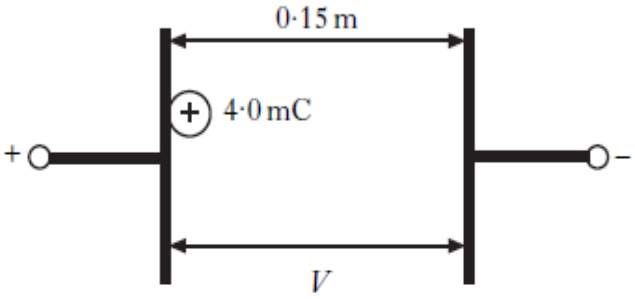
B II only

C I and II only

D I and III only

E I, II and III

4. A potential difference, V, is applied between two metal plates. The plates are 0·15 m apart. A charge of +4·0 mC is released from rest at the positively charged plate as shown.



The kinetic energy of the charge just before it hits the negative plate is 8·0 J.

The potential difference between the plates is

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

B 1·2 V

C 2·0 V

D $2{\cdot}0 \times 10^{3}$ V

E $4{\cdot}0 \times 10^{3}$ V.

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.

6. A student writes the following statements about electric fields.

I There is a force on a charge in an electric field.

II When an electric field is applied to a conductor, the free electric charges in the conductor move.

III Work is done when a charge is moved in an electric field.

Which of the statements is/are correct?

A I only

B II only

C I and II only

D I and III only

E I, II and III

7. One volt is equivalent to one

A farad per coulomb

B ampere per ohm

C joule per ampere

D joule per ohm

E joule per coulomb.

8. The letters **X**, **Y** and **Z** represent the missing words from the following passage.

There are four fundamental forces.

*Gravity and the electromagnetic force act over a …***X**… *range.*

*The strong and weak force act over a …***Y**… range.

*The …***Z**… *force is responsible for beta decay.*

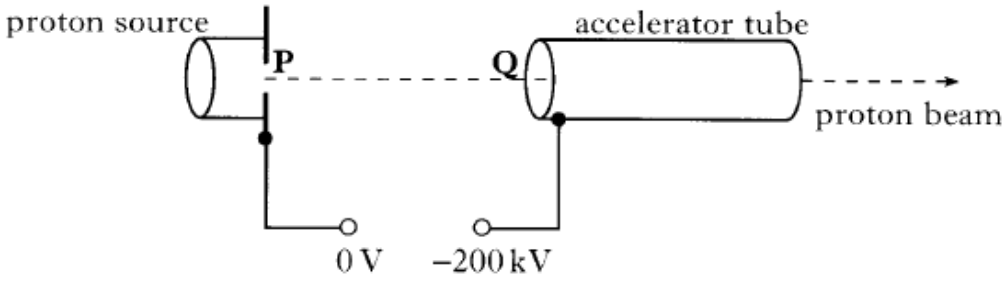
Which row in the table identifies the missing words represented by the letters **X**, **Y** and **Z**?

	X	**Y**	**Z**
A	short	long	strong
B	long	short	strong
C	long	short	weak
D	long	long	electromagnetic
E	short	long	weak

9. Which row in the table shows an example of a hadron, lepton and boson?

	Hadron	*Lepton*	*Boson*
A	neutron	photon	electron
B	electron	neutron	photon
C	photon	electron	neutron
D	neutron	electron	photon
E	electron	photon	neutron

10. The diagram below shows the basic features of a proton accelerator. It is enclosed in an evacuated container.



Protons released from the proton source start from rest at **P**.
A potential difference of 200 kV is maintained between **P** and **Q**.

(*a*) What is meant by the term *potential difference of 200 kV*? **1**

(*b*) Explain why protons released at **P** are accelerated towards **Q**. **1**

(*c*) Calculate:

(i) the work done on a proton as it accelerates from **P** to **Q**; **2**

(ii) the speed of a proton as it reaches **Q**. **2**

(*d*) The distance between **P** and **Q** is now halved.

What effect, if any, does this change have on the speed of a proton as it reaches **Q**? Justify your answer. **2**

(8)

11. (*a*) A conversation is overheard between two young pupils who are discussing their science lessons.

Pupil A *"We learned in science today that the nucleus of an atom is made of protons which are positively charged and neutrons which have no charge."*

Pupil B *"That's interesting because we learned in science that like charges repel. How come the protons in the nucleus don't fly apart?"*

Pupil A *"I don't know."*

Write a paragraph that would explain to the pupils why the protons in a nucleus do not fly apart. **3**

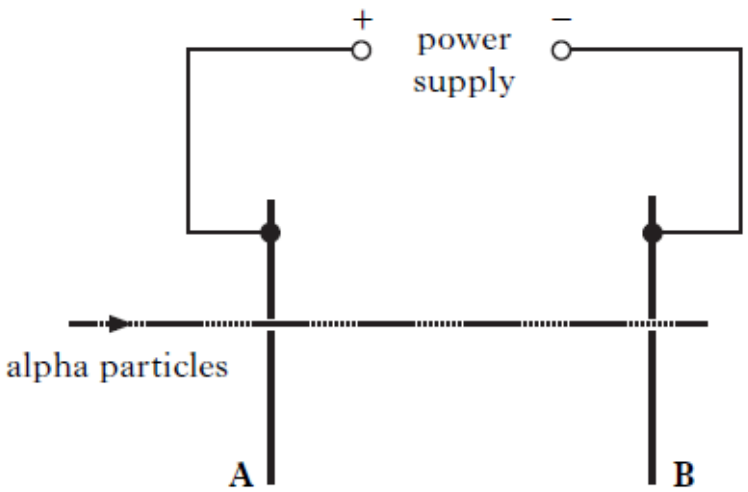
(*b*) Protons and neutrons each contain two different types of quark: the up quark which has an electric charge of $+\frac{2}{3}$ and the down quark which has an electric charge of $-\frac{1}{3}$.

Use this information to show:

(i) the overall charge on the proton is +1;

(ii) the overall charge on the neutron is zero. **2**

12. The apparatus shown in the diagram is designed to accelerate alpha particles.



An alpha particle travelling at a speed of $2{\cdot}60 \times 10^{6}\,\text{m s}^{-1}$ passes through a hole in plate A. The mass of an alpha particle is $6{\cdot}64 \times 10^{-27}\,\text{kg}$ and its charge is $3{\cdot}2 \times 10^{-19}\,\text{C}$.

(*a*) When the alpha particle reaches plate B, its kinetic energy has increased to $3{\cdot}05 \times 10^{-14}\,\text{J}$.

Show that the work done on the alpha particle as it moves from plate A to plate B is $8{\cdot}1 \times 10^{-15}\,\text{J}$. **2**

(*b*) Calculate the potential difference between plates A and B. **2**

(*c*) The apparatus is now adapted to accelerate **electrons** from A to B through the same potential difference.

How does the increase in the kinetic energy of an electron compare with the increase in kinetic energy of the alpha particle in part (*a*)?

Justify your answer. **2**

(6)

13. (*a*) A conversation is overheard between two young pupils who are discussing their science lessons.

Pupil A *"We learned in science today that the nucleus of an atom is made of protons which are positively charged and neutrons which have no charge."*

Pupil B *"That's interesting because we learned in science that like charges repel. How come the protons in the nucleus don't fly apart?"*

Pupil A *"I don't know."*

Write a paragraph that would explain to the pupils why the protons in a nucleus do not fly apart. **3**

(*b*) Protons and neutrons each contain two different types of quark: the up quark which has an electric charge of $+\frac{2}{3}$ and the down quark which has an electric charge of $-\frac{1}{3}$.

Use this information to show:

(i) the overall charge on the proton is +1;

(ii) the overall charge on the neutron is zero. **2**

Exercise 12- Nuclear Reactions

Past Paper Homework Questions

1. The statement below represents a nuclear reaction.

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{92}_{36}\text{Kr} + ^{141}_{56}\text{Ba} + ^{1}_{0}\text{n} + ^{1}_{0}\text{n} + ^{1}_{0}\text{n}$$

This is an example of

A nuclear fusion

B alpha particle emission

C beta particle emission

D spontaneous nuclear fission

E induced nuclear fission.

2. Which row of the table shows the correct values of x, y and z for the nuclear reaction described below?

$$^{214}_{x}\text{Pb} \rightarrow ^{y}_{83}\text{Bi} + ^{0}_{z}\text{e}$$

	x	y	z
A	84	214	1
B	83	210	4
C	85	214	2
D	82	214	−1
E	82	210	−1

3. Under certain conditions, a nucleus of nitrogen absorbs an alpha particle to form the nucleus of another element and releases a single particle.

Which one of the following statements correctly describes this process?

A $^{14}_{7}\text{N} + ^{3}_{2}\text{He} \rightarrow ^{16}_{9}\text{F} + ^{1}_{0}\text{n}$

B $^{14}_{7}\text{N} + ^{4}_{2}\text{He} \rightarrow ^{17}_{10}\text{Ne} + ^{0}_{-1}\text{e}$

C $^{14}_{7}\text{N} + ^{3}_{2}\text{He} \rightarrow ^{16}_{8}\text{O} + ^{1}_{1}\text{p}$

D $^{14}_{7}\text{N} + ^{4}_{2}\text{He} \rightarrow ^{18}_{9}\text{F} + 2\,^{0}_{-1}\text{e}$

E $^{14}_{7}\text{N} + ^{4}_{2}\text{He} \rightarrow ^{17}_{8}\text{O} + ^{1}_{1}\text{p}$

4. Which of the following statements describes nuclear fission?

A A nucleus of large mass number splits into two nuclei, releasing several neutrons.

B A nucleus of large mass number splits into two nuclei, releasing several electrons.

C A nucleus of large mass number splits into two nuclei, releasing several protons.

D Two nuclei combine to form one nucleus, releasing several electrons.

E Two nuclei combine to form one nucleus, releasing several neutrons.

5. A series of radioactive decays starts from the isotope Uranium 238.

Two alpha particles and two beta particles are emitted during the decays.

Which row in the table gives the mass number and the atomic number of the resulting nucleus?

	Mass number	*Atomic number*
A	232	88
B	230	86
C	230	90
D	246	94
E	246	98

6. The following statement describes a fusion reaction.

$$^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \longrightarrow {}^{3}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n} + \text{energy}$$

The total mass of the particles before the reaction is $6{\cdot}684 \times 10^{-27}$ kg.

The total mass of the particles after the reaction is $6{\cdot}680 \times 10^{-27}$ kg.

The energy released in this reaction is

A $6{\cdot}012 \times 10^{-10}$ J

B $6{\cdot}016 \times 10^{-10}$ J

C $1{\cdot}800 \times 10^{-13}$ J

D $3{\cdot}600 \times 10^{-13}$ J

E $1{\cdot}200 \times 10^{-21}$ J.

7. Compared with a proton, an alpha particle has

A twice the mass and twice the charge

B twice the mass and the same charge

C four times the mass and twice the charge

D four times the mass and the same charge

E twice the mass and four times the charge.

8. For the nuclear decay shown, which row of the table gives the correct values of x, y and z?

$$^{214}_{x}\mathrm{Pb} \longrightarrow {}^{y}_{83}\mathrm{Bi} + {}^{0}_{z}\mathrm{e}$$

	x	y	z
A	85	214	2
B	84	214	1
C	83	210	4
D	82	214	–1
E	82	210	–1

9. Radium (Ra) decays to radon (Rn) by the emission of an alpha particle.
Some energy is also released by this decay.
The decay is represented by the statement shown below.

$$^{226}_{88}\text{Ra} \longrightarrow {}^{x}_{y}\text{Rn} + {}^{4}_{2}\text{He}$$

The masses of the nuclides involved are as follows.

Mass of $^{226}_{88}\text{Ra} = 3{\cdot}75428 \times 10^{-25}\,\text{kg}$

Mass of $^{x}_{y}\text{Rn} = 3{\cdot}68771 \times 10^{-25}\,\text{kg}$

Mass of $^{4}_{2}\text{He} = 6{\cdot}64832 \times 10^{-27}\,\text{kg}$

(*a*) (i) What are the values of x and y for the nuclide $^{x}_{y}\text{Rn}$?

(ii) Why is energy released by this decay?

(iii) Calculate the energy released by one decay of this type. **5**

(*b*) The alpha particle leaves the radium nucleus with a speed of $1{\cdot}5 \times 10^{7}\,\text{m s}^{-1}$.

The alpha particle is now accelerated through a potential difference of 25 kV.

Calculate the **final** kinetic energy, in joules, of the alpha particle. **3**

10. (*a*) The following statement represents a nuclear reaction.

$$^{239}_{94}\text{Pu} + {}^{1}_{0}\text{n} \longrightarrow {}^{137}_{52}\text{Te} + {}^{100}_{42}\text{Mo} + 3\,{}^{1}_{0}\text{n} + \text{energy}$$

The total mass of the particles before the reaction is $3{\cdot}9842 \times 10^{-27}\,\text{kg}$ and the total mass of the particles after the reaction is $3{\cdot}9825 \times 10^{-27}\,\text{kg}$.

(i) State and explain whether this reaction is spontaneous or induced.

(ii) Calculate the energy, in joules, released by this reaction. **3**

11. (*a*) Torbernite is a mineral which contains uranium.

The activity of 1·0 kg of pure torbernite is $5{\cdot}9 \times 10^6$ decays per second.

A sample of material of mass 0·6 kg contains 40% torbernite. The remaining 60% of the material is not radioactive.

What is the activity of the sample in becquerels? **2**

12. A technician is studying samples of radioactive substances.

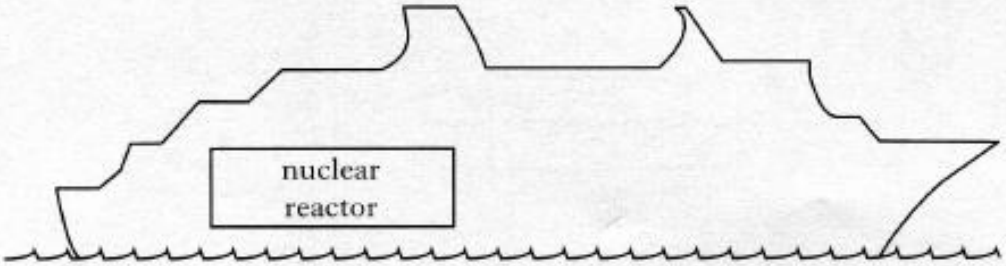
(*a*) The following statement describes a nuclear decay in one of the samples used by the technician.

$$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$$

(i) What type of particle is emitted during this decay?

(ii) In this sample $7{\cdot}2 \times 10^5$ nuclei decay in two minutes.
Calculate the average activity of the sample during this time. **3**

13. A ship is powered by a nuclear reactor.



One reaction that takes place in the core of the nuclear reactor is represented by the statement below.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{140}_{58}\mathrm{Ce} + {}^{94}_{40}\mathrm{Zr} + 2\,{}^{1}_{0}\mathrm{n} + 6\,{}^{0}_{-1}\mathrm{e}$$

(*a*) The symbol for the Uranium nucleus is $^{235}_{92}\mathrm{U}$.

What information about the nucleus is provided by the following numbers?

(i) 92

(ii) 235 **2**

(*b*) Describe how neutrons produced during the reaction can cause further nuclear reactions. **1**

(*c*) The masses of particles involved in the reaction are shown in the table.

Particles	*Mass*/kg
$^{235}_{92}\mathrm{U}$	$390{\cdot}173 \times 10^{-27}$
$^{140}_{58}\mathrm{Ce}$	$232{\cdot}242 \times 10^{-27}$
$^{94}_{40}\mathrm{Zr}$	$155{\cdot}884 \times 10^{-27}$
$^{1}_{0}\mathrm{n}$	$1{\cdot}675 \times 10^{-27}$
$^{0}_{-1}\mathrm{e}$	negligible

Calculate the energy released in the reaction. **3**

(6)