National 5 Physics

Electricity and Energy

Questions by Topic

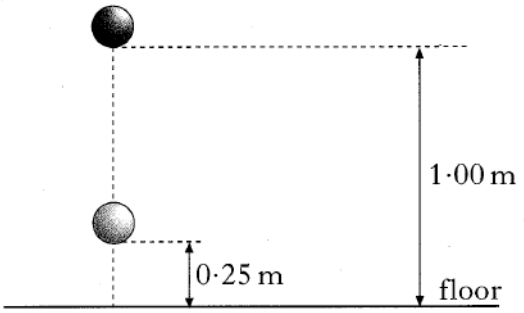
Based on Past SQA Papers 2000 - 2008

Contents

Conservation of Energy

2002 Int 2

4. A ball of mass 0·50 kg is released from a height of 1·00 m.



When the ball is 0·25 m from the floor, the gravitational potential energy and the kinetic energy of the ball are

	Gravitational potential energy (J)	*Kinetic energy* (J)
A	0·125	0·125
B	1·25	1·25
C	1·25	3·75
D	3·75	1·25
E	5·00	1·25

2003 Int 2

3. A man of mass 80 kg dives from a diving board which is 10 m above water. Neglecting air friction, the kinetic energy of the diver immediately before he hits the water is

A 14 J

B 800 J

C 1200 J

D 4000 J

E 8000 J.

5. Which of the following could be the unit of kinetic energy?

A $\mathrm{N\,m^2}$

B $\mathrm{N\,m/s}$

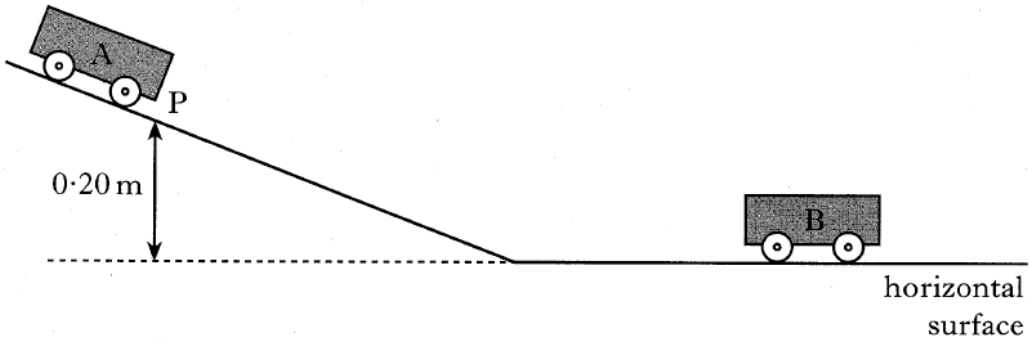
C $\mathrm{kg\,m/s}$

D $\mathrm{N/kg}$

E $\mathrm{kg\,m^2/s^2}$

2004 Int 2

21. A cart A of mass 1·2 kg is held at point P on a slope. P is 0·20 m above a horizontal surface. A second cart B of mass 2·8 kg is placed close to the bottom of the slope as shown.



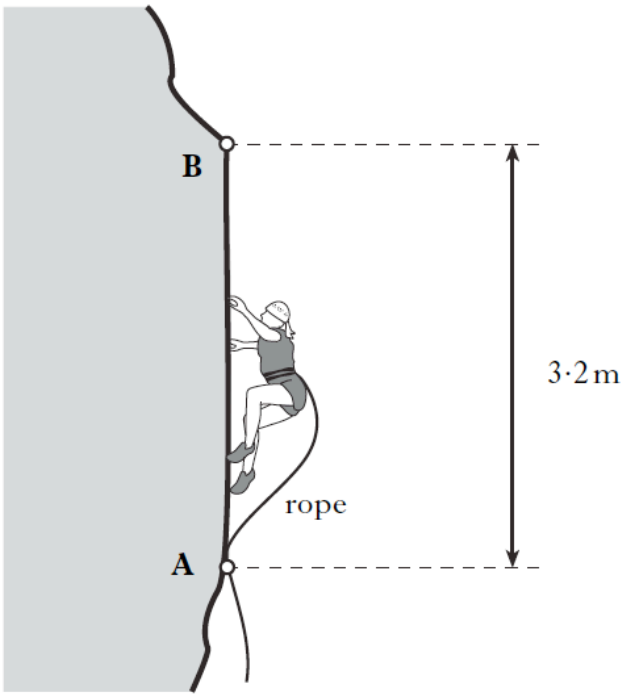
Cart A is released, runs down the slope and collides with cart B. The carts stick together and move off along the horizontal surface.

(*a*) Calculate the change in gravitational potential energy of cart A from point P to the bottom of the slope. **2**

(*b*) Assuming no energy losses, show that the speed of cart A at the bottom of the slope is 2·0 m/s. **2**

2007 Int 2

21. A climber of mass 60 kg is attached by a rope to point A on a rock face. She climbs up to point B in 20 seconds. Point B is 3·2 m vertically above point A.



(*a*) (i) Calculate the average speed of the climber between A and B. **2**

(ii) Calculate the weight of the climber. **2**

(iii) Calculate her gain in potential energy. **2**

(*b*) She then loses her footing and free falls from point B. After passing point A she is held safely by the rope.

(i) Calculate her speed as she passes point A. **2**

(ii) How would her actual speed when passing point A compare with the speed calculated in (*b*) (i)?

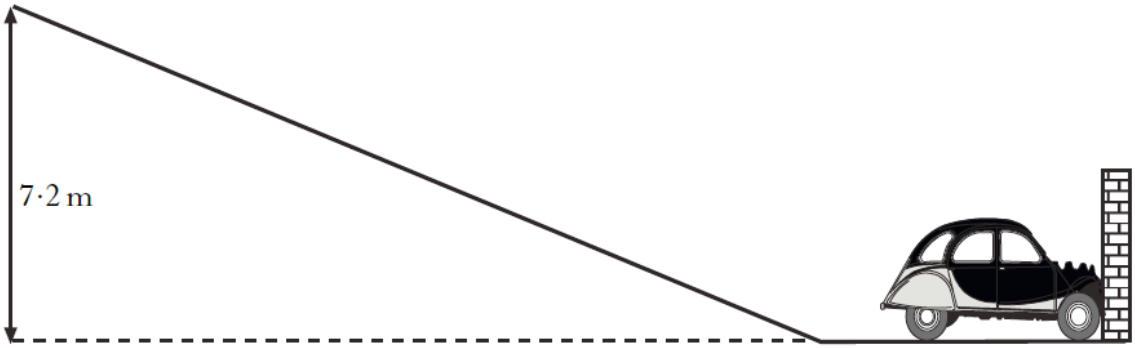
You **must** explain your answer. **2**

(10)

2008 Int 2

24. An early method of crash testing involved a car rolling down a slope and colliding with a wall.

In one test, a car of mass 750 kg starts at the top of a 7·2 m high slope.



(*a*) Calculate the gravitional potential energy of the car at the top of the slope. **2**

(*b*) (i) State the value of the kinetic energy of the car at the bottom of the slope, assuming no energy losses. **1**

(ii) Calculate the speed of the car at the bottom of the slope, before hitting the wall. **2**

(5)

Electrical Charge Carriers and Electric Fields

2002 Int 2

11. A kettle is rated at 230 V, 2300 W.

The charge passing through the element of the kettle in 200 s is

A 20 C

B 2000 C

C 46 000 C

D 460 000 C

E 529 000 C.

2005 Int 2

7. An ampere is one

A volt per joule

B joule per second

C joule per coulomb

D coulomb per second

E ohm per volt.

9. The charge passing a point in a conductor when a current of 4 mA flows for 1000 s is

A 0·25 C

B 0·4 C

C 4 C

D 250 C

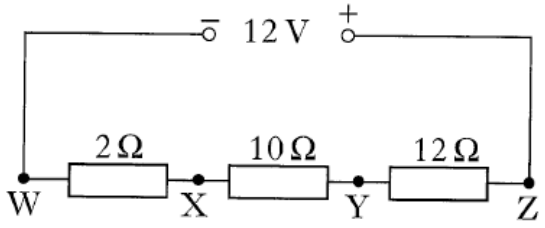
E 4000 C.

26. (*a*) Explain the difference between direct current (d.c.) and alternating current (a.c.) in terms of the movement of charges in a conductor. **2**

Potential Difference (Voltage)

2001 Int 2

9. A circuit is set up as shown below.



The potential difference between X and Y is

A 1·2 V

B 4·0 V

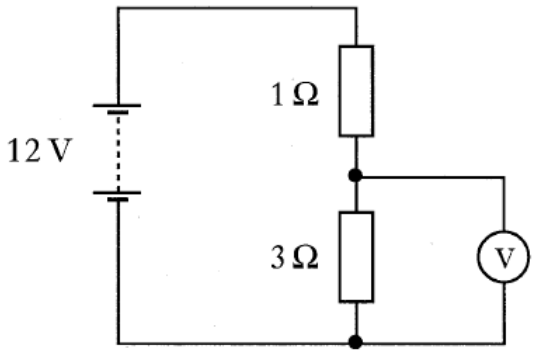
C 5·0 V

D 10·0 V

E 12·0 V.

2004 Int 2

11. Consider the following circuit.



The reading on the voltmeter is

A 3 V

B 4 V

C 8 V

D 9 V

E 12 V.

7. Which of the following statements is/are correct?

I The voltage of a battery is the number of joules of energy it gives to each coulomb of charge.

II A battery only has a voltage when it is connected in a complete circuit.

III Electrons are free to move within an insulator.

A I only

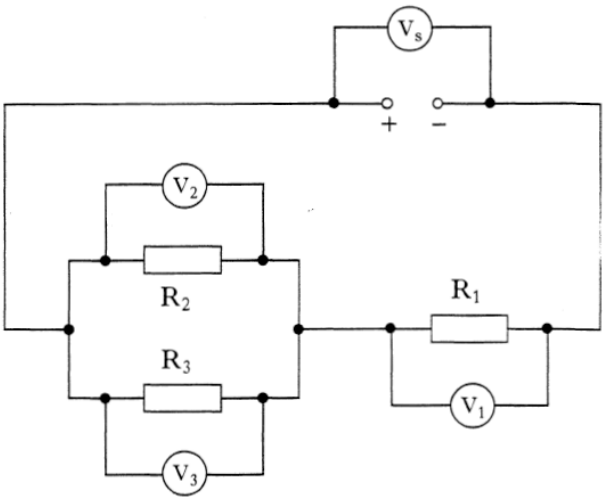
B II only

C III only

D II and III only

E I, II and III

9. A circuit is set up as shown.



Which of the following statements about the readings on the voltmeters **must always** be true?

I $V_1 = V_2$

II $V_2 = V_3$

III $V_s = V_1 + V_2$

A II only

B I and II only

C I and III only

D II and III only

E I, II and III

7. The voltage of an electrical supply is a measure of the

A resistance of the circuit

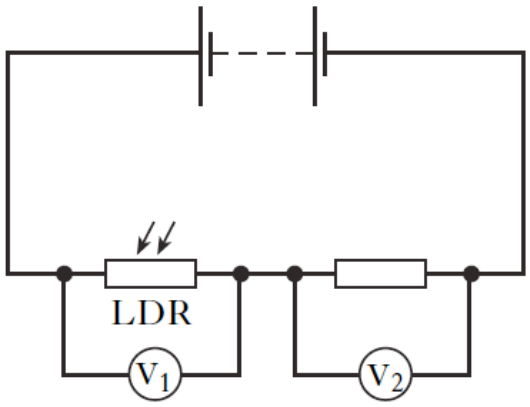
B speed of the charges in the circuit

C energy given to the charges in the circuit

D power developed in the circuit

E current in the circuit.

14. A circuit is set up as shown.



The initial reading on both voltmeters V_1 and V_2 is 2·5 V.

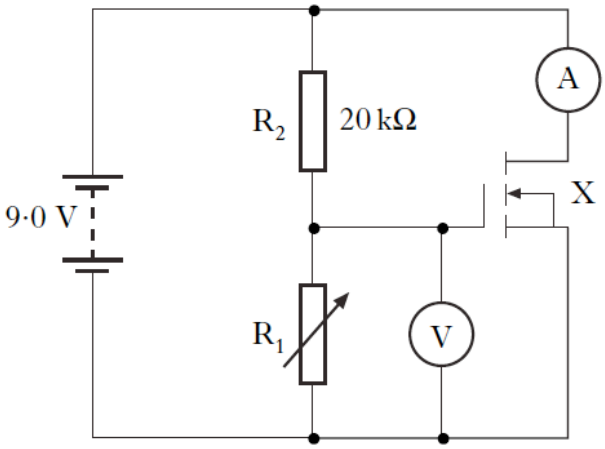
The light shining on the LDR is made brighter.

Which row in the table shows possible new readings on voltmeters V_1 and V_2?

	Reading on V_1 (V)	*Reading on V_2* (V)
A	2·0	3·0
B	2·5	2·0
C	2·5	2·5
D	2·5	3·0
E	3·0	2·0

2000 Int 2

27. The circuit shown below is used to investigate the behaviour of component X.

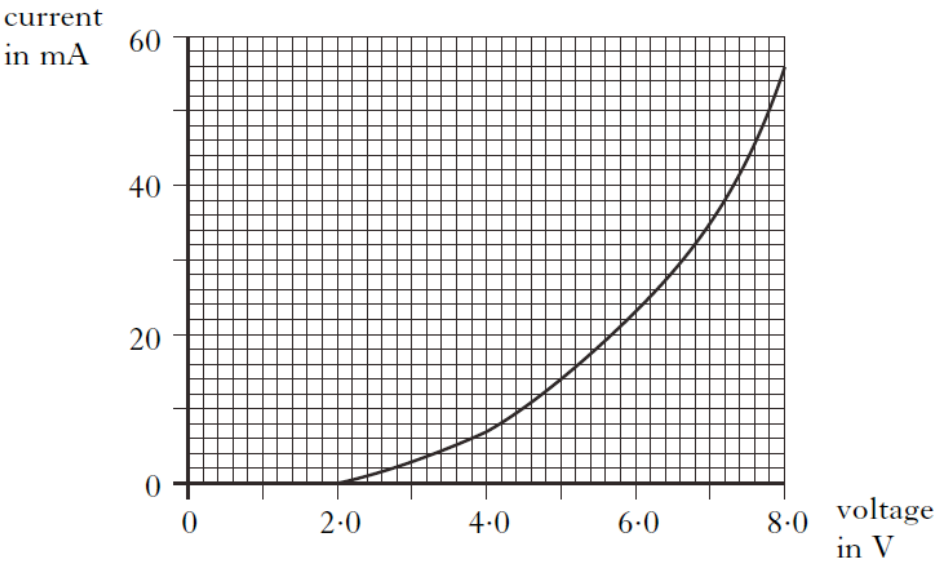


(*a*) (i) What is the name of component X?

(ii) What name is given to the arrangement of the two series resistors R_1 and R_2 connected across the 9·0 V supply? **2**

(*b*) By using different values of resistor R_1, different voltages are applied to the input of X.

The graph below shows how the current through X changes as the voltage applied to the input is altered.

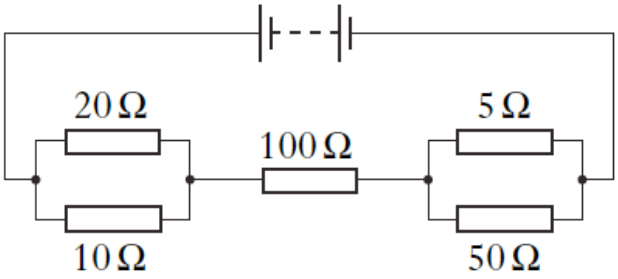


(i) What is the reading on the voltmeter when device X starts to conduct?

(ii) Calculate the value of resistor R_1 which is required to obtain this voltage. **3**

2000 Int 2

11. In the circuit shown below, the current in each resistor is different.



The current is **smallest** in the

A 5 Ω resistor

B 10 Ω resistor

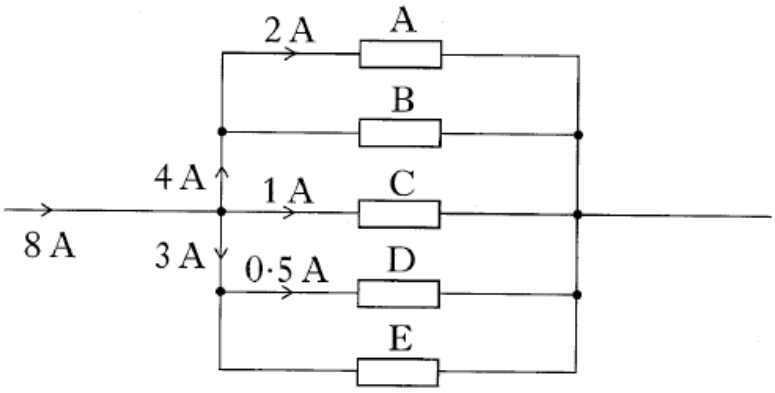
C 20 Ω resistor

D 50 Ω resistor

E 100 Ω resistor.

2001 Int 2

13. Which resistor in the diagram below has the smallest resistance?



14. Which of the following devices converts heat energy into electrical energy?

A Solar cell

B Resistor

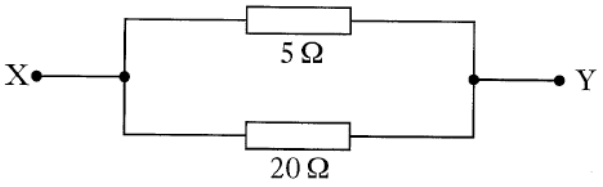
C Thermocouple

D Transformer

E Transistor

2002 Int 2

10. A 5 Ω and a 20 Ω resistor are connected in parallel.



The resistance between X and Y is

A 0·25 Ω

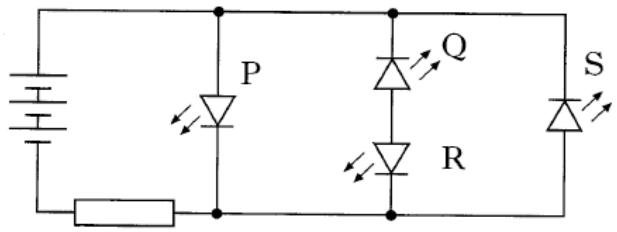
B 4·0 Ω

C 12·5 Ω

D 15 Ω

E 25 Ω.

12. A circuit contains a battery, a resistor and four LEDs P, Q, R and S.



Which LED(s) is/are lit?

A P only

B S only

C P and R only

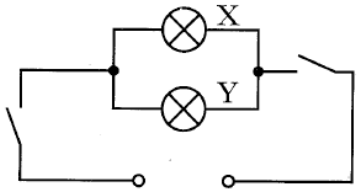
D Q and S only

E P and S only

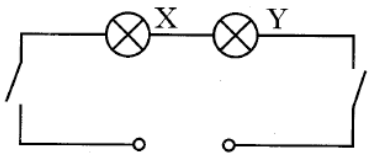
8. A room in a house has two lamps X and Y. With different switch positions, either lamp X or lamp Y or both lamps X and Y can be lit.

Which circuit allows the lamps to operate in this way?

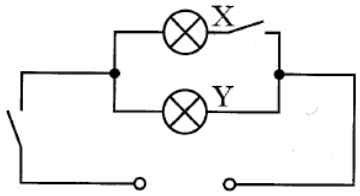
A



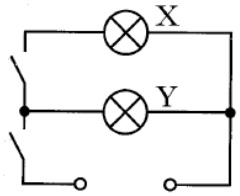
B



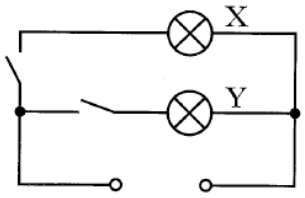
C



D



E

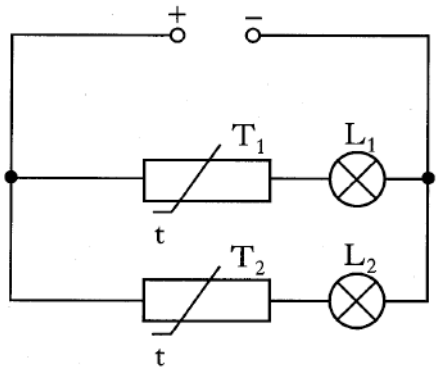


15. Which row in the table correctly shows input and output devices?

	Input device	*Output devices*
A	microphone	loudspeaker LED
B	solar cell	thermocouple LED
C	loudspeaker	microphone relay
D	LED	loudspeaker solar cell
E	thermocouple	microphone LED

2004 Int 2

14. Identical thermistors T_1 and T_2 are connected with lamps L_1 and L_2 as shown.



The resistance of these thermistors falls when their temperature rises.

T_1 is heated, T_2 is not heated.

What happens to the brightness of the lamps?

	Brightness of L_1	*Brightness of L_2*
A	gets dimmer	stays the same
B	stays the same	stays the same
C	gets brighter	gets brighter
D	gets dimmer	gets brighter
E	gets brighter	stays the same

11. Which of the following devices converts electrical energy to kinetic energy?

A Motor

B Lamp

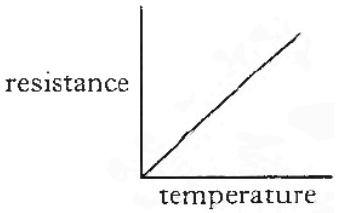
C LED

D LDR

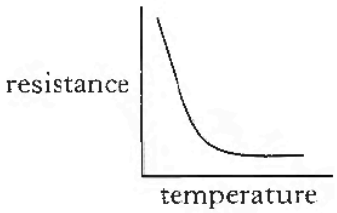
E Microphone

13. Which graph shows how the resistance of most thermistors varies with temperature?

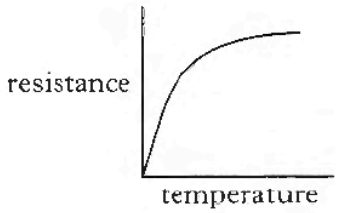
A



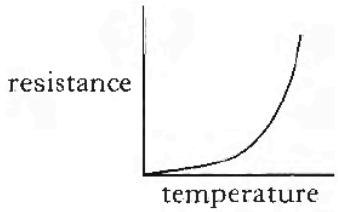
B



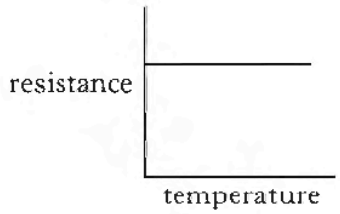
C



D



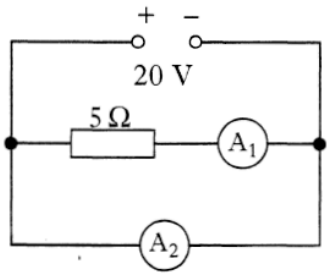
E



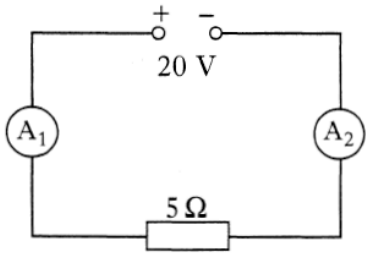
8. A student suspects that ammeter A_1 may be inaccurate. Ammeter A_2 is known to be accurate.

Which of the following circuits should be used to compare A_1 with A_2?

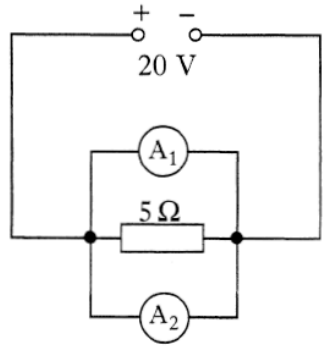
A



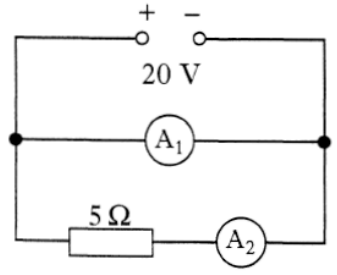
B



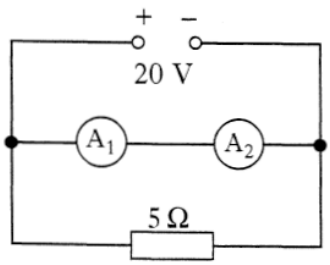
C



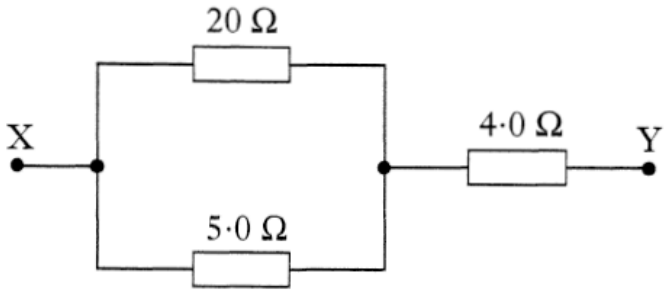
D



E



10. Three resistors are connected as shown.



The resistance between X and Y is

A 0·5 Ω

B 2·0 Ω

C 4·25 Ω

D 8·0 Ω

E 29 Ω.

2008 Int 2

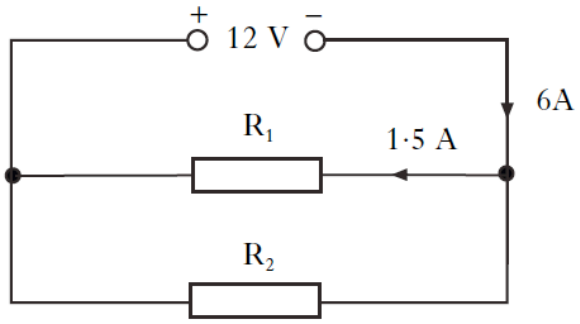
8. Three circuit symbols X, Y and Z are shown.

X Y Z

Which row in the table identifies the symbols X, Y and Z?

	X	Y	Z
A	thermistor	transistor	resistor
B	fuse	variable resistor	thermistor
C	transistor	fuse	variable resistor
D	fuse	variable resistor	resistor
E	variable resistor	resistor	fuse

9. A circuit is set up as shown.

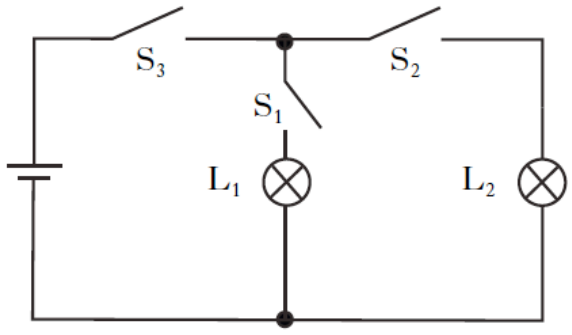


The current from the supply is 6 A.
The current in resistor R_1 is 1·5 A.

Which row in the table shows the potential difference across resistor R_2 and the current in resistor R_2?

	Potential difference across R_2 (V)	*Current in R_2* (A)
A	12	1·5
B	6	1·5
C	12	4·5
D	6	4·5
E	12	7·5

10. A circuit is set up as shown.



Which switch or switches must be closed to light lamp L_1 **only**?

A S_1 only

B S_2 only

C S_1 and S_2 only

D S_1 and S_3 only

E S_2 and S_3 only

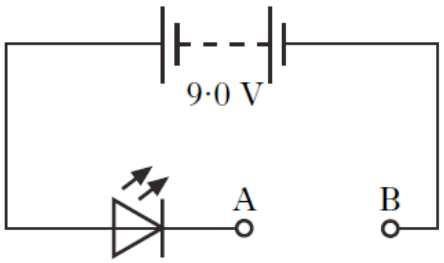
2000 Int 2

26.

(*b*) One design of smoke detector has an LED which lights to show that the battery is in good condition.

A 9·0 V battery is used in the LED circuit shown below.

One component is missing, between A and B.



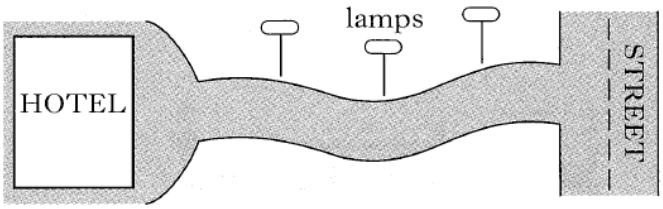
In normal operation, the LED carries a current of 20 mA and the voltage across it is 1·9 V.

(i) What is the name of the component that should be connected between A and B?

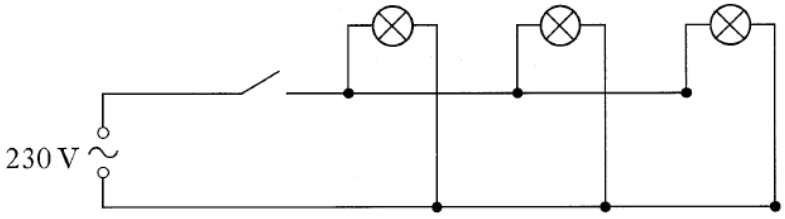
(ii) Calculate the value which this component should have so that the LED operates normally. **4**

2001 Int 2

25. A hotel owner decides to instal three lamps on the drive between the hotel and the street.



The circuit diagram below shows how the lamps are connected to the mains supply.



Each lamp has a rating of 230 V, 200 W.

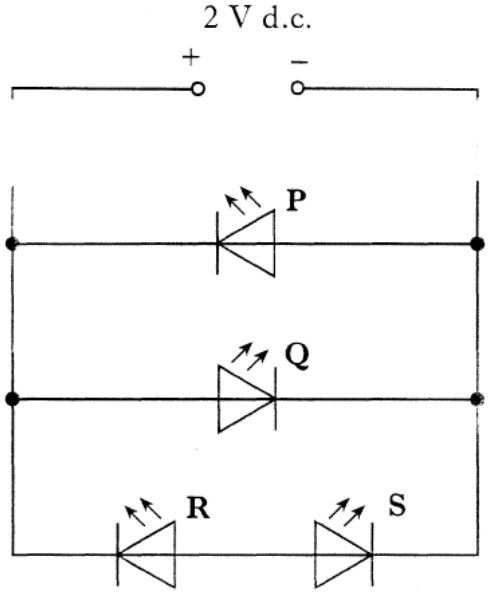
(*a*) Explain why the lamps must be connected in parallel. **1**

(*b*) Calculate the resistance of each lamp. **2**

(*c*) Calculate the current drawn from the supply when all three lamps are operating. **3**

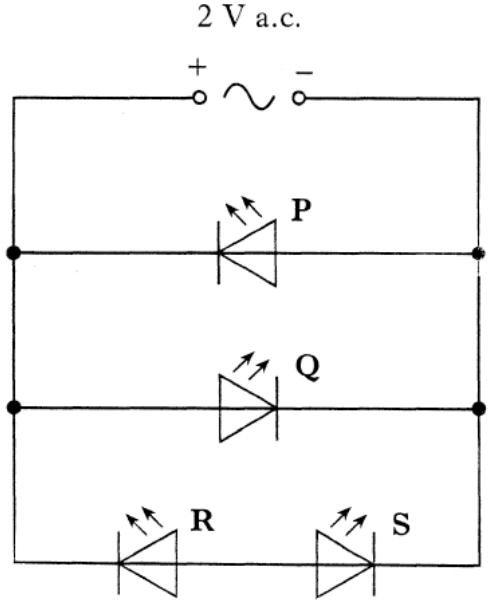
2006 Int 2
26

(*d*) The student now connects some LEDs to a 2 V d.c. supply as shown.



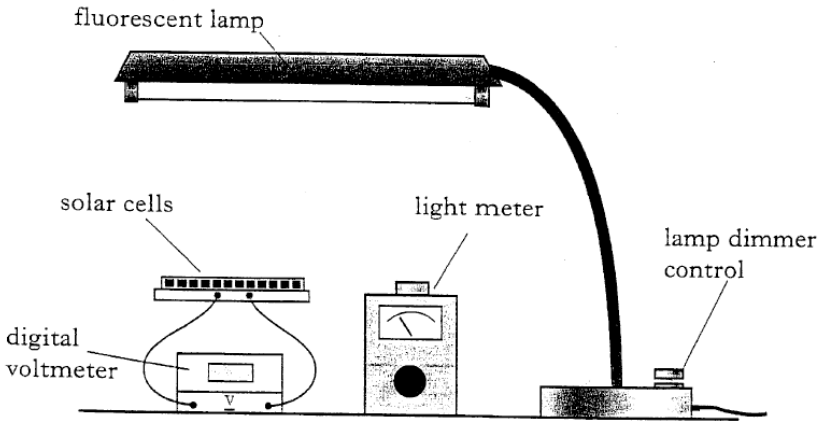
Which of the LEDs P, Q, R and S will light? **1**

(*e*) The student now replaces the 2 V d.c. supply with a 2 V a.c. supply as shown.

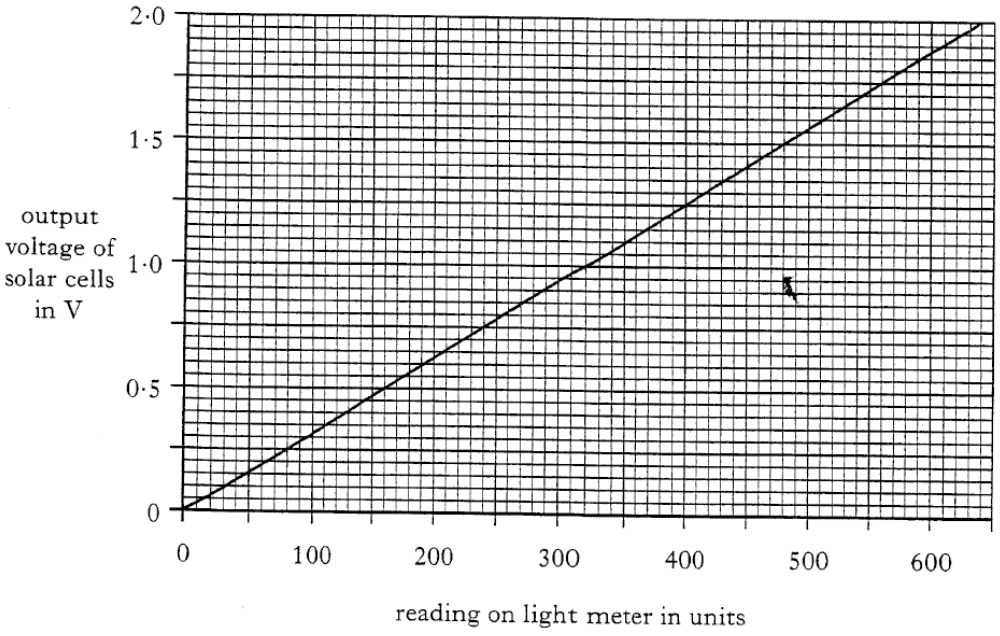


Which LED or LEDs will **now** light? **1**

27. A student investigates solar cells connected in series. She uses a lamp with a dimmer control, a light meter, and a voltmeter as shown.



From her results, the student plots the following graph of the output voltage of the solar cells against the reading shown on the light meter.



(*a*) What reading on the light meter (in units) gives an output voltage of 0·7 V from the cells? **1**

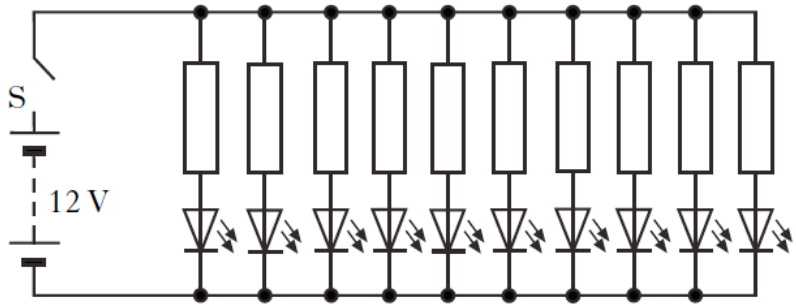
(*b*) Why should the cells be positioned at the same height as the light meter? **1**

(*c*) There are four solar cells connected in series. The circuit symbol for one solar cell is

Sketch a circuit diagram of the solar cells connected to the voltmeter. **1**

28. The rear light of a car is made up of a row of 10 **identical** red LEDs. Each LED requires 2 V and 20 mA to operate correctly.

(*a*) The circuit for this is shown.



(i) Why does each LED need a resistor in series? **1**

(ii) The voltage of the car battery is 12 V.

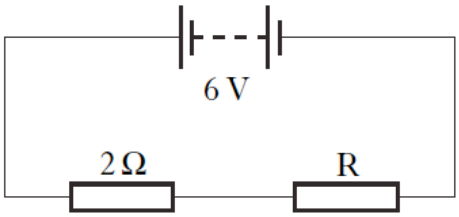
Calculate the value of each resistor. **3**

(iii) Calculate the total current, **in amperes**, from the battery when the rear light is operating correctly. **2**

Ohm's Law

2000 Int 2

10. The circuit diagram shows a 2 Ω resistor and a resistor R of unknown value connected across a 6 V supply.

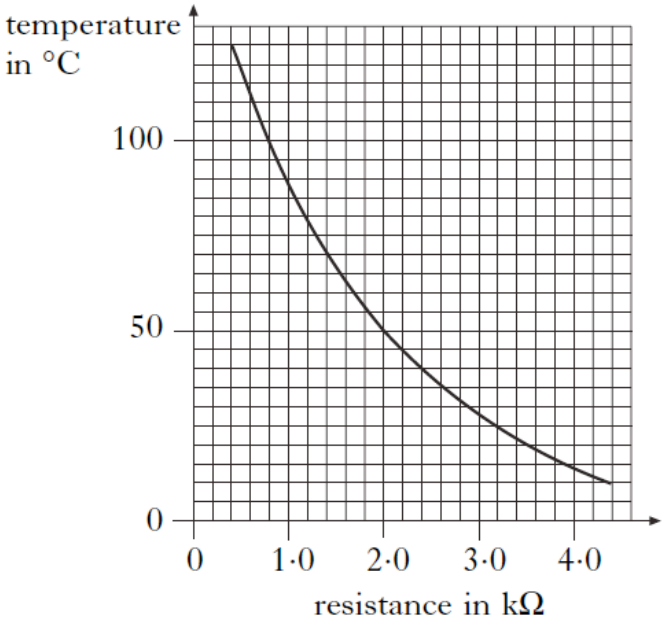


The current in the 2 Ω resistor is 2 A.

Which line correctly shows the voltage across resistor R and the current through R?

	Voltage	*Current*
A	2 V	2 A
B	2 V	4 A
C	4 V	2 A
D	6 V	2 A
E	6 V	4 A

14. The graph below shows how the resistance of a thermistor varies with temperature.



The thermistor is connected in a circuit. At a temperature of 50 °C, the current in the thermistor is 4 mA.

At this temperature the voltage across the thermistor is

A 0·008 V

B 0·5 V

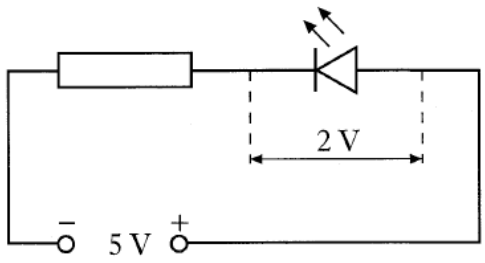
C 2 V

D 8 V

E 8 000 V.

2002 Int 2

15. A resistor and LED are connected in series across a 5 V d.c. supply.



The current in the LED is 20 mA.
The voltage across the LED is 2 V.

The resistance of the resistor is

A 0·10 Ω

B 0·15 Ω

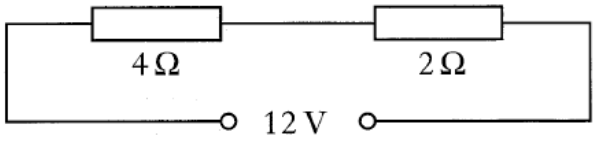
C 100 Ω

D 150 Ω

E 250 Ω.

2003 Int 2

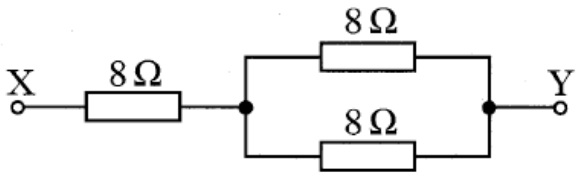
11. Two resistors are connected in series with a 12 volt d.c. supply.



The current in the 2 Ω resistor is 2 A.
Which row of the table gives the current in the 4 Ω resistor and the voltage across the 4 Ω resistor?

	Current in A	*Voltage in* V
A	1	4
B	1	12
C	2	8
D	2	12
E	4	8

8. Three resistors are connected as shown.



The total resistance between X and Y is

A 4 Ω

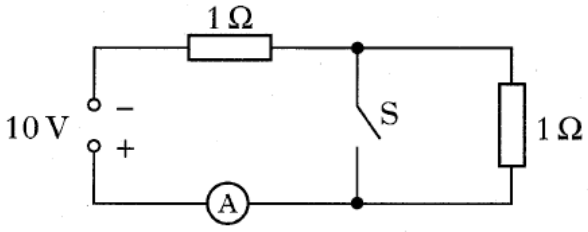
B 8 Ω

C 12 Ω

D 16 Ω

E 24 Ω.

9. In the circuit shown, switch S is initially open.

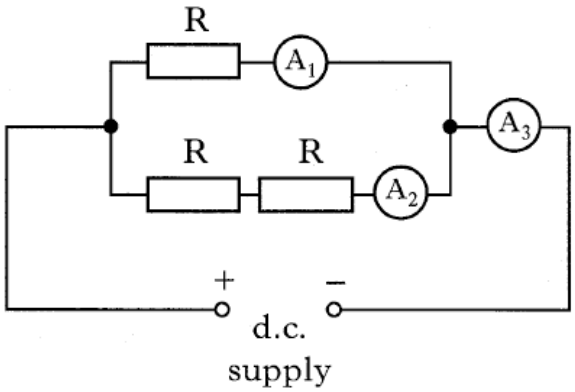


Switch S is now closed.

Which row in the table shows the current with S open and the current with S closed?

	Current with S open	*Current with S closed*
A	0·1 A	0·2 A
B	0·2 A	0·1 A
C	5 A	2·5 A
D	5 A	10 A
E	10 A	5 A

10. Three identical resistors are connected with three ammeters to a d.c. supply as shown.

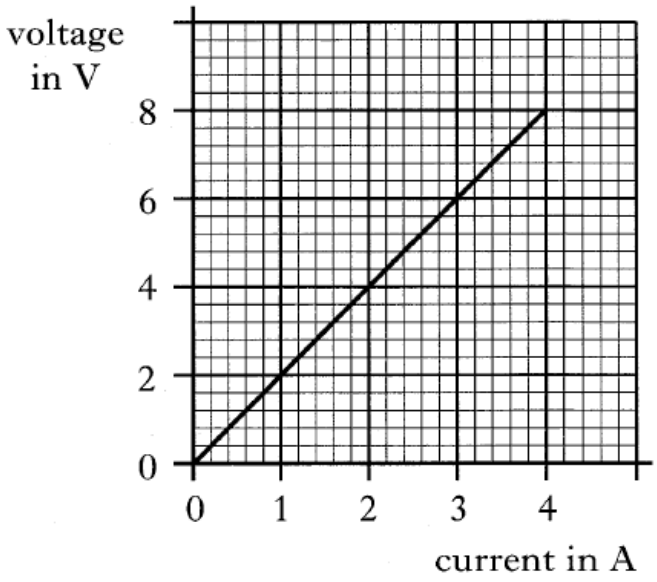


The reading on A_3 is 0·6 A.

Which row shows the readings on A_1 and A_2?

	Ammeter A_1	*Ammeter A_2*
A	0·2 A	0·4 A
B	0·3 A	0·3 A
C	0·4 A	0·2 A
D	0·6 A	0·3 A
E	0·6 A	0·6 A

13. The graph shows the relationship between the voltage across a resistor and the current in the resistor.



The resistance of the resistor is

A 0·5 Ω

B 2 Ω

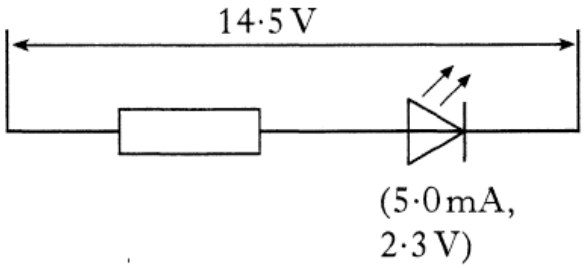
C 4 Ω

D 12 Ω

E 32 Ω.

13. A light-emitting diode (LED) is used to show that a car windscreen heater is switched on.

The supply voltage is 14·5 V. The current through the LED is 5·0 mA, when the potential difference across it is 2·3 V.



The resistance of the series resistor is

A 0·46 Ω

B 2·90 Ω

C 460 Ω

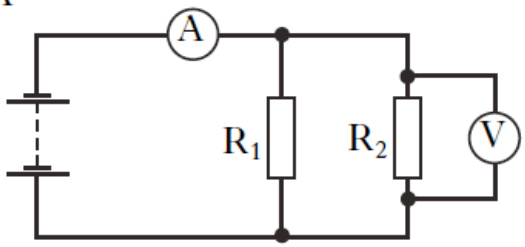
D 2440 Ω

E 2900 Ω.

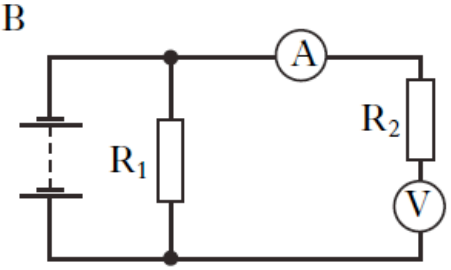
2007 Int 2

8. Which circuit is used to find the resistance of resistor R_2?

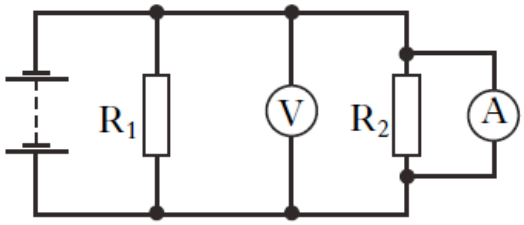
A



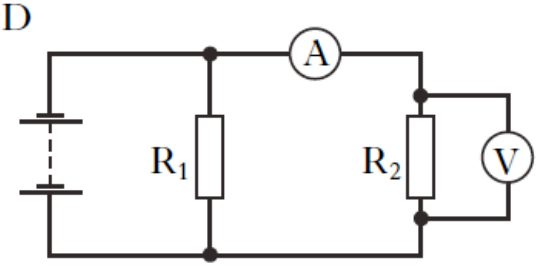
B



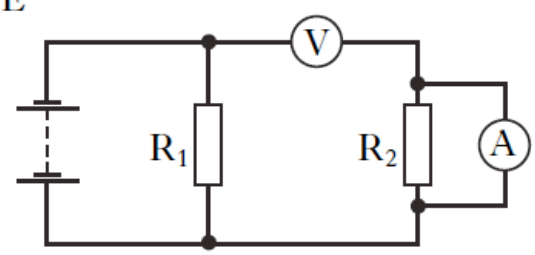
C



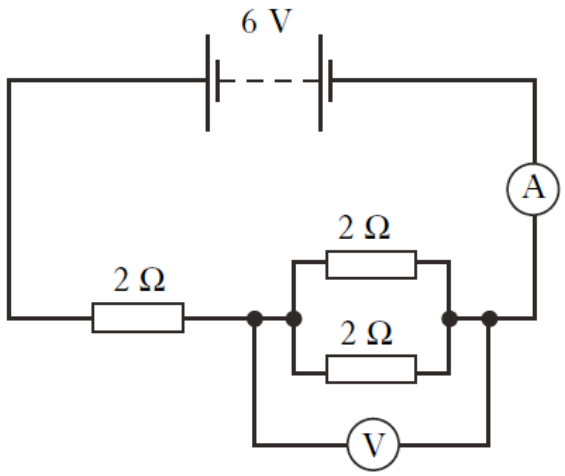
D



E



9. A circuit is set up as shown.



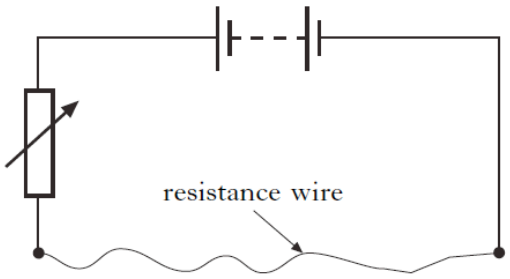
Which row in the table shows the readings on the meters?

	Reading on voltmeter (V)	*Reading on ammeter* (A)
A	2	1
B	2	2
C	3	2
D	4	1
E	4	2

2000 Int 2

25. A student is given a piece of resistance wire 200 mm long and is asked to find its resistance.

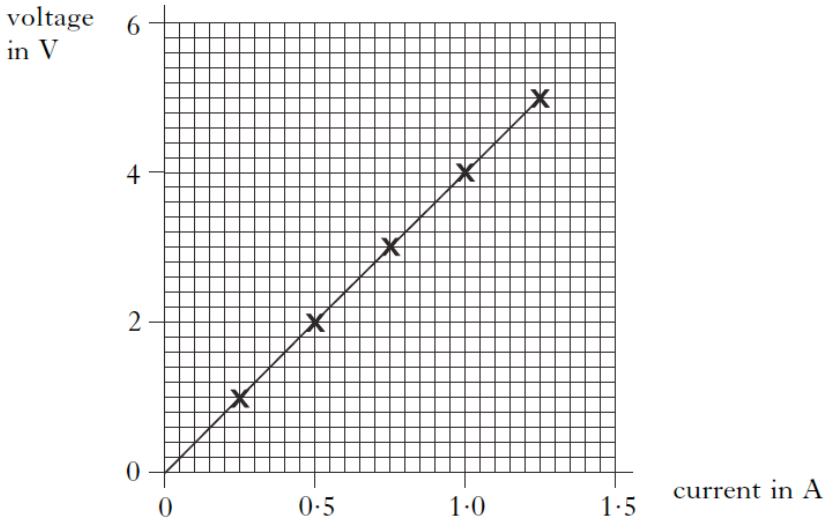
Part of the circuit the student builds is shown below.



The student is also provided with a voltmeter and an ammeter.

(*a*) Redraw the diagram to show how the student should connect the meters to measure the resistance of the wire. **2**

(*b*) The student now uses measurements from the experiment to draw the following graph.

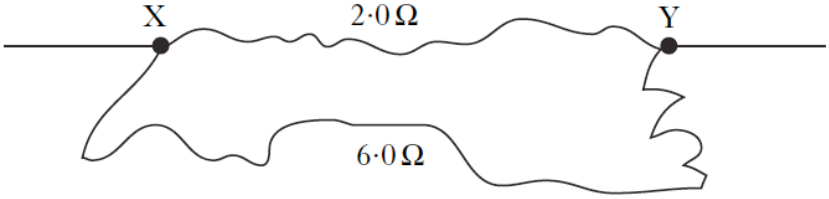


(i) Describe how the student uses the circuit to obtain the measurements for the graph.

(ii) Calculate the resistance of **one metre** of the wire. **5**

(*c*) Two pieces of wire have resistances of 2·0 Ω and 6·0 Ω.

The wires are connected together as shown below.



Calculate the resistance between points X and Y. **2**

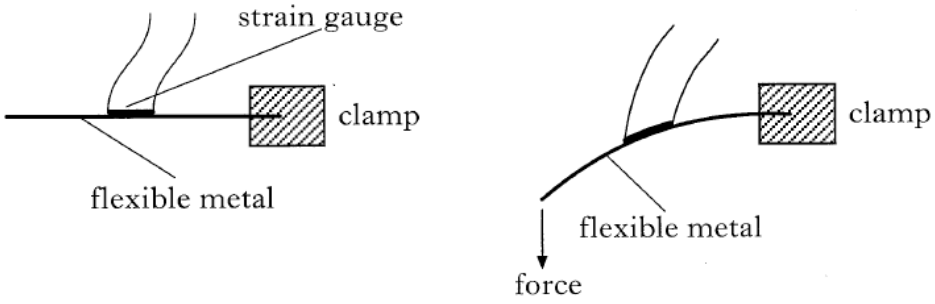
(9)

2001 Int 2

27. A strain gauge is an electrical device that is attached to an object.

The strain gauge detects a change in the shape of the object.

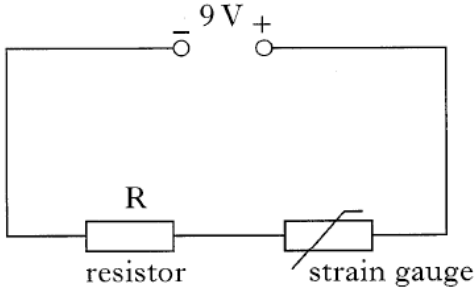
In the following diagrams, the strain gauge is shown attached to a piece of flexible metal.



When a force is applied to the end of the piece of metal, it bends.

When the metal is bent, the strain gauge also bends and its resistance changes.

The strain gauge is connected in series with a resistor, R, and a 9 V supply as shown in the circuit diagram below.



(*a*) A student is asked to find the resistance of the strain gauge using a voltmeter and an ammeter.

Redraw the diagram to show how the student should connect the meters to measure the resistance of the strain gauge. **2**

(*b*) The student obtains the following results.

	Voltmeter reading (V)	*Ammeter reading* (mA)
No force applied	7·20	60·0
Force applied	7·23	59·0

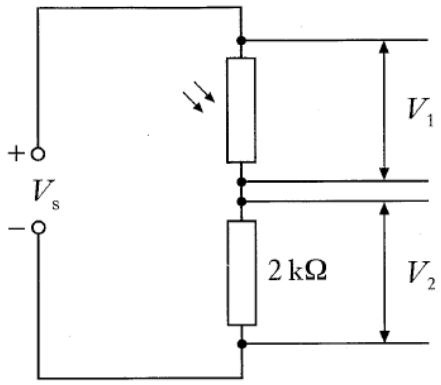
Does the resistance of the strain gauge increase or decrease when the force is applied to the piece of metal? You must justify your answer. **3**

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

(8)

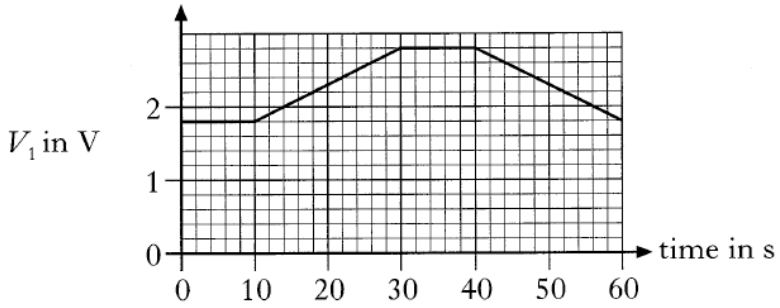
2002 Int 2

25. A light dependent resistor and a 2 kΩ resistor are connected in series across a d.c. supply.

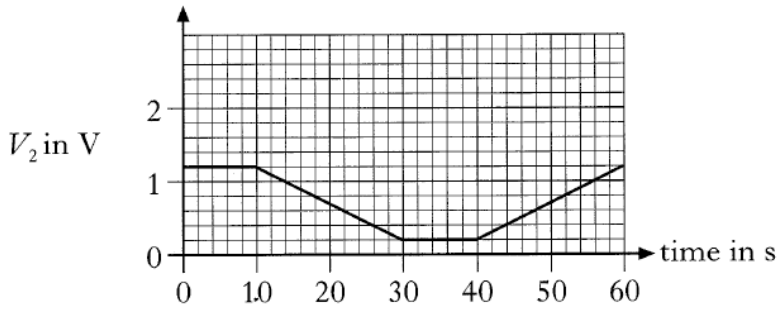


In an experiment the light intensity incident on the LDR is varied during a 60 s period. The voltages across both components are measured over the 60 s period and the following graphs are obtained.

graph 1



graph 2



(*a*) (i) State the values of V_1 and V_2 at the start of the 60 s period. **1**

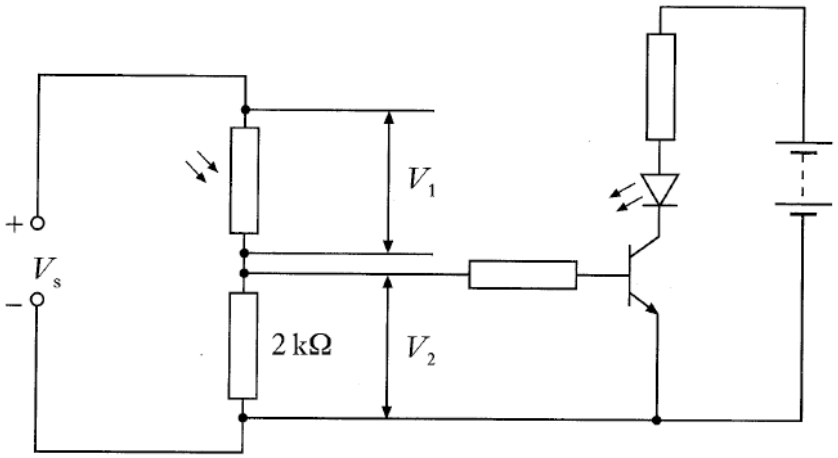
(ii) State the value of the supply voltage V_s. **1**

(*b*) Calculate the resistance of the light dependent resistor at the start of the 60 s period. **2**

(*c*) Is the light intensity incident on the LDR increasing or decreasing during the time interval between 10 s and 30 s? You must explain your answer. **3**

25. (continued)

(*d*) An additional circuit is connected across the 2 kΩ resistor.



The experiment is now repeated and identical graphs are obtained.

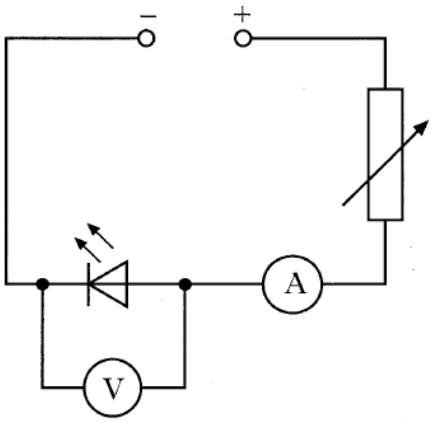
A student observes that the LED is lit between 0 s and 20 s, off between 20 s and 50 s and lit between 50 s and 60 s.

Use graph 2 to explain why the LED is off between 20 s and 50 s. **2**

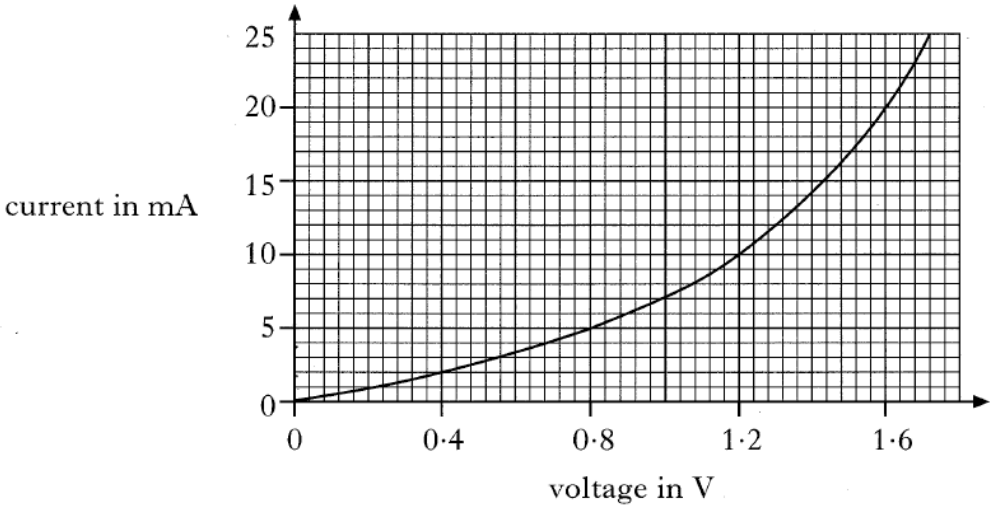
(9)

2003 Int 2

25. An LED is connected in the circuit shown.



The variable resistor is adjusted and voltmeter and ammeter readings are taken. The following graph is obtained from the experimental results.

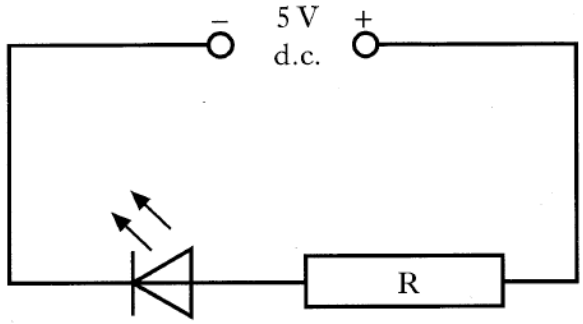


(*a*) Using information from the graph, determine how the resistance of the LED changes as the voltage across it is increased.

You **must** justify your answer by calculation. **3**

25. (continued)

(*b*) The LED is now connected into a circuit with a resistor R as shown.



(i) The current in the LED is 20 mA. Using the graph on *Page fourteen*, state the voltage across the LED. **1**

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

(7)

Electrical Power

2001 Int 2

8. An electric motor with an input power of 1 kW is 80% efficient. The "wasted" energy is all transferred as heat energy. How much heat energy is produced in 1 s?

A 200 J

B 800 J

C 1000 J

D 2000 J

E 8000 J

10. A car headlamp is operating at its rated values of 12 V and 48 W.

Which of the following statements is/ are correct?

I The lamp uses energy at the rate of 48 joules per second.

II The current through the lamp is 4 amperes.

III 12 coulombs of charge flow through the lamp every second.

A I only

B II only

C I and II only

D II and III only

E I, II and III

11. The filament of a lamp has a resistance of 3 Ω and the current through the filament is 2 A.

The electrical power produced by the lamp is

A 1·5 W

B 6 W

C 12 W

D 18 W

E 36 W.

2002 Int 2

9. Which row correctly shows the units of charge, current and power?

	Charge	*Current*	*Power*
A	coulomb	ampere	watt
B	coulomb	ampere	joule
C	volt	ampere	watt
D	volt	ampere	joule
E	volt	coulomb	watt

13. An electric motor connected to a 12 V supply draws a current of 0·5 A. The energy supplied to the motor in 30 s is

A 6 J

B 15 J

C 180 J

D 360 J

E 720 J.

14. Which of the following equations can be used to find the power supplied to a resistor?

I $P = VI$

II $P = I^2R$

III $P = \frac{V^2}{R}$

A I only

B II only

C III only

D I and II only

E I, II and III

2003 Int 2

9. The information shown applies to an electric iron.

ELECTRIC IRON	
Operating voltage	230 V
Power	2·3 kW
Resistance	23 Ω

The iron is switched on for 10 minutes. How much electrical energy is converted to heat energy during this time?

A 5290 J

B 529 000 J

C 717 600 J

D 1 380 000 J

E 2 116 000 J

2005 Int 2

14. An electric kettle is rated at 2·76 kW for use on a 230 V supply. Which of the following statements is/are correct?

I The kettle uses energy at the rate of 2·76 joules per second.

II The current through the element of the kettle is 12 A.

III 230 coulombs of charge flow through the element every second.

A I only

B II only

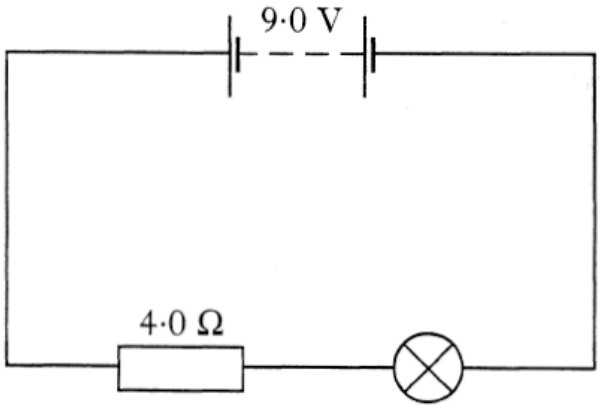
C I and II only

D II and III only

E I, II and III

2006 Int 2

11. A battery is connected in series to a lamp and resistor as shown.



The current in the lamp is 1·5A.

The power developed in the lamp is

A 3·0 W

B 4·5 W

C 6·0 W

D 9·0 W

E 13·5 W.

2007 Int 2

13. A car headlamp is rated at 60 W.

The light produced is 20% of the total energy transferred by the lamp.

The energy transferred as light in 10 s is

A 12 J

B 120 J

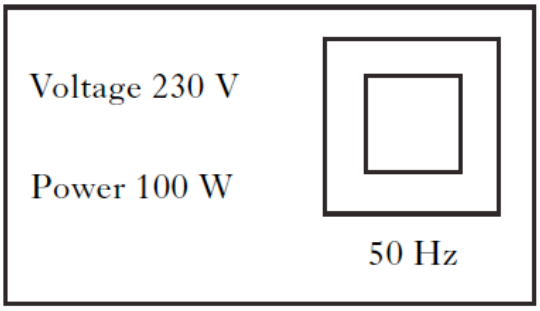
C 600 J

D 3000 J

E 12 000 J.

2008 Int 2

11. The information shown is for an electric food mixer.



The resistance of the mixer is

A 0·43 Ω

B 2·3 Ω

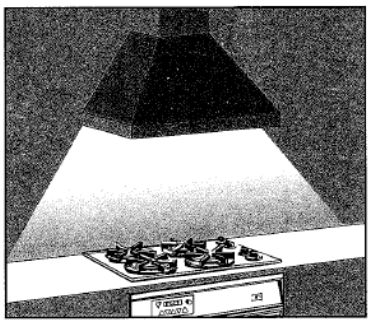
C 4·6 Ω

D 529 Ω

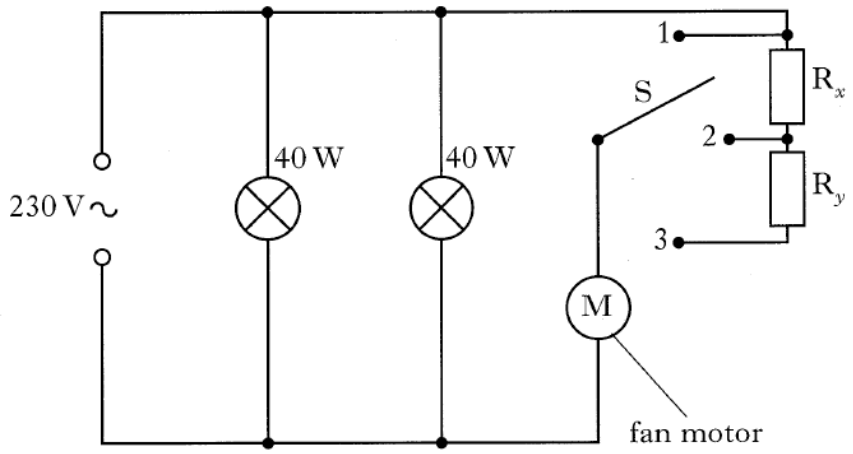
E 23 000 Ω.

2002 Int 2

26. A cooker hood contains two 40 W lamps and an extractor fan.



A circuit diagram for the cooker hood is shown below.



(*a*) Calculate the current drawn by one lamp. **2**

(*b*) Calculate the resistance of one lamp. **2**

(*c*) The speed of the fan motor is varied by moving switch S to position 1, 2 or 3.

State the position of S for maximum speed of the extractor fan motor. You must explain your reason for selecting that position. **2**

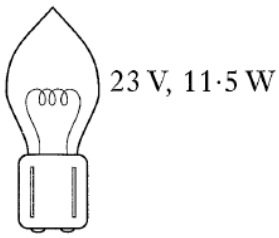
(*d*) When S is in position 2 the voltage across the motor is 180 V and the current through the motor is 0·25 A.

Calculate the resistance of R_x. **3**

(9)

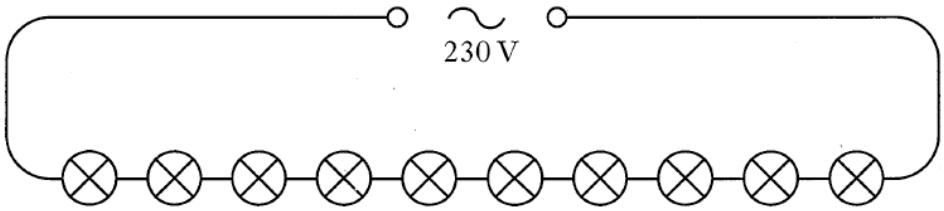
2003 Int 2

24. One type of lamp used for Christmas tree sets is rated as follows.



(*a*) Show that the resistance of one lamp is 46 Ω. **2**

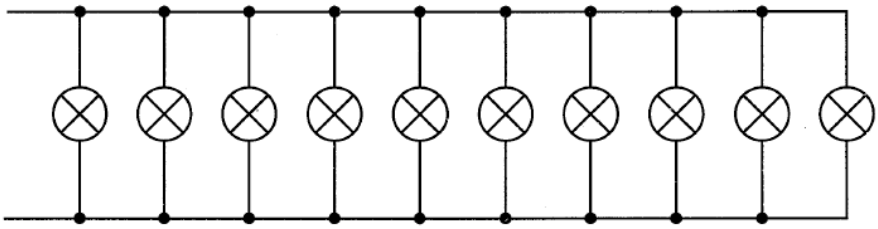
(*b*) In one arrangement, ten of these lamps are connected in series to the mains as shown.



(i) Show that the voltage across each lamp is 23 V. **1**

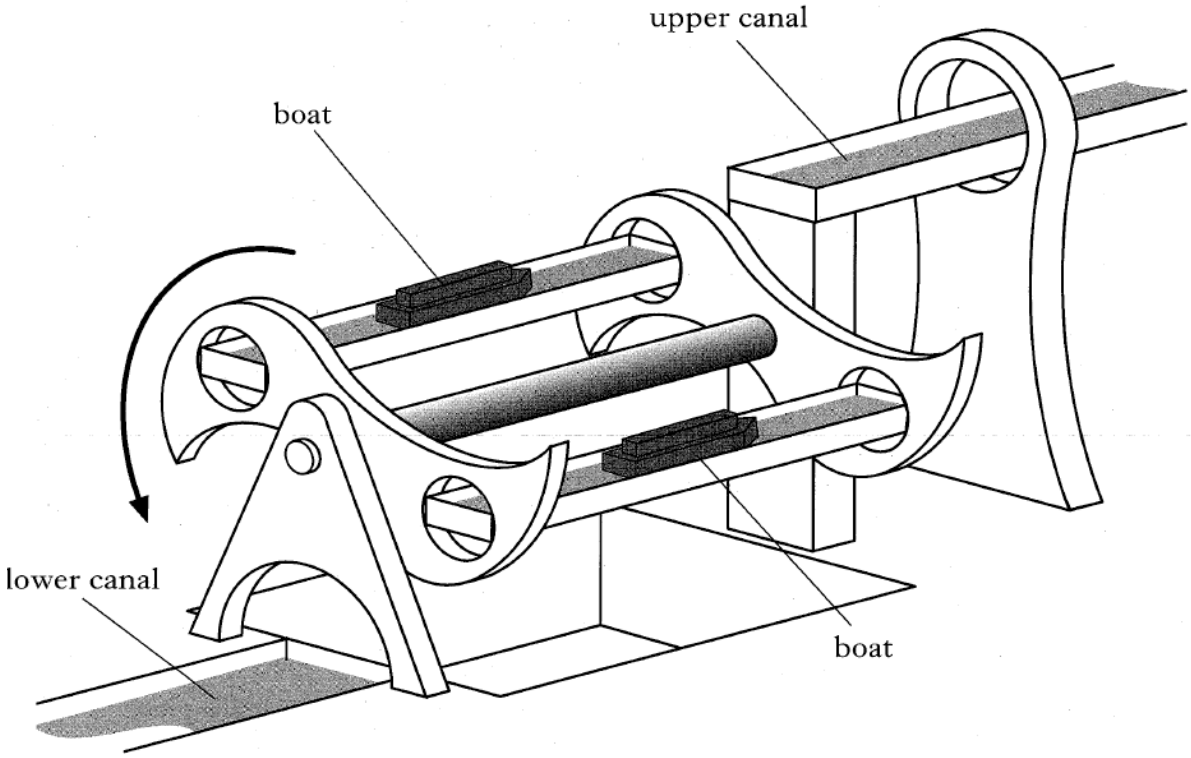
(ii) State **one** disadvantage of wiring lamps in this way. **1**

(*c*) In another arrangement, the ten lamps are connected in parallel as shown.



(i) Calculate the total resistance of this arrangement of lamps. **2**

23. A boat lift is used to move boats between two canals at different heights as shown.



The lift rotates, lowering a boat on one side while raising a boat on the other side.

The system is balanced. The motor rotating the lift has to overcome only frictional forces. Information about the lifting process is shown below.

Frictional force	= 84 000 N
Distance through which force acts	= 12 m
Time for lifting process to be completed	= 4 minutes

(*a*) Show that the power required to operate the lift is 4·2 kW. **3**

(*b*) The motor operates at 400 V and draws a current of 16 A.

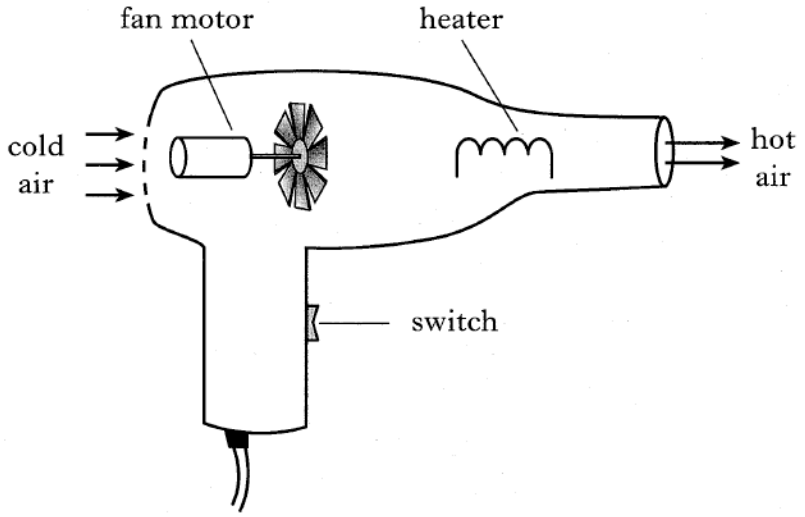
Calculate the input electrical power. **2**

(*c*) Calculate the efficiency of the motor. **2**

(*d*) State whether the power required to start the lift moving is greater than, less than or equal to 4·2 kW. You must explain your answer. **2**

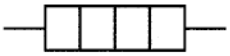
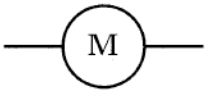
(9)

27. A paint stripper contains a heater and a motor which drives a fan.



The heater and the motor both operate at mains voltage, 230 V.

Information about the heater and motor is shown in the table below.

	Heater	*Motor*
Symbol		
Operating voltage	230 V	230 V
Power	1425 W	575 W

(*a*) Calculate the resistance of the motor. **2**

(*b*) Draw the circuit diagram for the paint stripper. **2**

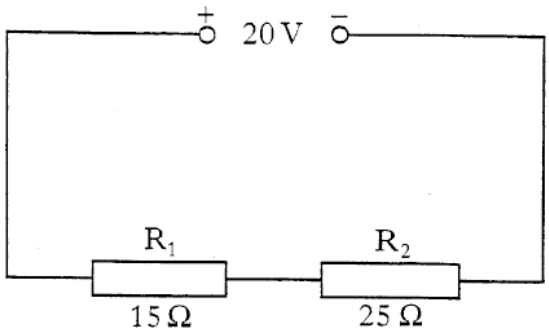
(*c*) The heater burns out. What effect, if any, does this have on the speed of the fan motor?

You **must** explain your answer. **2**

(6)

2005 Int 2

25. (*a*) A student connects two resistors in series with a power supply set at 20 V.



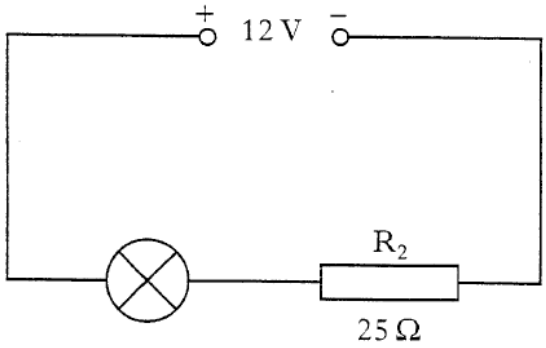
(i) Calculate the current in the circuit. **3**

(ii) Calculate the potential difference across resistor R_1. **2**

(iii) Redraw the above circuit diagram showing meters correctly connected to measure the quantities in (i) and (ii) above. **2**

(*b*) R_1 is now replaced by a 4 V lamp and the supply voltage is reduced to 12 V.

The lamp is operating at its stated voltage.

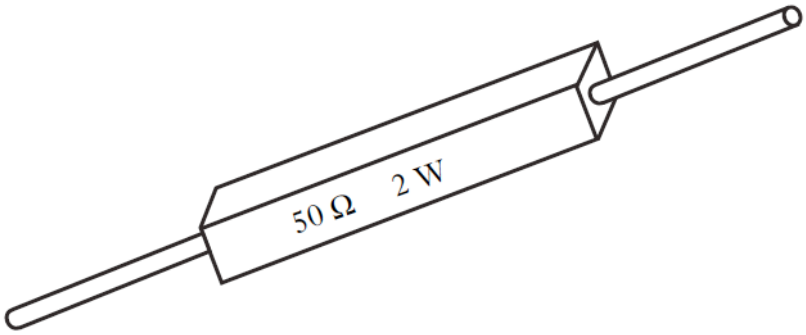


Calculate the rate at which electrical energy is converted to heat energy in resistor R_2. **3**

(10)

2008 Int 2

25. Some resistors are labelled with a power rating as well as their resistance value. This is the maximum power at which they can operate without overheating.

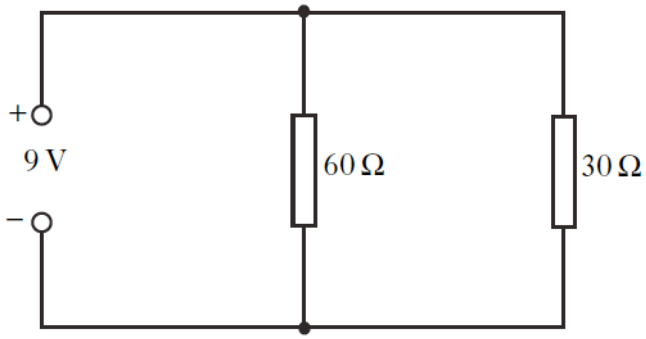


(*a*) A resistor is labelled 50 Ω, 2 W.

Calculate the maximum operating current for this resistor. **2**

(*b*) Two resistors, each rated at 2 W, are connected in parallel to a 9 V d.c. supply.

They have resistances of 60 Ω and 30 Ω.



(i) Calculate the total resistance of the circuit. **2**

(ii) Calculate the power produced in each resistor. **3**

(iii) State which, if any, of the resistors will overheat. **1**

(*c*) The 9 V **d.c.** supply is replaced by a 9 V **a.c.** supply.

What effect, if any, would this have on your answers to part (*b*) (ii)? **1**

(9)

Specific Heat Capacity

2000 Int 2

8. Below are three statements concerning the transfer of heat energy.

Which of these statements is/are correct?

I Different substances require different quantities of heat energy to raise the temperature of 1 kg by 1 °C.

II When a substance changes state, no heat energy is gained or lost.

III When a substance changes state, its temperature does not change.

A I only

B I and II only

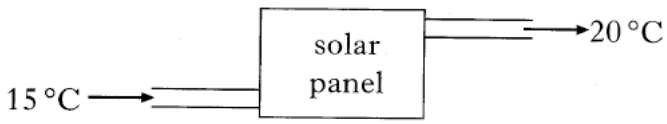
C I, II and III

D II and III only

E I and III only

2002 Int 2

8. Water enters a solar panel at 15 °C and leaves at 20 °C.



The specific heat capacity of water is 4200 J/kg °C.

4 kg of water passes through the panel every minute.

The heat energy gained by the water in 1 minute is

A 16 800 J

B 84 000 J

C 252 000 J

D 336 000 J

E 1 000 800 J.

7. A sample of water is at a temperature of 100 °C. The sample absorbs $2{\cdot}3 \times 10^4$ J of energy.

The specific latent heat of vaporisation of water is $22{\cdot}6 \times 10^5$ J/kg.

The mass of water changed into steam at 100 °C is

A 0·01 kg

B 5·3 kg

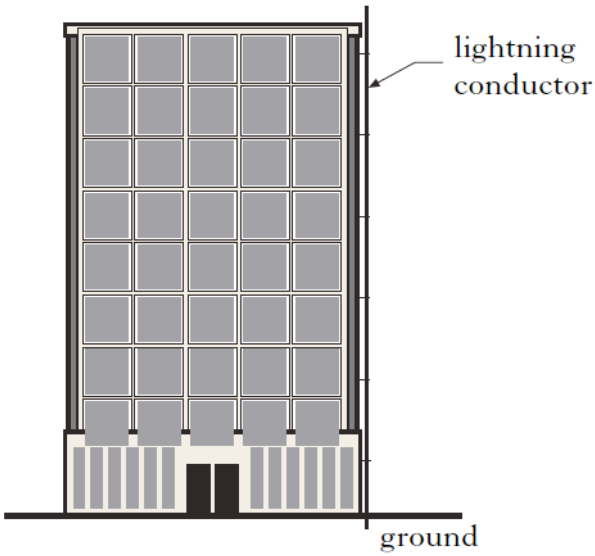
C 100 kg

D $2{\cdot}3 \times 10^4$ kg

E $2{\cdot}3 \times 10^6$ kg.

2000 Int 2

24. A lightning conductor is fitted to a tall building.



The specification for the lightning conductor is:

length	50·0 m
resistance per metre	0·080 Ω
mass	100 kg
specific heat capacity	385 J/kg °C.

During a thunderstorm, a total charge of 300 C flows through the lightning conductor to the ground in 0·120 s.

(*a*) Calculate the current in the lightning conductor during this time. **2**

(*b*) Show that the power in the lightning conductor is 25 MW. **3**

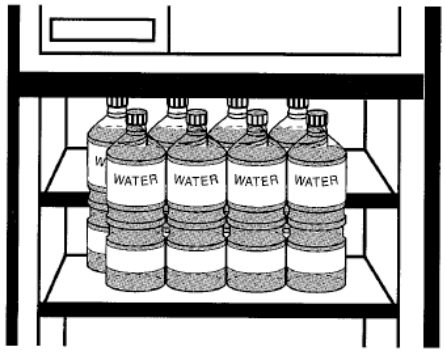
(*c*) (i) Calculate the maximum temperature rise that could be produced in the lightning conductor by this flow of charge.

(ii) What assumption have you made in your calculation for (*c*) (i)? **4**

(9)

2001 Int 2

24. Some bottles of water are placed in a compartment of a refrigerator.
The refrigerator reduces the temperature of the water from 22·0 °C to 10·0 °C.
The **total** mass of water in the bottles is 2·40 kg.



(*a*) The specific heat capacity of the water is 4200 J/kg °C.
Show that the heat energy lost by the water is 121 kJ, correct to 3 significant figures. **2**

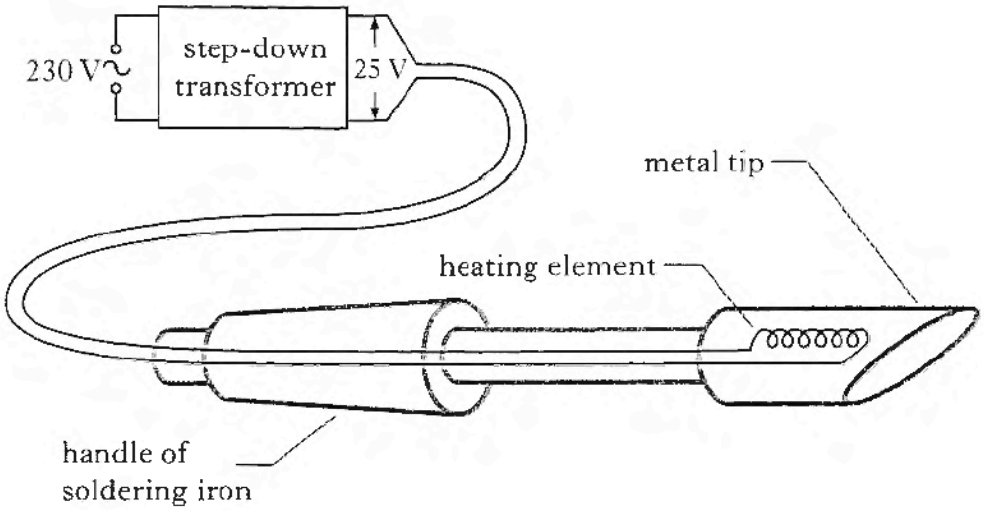
(*b*) The refrigeration system removes heat energy from the compartment at a rate of 100 J/s.

(i) Assuming that heat is removed **from the water** at this rate, how long will it take to lower the water temperature from 22·0 °C to 10·0 °C? **2**

(ii) Explain why the actual time taken to lower the temperature of the water will be longer than the value you calculated in part (i). **1**

(5)

24. A technician uses the soldering iron shown when connecting electrical components.



The heating element is used to raise the temperature of the metal tip above the melting point of solder. The heating element is rated at 25 V, 90 W.

(*b*) The heating element is switched on for 50 s.

Calculate the electrical energy supplied to the element. 2

(*c*) The metal tip is made of copper and has a mass of 0·03 kg. The temperature of the metal tip rises from 20 °C to 370 °C during the period that the element is switched on.

The specific heat capacity of copper is 386 J/kg °C.

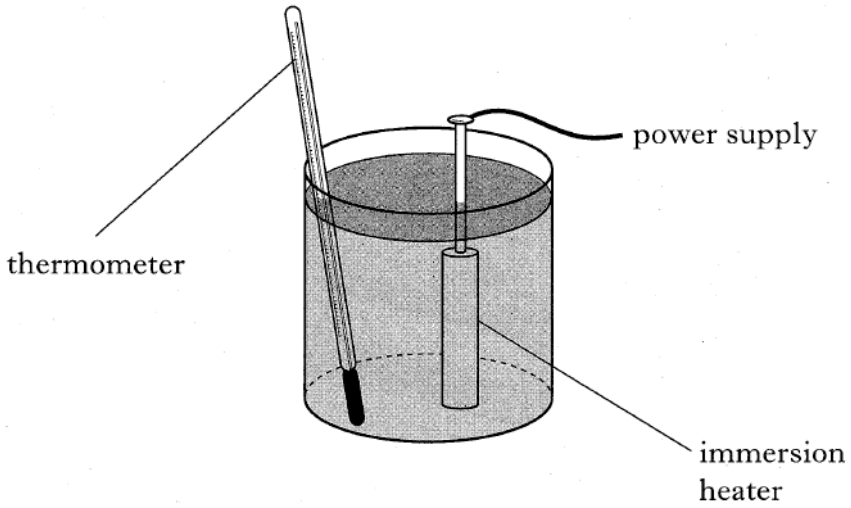
Calculate the heat energy gained by the metal tip. 2

(*d*) Explain why the heat energy gained by the metal tip is less than the electrical energy supplied to the element. 2

(*e*) A device which uses a thermocouple is used to measure the temperature of the metal tip. State the energy change which takes place in a thermocouple. 1

2004 Int 2

24. A heater immersed in 0·40 kg of a liquid is switched on for 4 minutes. The temperature of the liquid rises by 5 °C in this time. The specific heat capacity of the liquid is 2400 J/kg °C.



(*a*) State the useful energy transformation that takes place in the heater. **1**

(*b*) State the part of the heater in which the energy transformation takes place. **1**

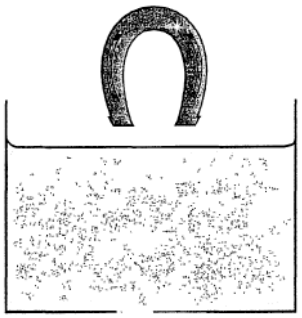
(*c*) Calculate the heat energy gained by the liquid. **2**

(*d*) Calculate the power rating of the heater.

State **one** assumption you have made. **3**

(7)

24. A blacksmith cools a hot iron horse-shoe of mass 0·75 kg by dropping it into water. The mass of the water is 15 kg and its initial temperature is 17 °C. Heat energy from the iron warms the water until both iron and water are at 23 °C.



Data on page two will be required for this question.

(*a*) Calculate the heat energy absorbed by the water. **2**

(*b*) Calculate the initial temperature of the horse-shoe. **3**

(*c*) State **one** assumption required for the calculation in part (*b*). **1**

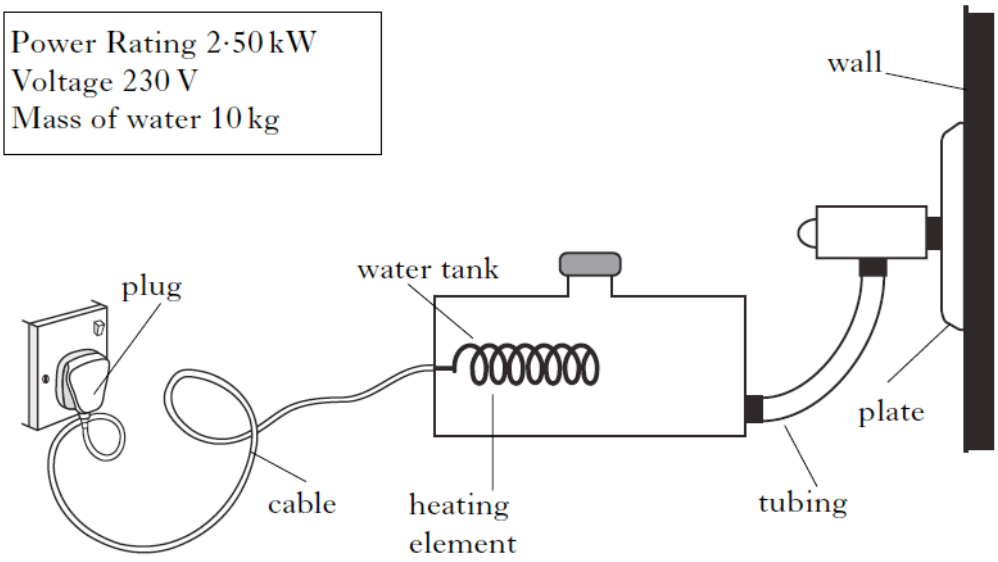
(*d*) What would happen to the temperature rise of the liquid if the blacksmith had replaced the water with the same mass of oil? You **must** explain your answer. **2**

(8)

2007 Int 2

23. A steam wallpaper stripper is used on the walls of a room.

Water is heated until it boils and produces steam. The plate is held against the wall and steam is released from the plate.



The tank is filled with water. The water has an initial temperature of 20 °C.

(*a*) (i) Calculate the energy required to bring the water to its boiling point. **2**

(ii) Calculate the time taken for this to happen. **2**

(iii) The actual time taken for this to happen was found to be longer than that calculated in (*a*) (ii). Explain why. **1**

(*b*) Calculate the current required by the wallpaper stripper. **2**

(*c*) After using the wallpaper stripper for some time, 1·2 kg of water is converted into steam. Calculate the energy used to do this. **2**

(9)

Gas Laws and the Kinetic Model

2000 Higher

6. The pressure of a fixed mass of gas is 100 kPa at a temperature of −52 °C. The volume of the gas remains constant.

At what temperature would the pressure of the gas be 200 kPa?

A −26 °C

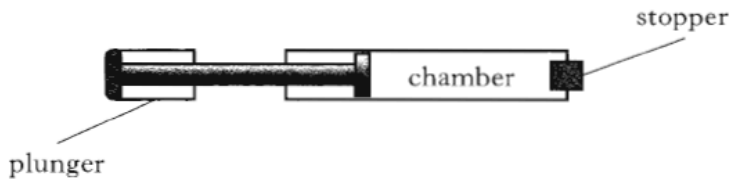
B +52 °C

C +147 °C

D +169 °C

E +442 °C

7. The end of a bicycle pump is sealed with a stopper so that the air in the chamber is trapped.



The plunger is now pushed in slowly causing the air in the chamber to be compressed. As a result of this the pressure of the trapped air increases.

Assuming that the temperature remains constant, which of the following explain/s why the pressure increases?

I The air molecules increase their average speed.

II The air molecules are colliding more often with the walls of the chamber.

III Each air molecule is striking the walls of the chamber with greater force.

A II only

B III only

C I and II only

D I and III only

E I, II and III

2001 Higher

7. Ice at –10 °C is heated until it becomes water at 80 °C.

The temperature change on the kelvin scale is

A 70 K

B 90 K

C 343 K

D 363 K

E 636 K.

2002 Higher

7. A sealed hollow buoy drifts from warm Atlantic waters into colder Arctic waters.

The volume of the buoy remains constant.

The pressure of the air trapped inside the buoy changes.

This is because the pressure of the trapped air is

A directly proportional to the kelvin temperature

B inversely proportional to the kelvin temperature

C inversely proportional to the volume of the air in the buoy

D inversely proportional to the celsius temperature

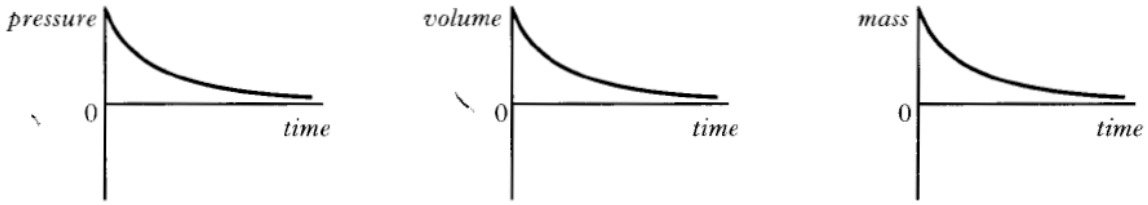
E directly proportional to the celsius temperature.

2003 Higher

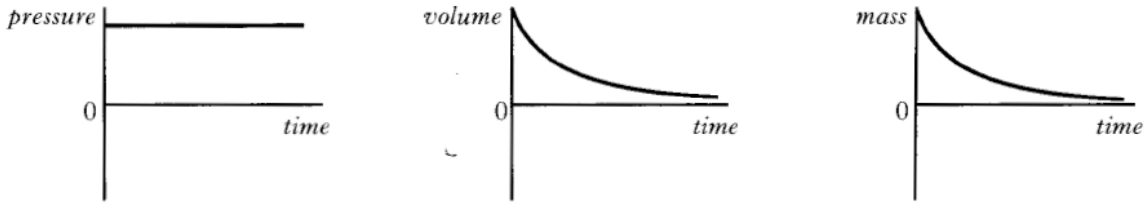
7. A rigid metal cylinder stores compressed gas. Gas is gradually released from the cylinder. The temperature of the gas remains constant.

Which set of graphs shows how the pressure, the volume and the mass of the gas **in the cylinder** change with time?

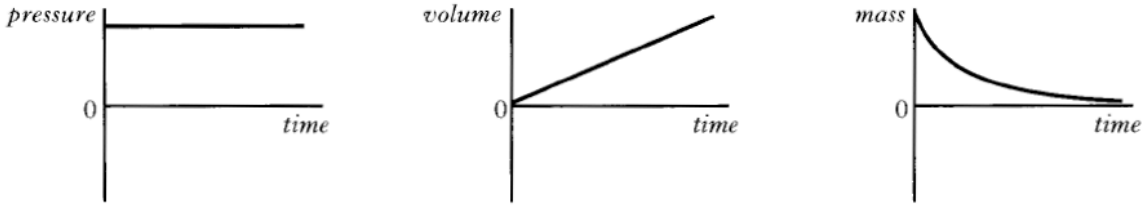
A



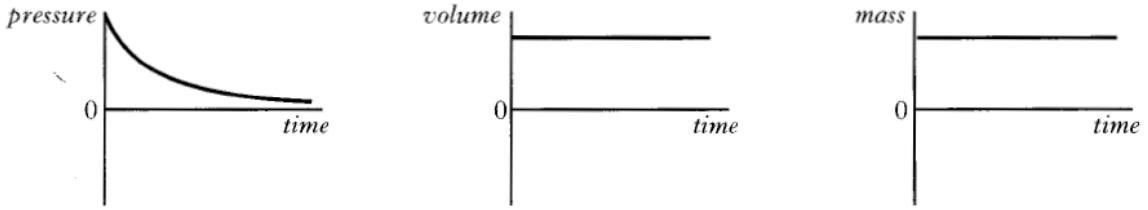
B



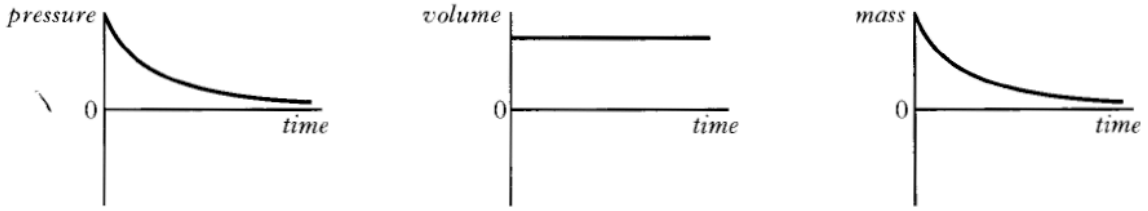
C



D



E



2004 Higher

7. The density of steam at 100 °C is less than the density of water at 100 °C. The explanation for this is that when water changes to steam its particles

A move further apart

B move with greater speed

C have smaller mass

D are no longer joined together

E collide more often with each other.

9. A balloon of volume of $6{\cdot}0\,m^3$ contains a fixed mass of gas at a temperature of 300 K and a pressure of 2·0 kPa. The gas is heated to 600 K and the pressure reduced to 1·0 kPa. The new volume of the gas is

A $1{\cdot}5\,m^3$

B $3{\cdot}0\,m^3$

C $6{\cdot}0\,m^3$

D $12{\cdot}0\,m^3$

E $24{\cdot}0\,m^3$.

2005 Higher

6. A solid at a temperature of −20 °C is heated until it becomes a liquid at 70 °C.

The temperature change in kelvin is

A 50 K

B 90 K

C 343 K

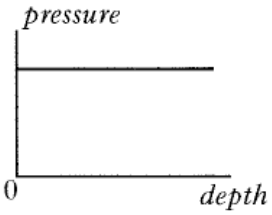
D 363 K

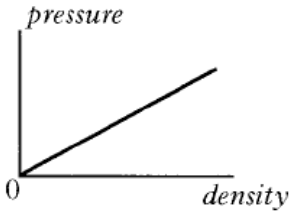
E 596 K.

2006 Higher

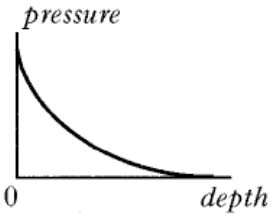
7. Which pair of graphs shows how the pressure produced by a liquid depends on the depth and density of the liquid?

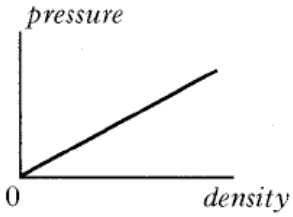
A



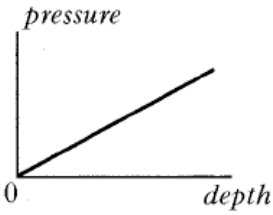


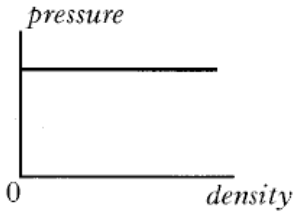
B



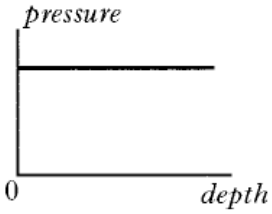


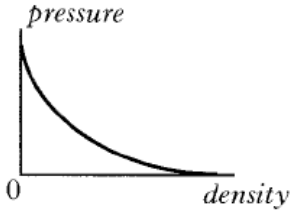
C



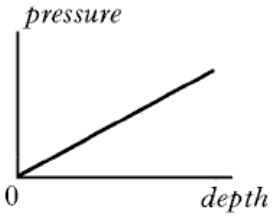


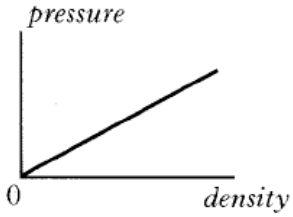
D





E





7. One pascal is equivalent to

A $1\ \text{N m}$

B $1\ \text{N m}^2$

C $1\ \text{N m}^3$

D $1\ \text{N m}^{-2}$

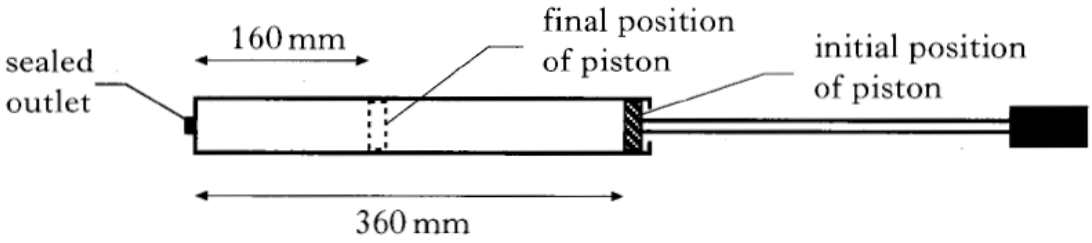
E $1\ \text{N m}^{-3}$.

2001 Higher
22

(*b*) The cylinder of a bicycle pump has a length of 360 mm as shown in the diagram.

The outlet of the pump is sealed.

The piston is pushed inwards until it is 160 mm from the outlet.



The initial pressure of the air in the pump is $1{\cdot}0 \times 10^5$ Pa.

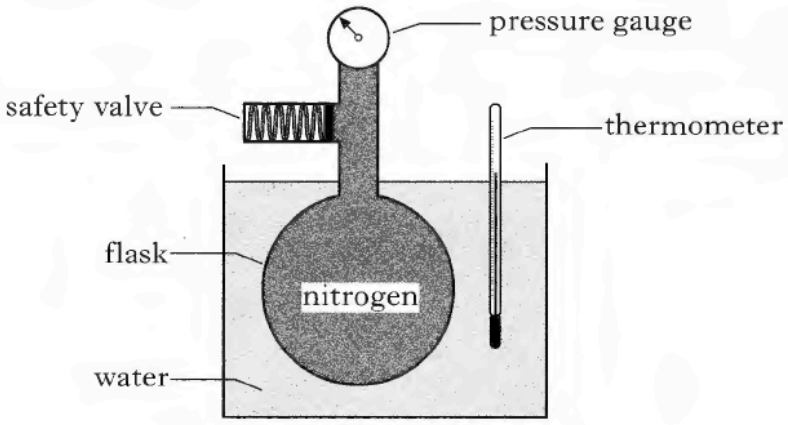
(i) Assuming that the temperature of the air trapped in the cylinder remains constant, calculate the final pressure of the trapped air.

(ii) State one other assumption you have made for this calculation.

(iii) Use the kinetic model to explain what happens to the pressure of the trapped air as its volume decreases. **5**

2002 Higher

22. A technician designs the apparatus shown in the diagram to investigate the relationship between the temperature and pressure of a fixed mass of nitrogen which is kept at a constant volume.



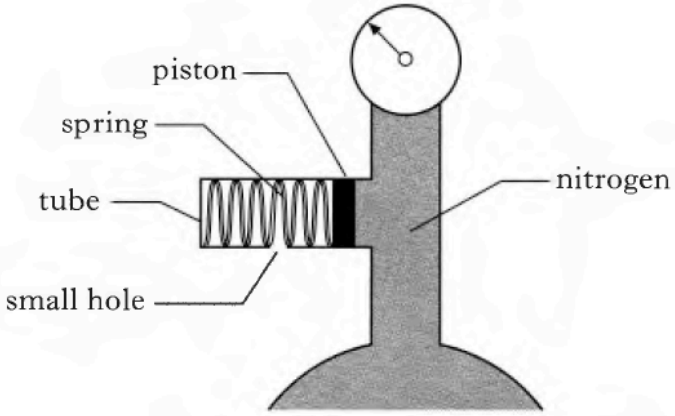
(*a*) The pressure of the nitrogen is 109 kPa when its temperature is 15 °C. The temperature of the nitrogen rises to 45 °C.

Calculate the new pressure of the nitrogen in the flask. **2**

(*b*) Explain, in terms of the movement of gas molecules, what happens to the pressure of the nitrogen as its temperature is increased. **2**

(*c*) The technician has fitted a safety valve to the apparatus.

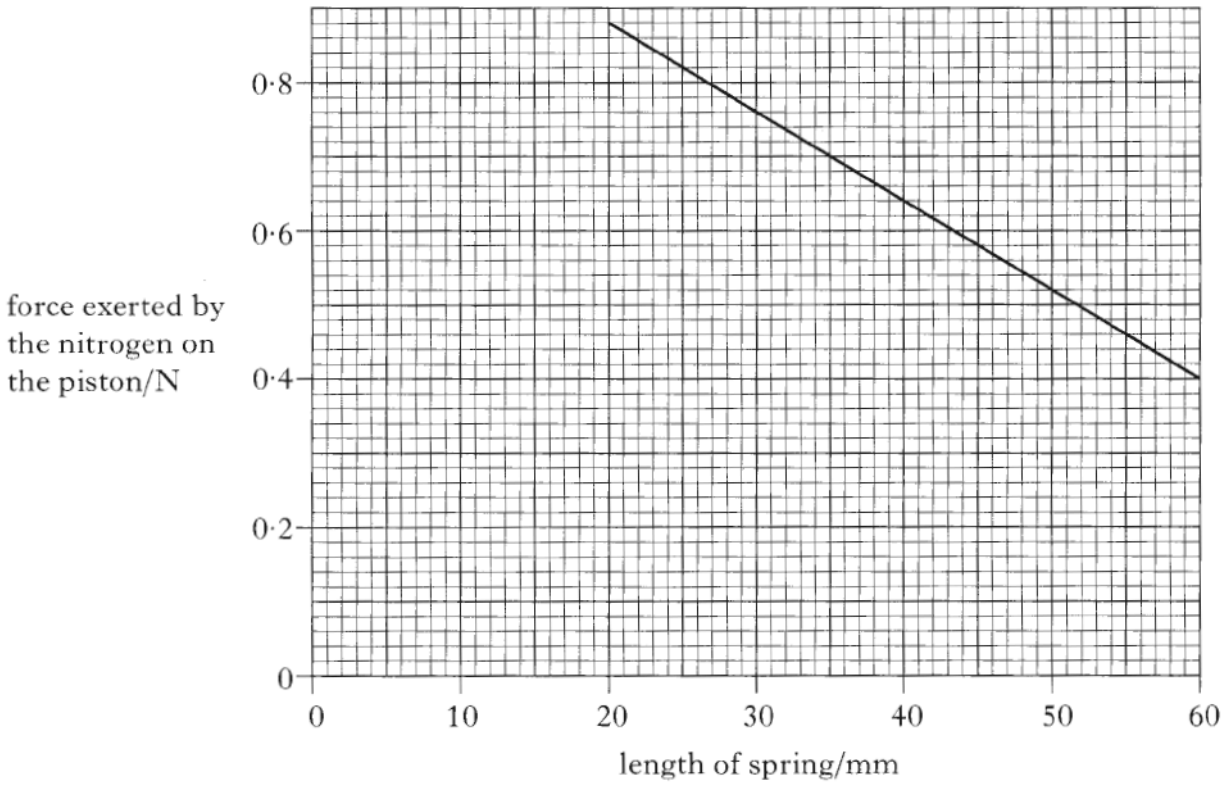
A diagram of the valve is shown below.



The piston of cross-sectional area $4{\cdot}0 \times 10^{-6}\,m^2$ is attached to the spring. The piston is free to move along the tube.

The following graph shows how the length of the spring varies with the force exerted by the nitrogen on the piston.

22. **(*c*) (continued)**



(i) Calculate the force exerted by the nitrogen on the piston when the reading on the pressure gauge is $1{\cdot}75 \times 10^5$ Pa.

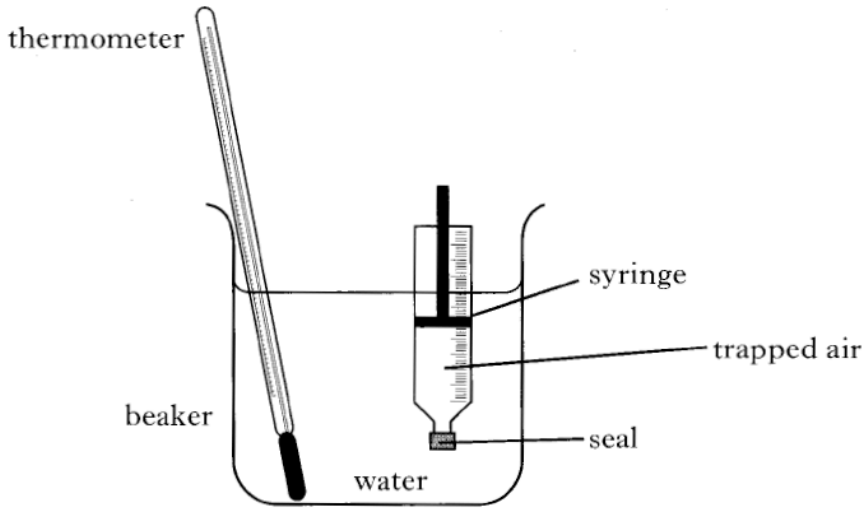
(ii) What is the length of the spring in the safety valve when the pressure of the nitrogen is $1{\cdot}75 \times 10^5$ Pa? **3**

(*d*) The technician decides to redesign the apparatus so that the bulb of the thermometer is placed inside the flask.

Give **one** reason why this improves the design of the apparatus. **1**

(8)

24. The apparatus used to investigate the relationship between volume and temperature of a fixed mass of air is shown.



The volume of the trapped air is read from the scale on the syringe.

The temperature of the trapped air is altered by heating the water in the beaker. It is assumed that the temperature of the air in the syringe is the same as that of the surrounding water. The pressure of the trapped air is constant during the investigation.

(*a*) Readings of volume and temperature for the trapped air are shown.

Temperature/ °C	25	50	75	100
Volume/ml	20·6	22·6	24·0	25·4

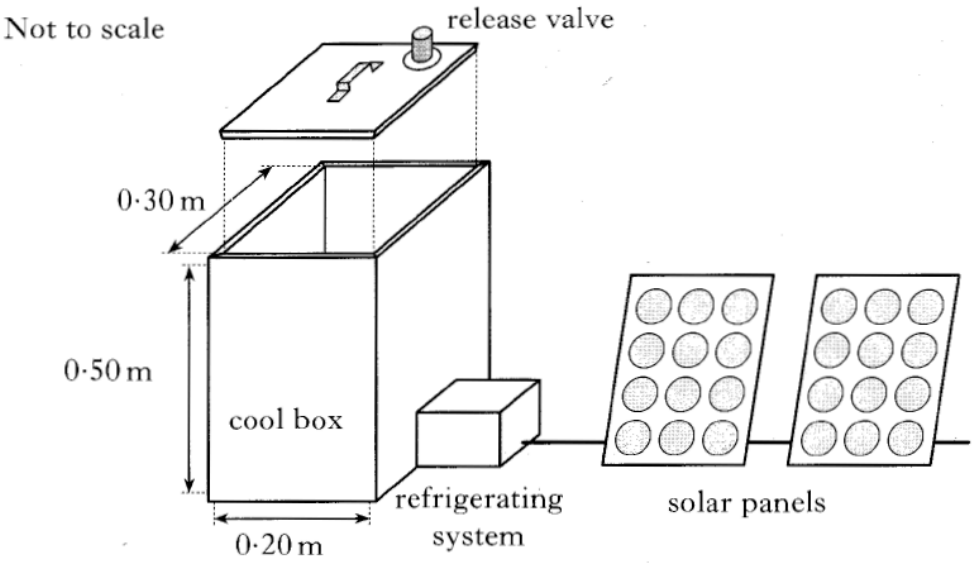
(i) Using **all** the data, establish the relationship between temperature and volume for the trapped air. **2**

(ii) Calculate the volume of the trapped air when the temperature of the water is 65 °C. **2**

(iii) Use the kinetic model of gases to explain the change in volume as the temperature increases in this investigation. **2**

2006 Higher

23. A refrigerated cool box is being prepared to carry medical supplies in a hot country. The **internal** dimensions of the box are 0·30 m × 0·20 m × 0·50 m.



The lid is placed on the cool box with the release valve closed. An airtight seal is formed. When the lid is closed the air inside the cool box is at a temperature of 33 °C and a pressure of $1{\cdot}01 \times 10^5$ Pa.

The refrigerating system then reduces the temperature of the air inside the cool box until it reaches its working temperature.

At this temperature the air inside is at a pressure of $9{\cdot}05 \times 10^4$ Pa.

(*a*) (i) Calculate the temperature of the air inside the cool box when it is at its working temperature. **2**

(ii) Describe, using the kinetic model, how the decrease in temperature affects the air pressure inside the cool box. **2**

(*b*) (i) Atmospheric pressure is $1{\cdot}01 \times 10^5$ Pa.

Show that the magnitude of the force on the lid due to the difference in air pressure between the inside and outside of the cool box is now 630 N. **2**

(ii) The mass of the lid is 1·50 kg.

Calculate the minimum force required to lift off the lid when the cool box is at its working temperature. **1**

(iii) The release valve allows air to pass into or out of the cool box.

Explain why this valve should be opened before lifting the lid. **1**

(*c*) The refrigerating system requires an average current of 0·80 A at 12 V.

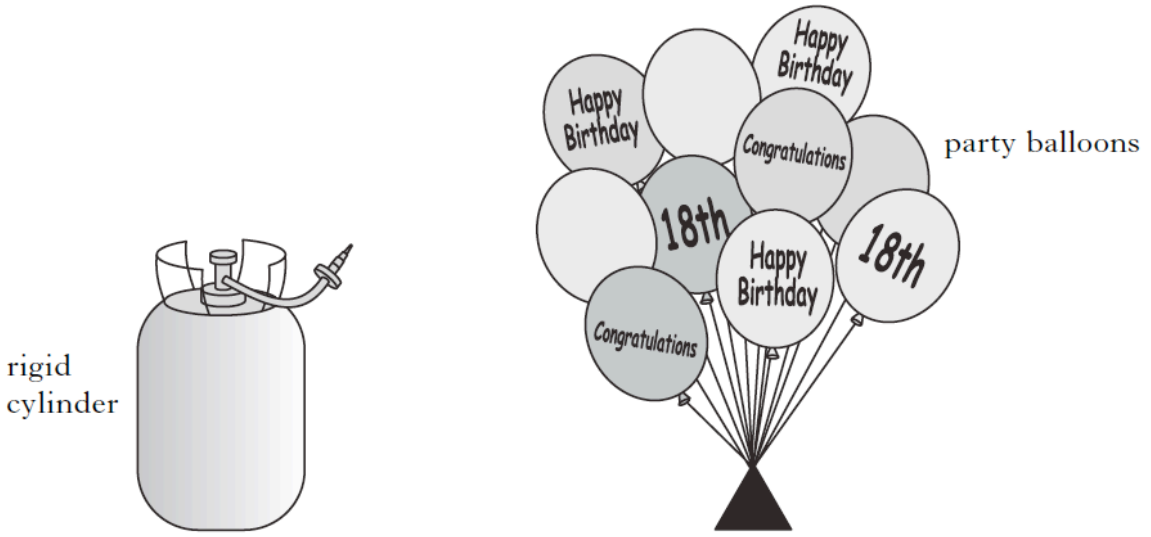
Each solar panel has a power output of 3·4 W at 12 V.

Calculate the minimum number of solar panels needed to operate the refrigerating system. **2**

(10)

2007 Higher

23. A rigid cylinder contains $8{\cdot}0 \times 10^{-2}\,m^3$ of helium gas at a pressure of 750 kPa. Gas is released from the cylinder to fill party balloons.



During the filling process, the temperature remains constant. When filled, each balloon holds $0{\cdot}020\,m^3$ of helium gas at a pressure of 125 kPa.

(*a*) Calculate the total volume of the helium gas when it is at a pressure of 125 kPa. **2**

(*b*) Determine the maximum number of balloons which can be fully inflated by releasing gas from the cylinder. **2**

2008 Higher

23. A cylinder of compressed oxygen gas is in a laboratory.

(*a*) The oxygen inside the cylinder is at a pressure of $2{\cdot}82 \times 10^6$ Pa and a temperature of 19·0 °C.

The cylinder is now moved to a storage room where the temperature is 5·0 °C.

(i) Calculate the pressure of the oxygen inside the cylinder when its temperature is 5·0 °C. **2**

(b)

(ii) The valve on the cylinder is opened slightly so that oxygen is gradually released.

The temperature of the oxygen inside the cylinder remains constant.

Explain, in terms of particles, why the pressure of the gas inside the cylinder decreases. **1**

(iii) After a period of time, the pressure of the oxygen inside the cylinder reaches a constant value of $1{\cdot}01 \times 10^5$ Pa. The valve remains open.

Explain why the pressure does not decrease below this value. **1**